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Improving Disciplinary Literacy in the Science Classroom with Scaffolding

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Improving Disciplinary Literacy in the Science Classroom with Scaffolding

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By

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DEDICATION

I want to dedicate this action research to my best friend and partner in all things, my husband, Kain Schow. We have been on this graduate program journey together. In many ways, he has given me support and motivation to succeed in this journey and to be the best teacher I can be. He inspired my decision to join the field of education, and I wouldn’t be where I am today without him.

ABSTRACT

This study examines the effects of scaffolding on students' scientific literacy skills. This study measured the scientific literacy skills of students before and after the use of four different scaffolding practices by the researcher. Participants included 41 students in grades 7-12 that are enrolled in a science course taught by the researcher. The data collected will be used to direct the researcher's future teaching of scientific literacy practices.

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CHAPTER 1

INTRODUCTION

Introduction

Across the United States, most states have adopted the Next Generation Science Standards (NGSS), or like in Minnesota, the states have developed their own that highly resemble NGSS. One of the foundation pieces of these new standards is the emphasis on science and engineering practices. A few practices include asking questions, planning and carrying out investigations, obtaining, evaluating, and communicating information. However, in general, these practices do not come naturally for most students because they rely on specialized reading and writing skills.

Brief Literature Review

Each discipline area has its unique process for reading, writing, talking, and thinking, and these skills must be taught for students to fully comprehend the knowledge of each content area (McConachie et al., 2006, Tang, 2016). Research has shown that by emphasizing literacy skills, teachers can focus on learning by process in order for students to achieve higher-order thinking and learning content (McConachie et al., 2006). The core process skills within the science discipline include conducting investigations, information analysis, curiosity and questioning, and epistemic knowledge (Sharon & Baram-Tsabari, 2020). These skills require that students have a strong foundation in reading and writing. The research has shown in many cases that students struggle to read within the sciences due to text structure, content-specific language, abstract concepts, and a lack of comprehension strategies (Botsas, 2017, Stott & Beedler, 2019, Akbash et al., 2016, Paul, 2018, Detillion, 2021, Slough & Rupley, 2010).

A recent shift in teaching has pushed students to take center stage while teachers become facilitators within the classroom. Studies by Poock et al. (2007), Sampson et al. (2013), and Slough & Rupley (2010) have tested student-centered hands-on learning activities with an emphasis on laboratory investigations. In each study, students performed real-world science tasks such as designing an investigation or developing an inquiry-based argument. Each study saw an increase in student understanding of content knowledge and science writing skills.

Statement of the Problem

Many studies have shown the benefits of student-led inquiry, and the gap in science reading comprehension. However, the problem many teachers face is how students can lead investigations or arguments if their foundational scientific reading and writing skills are poor? This study will investigate the impact scaffolding on students' scientific reading and writing ability with the hypothesis that by providing supports students' reading and writing will improve and lead to independence and success in scientific inquiry tasks.

Purpose of the Study

In my short time as a science teacher, I have been shocked by my students' general inability to read and write within the sciences. This inability often limits the level of rigor and amount of content that can be covered within my classes. I feel I spend more time telling students to write in complete sentences than instructing on science content. I am passionate about teaching my students the skills they need to become successful independent thinkers by providing appropriate challenges and rigor within science classes. The purpose of this study was to identify the value and impact scaffolding may have on improving students' scientific literacy.

Research Question

What impact does scaffolding have on grade 7-12 students' scientific reading and writing within a rural community setting?

Definition of Variables

Scaffolding Implementation: The implementation of scaffolding was the independent variable. This study used scaffolding strategies to assist students in understanding science-specific reading and writing skills.

Students' Reading and Writing Ability: The assessment of reading and writing ability was the dependent variable. Reading and writing ability was assessed using rubric grading. The researcher measured the students' ability before, during, and after implementing scaffolding and used this data to identify trends and the impact of scaffolding.

Significance of the Study

Science education is currently having a significant shift in teaching practices. In Minnesota, this shift is mandated by the new science standards. The focus is now on having students learn science by doing it and working with information rather than being told and memorizing information. Our students, however, are comfortable in the sit, listen, and cram for a test status quo and their scientific literacy skills are underdeveloped and out of practice. In addition, students often express frustration when asked to complete student-led tasks because they do not know how to begin or what steps to take. This study will examine the effectiveness of scaffolding to bridge students from this area of frustration to independence in scientific literacy tasks.

Research Ethics

Permission and IRB Approval

In order to conduct this study, the researcher will seek MSUM's Institutional Review Board (IRB) approval to ensure the ethical conduct of research involving human subjects (Mills & Gay, 2019). Likewise, authorization to conduct this study will seek from the school district where the research project will take place (See Appendix X and X).

Informed Consent

Protection of human subjects participating in research was assured. Participant minors were informed of the purpose of the study via the Method of Assent (See Appendix E) that the researcher read to participants before the beginning of the study. Participants were aware that this study was conducted as part of the researcher's Master's Degree Program and that it will benefit her teaching practice. Informed consent means that the parents of participants have been fully informed of the purpose and procedures of the study for which consent is sought and that parents understand and agree, in writing, to their child participating in the study (Rothstein & Johnson, 2014). Confidentiality was protected through the use of pseudonyms (e.g., Student 1) without the utilization of any identifying information. The choice to participate or withdraw at any time was outlined both verbally and in writing.

Limitations

The first limitation of this study would be the sample population. Each class varies in size from 14-20 students and grade level from 7th-12th grade. The sample population was a total of 86 students with 41 students providing participation consent for data collection. There is no repetition of classes. For example, there is one 7th grade life science class with 15 students and one $11^{th}/12^{th}$ grade environmental science class with 9 students. This means the small population size will have significant variation in grade level and subject content.

The second limitation of this study would be the time frame. This study was conducted over a six-week time frame during the second semester of school. The skills being assessed have been worked on in class prior to this study which may impact the data.

Conclusions

Scaffolding is a targeted approach instructors use to help guide students from areas of difficulty or misunderstanding to an area of independence and comprehension. Research has shown that students struggle to perform and comprehend science-specific reading and writing tasks. It is the goal of this research to use scaffolding to improve students understanding of scientific literacy. In the following chapter, key concepts such as disciplinary literacy, scaffolding, and scientific reading and writing will be further defined. The chapter will also analyze the current state of research within this topic and propose how to build upon it.

CHAPTER 2

LITERATURE REVIEW

Introduction

Students struggle with reading and writing in science. For example, students have difficulty finding the answer in their reading if the answer is not a word-for-word match to the question. Students need a sentence frame, outline for written responses, or they struggle to comprehend and use scientific terminology. In Minnesota, new science standards are phasing in, which resemble the Next Generation Science Standards (NGSS), which emphasize learning by doing science; this relies on students reading and writing like scientists. The purpose of this study is to improve student scientific literacy by using scaffolding strategies.

Disciplinary Literacy

Disciplinary literacy is the concept that each content area/discipline has its unique process for reading, writing, talking, and thinking, and in order for students to comprehend content knowledge, they must also learn the literacy skills specific to the content area (McConachie et al., 2006, Tang, 2016). Many teachers feel restricted on time, and that content will have to be diluted to teach disciplinary literacy. Studies have shown that disciplinary literacy is not emphasized in many science classrooms (Sharon & Baram-Tsabari, 2018, McConachie et al., 2006, Tang, 2016, Wright & Wenk Gotwals, 2017). However, many states have adopted the NGSS or standards similar, causing a recent push for implementing disciplinary literacy into content area teaching within the sciences.

The case study by Tang (2016) found two major patterns for teaching disciplinary language, Initiate Response Evaluate (IRE) questioning and logical conjunctions. Tang (2016) found that teachers often use IRE to assess students' understanding of scientific vocabulary formatively. The use of IRE leads to logical conjunctions where the teacher looks to make comparisons or explain scientific phenomena (Tang, 2016). Tang (2016) criticizes this level of disciplinary literacy teaching because it focuses on a surface-level understanding of terminology and explanation knowledge. Furthermore, Tang (2016) did not observe students who critically evaluated scientific knowledge and phenomena in this case study. Therefore, Tang (2016) calls for more teaching by process.

McConachie et al. (2006) provide examples of implementing the five principles of disciplinary literacy and propose that teaching content and process together learning can become more rigorous. The five principles are: knowledge and thinking must go hand in hand, learning is an apprenticeship, teachers mentor students, instructions and assessment drive each other, and classroom culture socializes intelligence (McConachie et al., 2006). These principles show that teaching disciplinary literacy should not remove focus from learning content, but rather that students should become apprentices in learning the content knowledge by practicing using the processes specific to that discipline. In order for students to learn the process, teachers must provide adequate supports and opportunities.

Sharon and Baram-Tsabari (2020) discussed the growing problem of scientific misinformation within the non-scientific community. Although many specific scientific literacy skills are critical to scientists, teachers have limited time. Sharon and Baram-Tsabari (2020) propose that science teachers should focus on four critical science disciplinary literacy strategies with direct instruction, modeling, and practice: an understanding of scientific practices, identifying and judging appropriate scientific expertise, epistemic knowledge, and disposition and habits of mind (e.g., curiosity, open-mindedness). In a commentary by Andrew Zucker

(2021), he also remarks on the dangers of misinformation, emphasizing how many people get their information from social media or other unreliable sources. Narrowing the focus of scientific literacy to four skills could be a valuable component to teachers when making lesson planning decisions.

Another common theme with implementing disciplinary literacy into science classrooms is driving questions and emphasizing real-world scenarios, also known as scientific phenomena (Wright & Wenk Gotwals, 2017, Zucker, 2021). Driving questions present real-world problems or scenarios that reflect a scientific phenomenon. Students can then learn content about the phenomenon by practicing scientific literacy skills where they read, write, and think like scientists to answer the driving question (Wright & Wenk Gotwals, 2017, Zucker, 2021).

Scaffolding Reading

In the article Differences in Strategy Use, author George Botsas (2017) analyzed the reading comprehension strategies used in narrative versus expository text for students with and without learning disabilities. Botsas (2017) describes expository texts as informational texts that are often organized in a complicated way, making comprehension difficult for students. For example, in science class, the reading material would be classified as expository text because of the text structure, content-specific language, and abstract concepts. However, the study found that both groups of students struggled to comprehend expository text and only obtained surface-level understanding due to a lack of discipline-specific reading strategies (Botsas, 2017).

In another study, researchers Stott and Beelder (2019) evaluated students' reading comprehension skills in eighth and ninth grade with science content text. The study used texts and electronic quizzes about electrical circuits and lighting. The students' comprehension was measured using their quiz scores and eye-tracking technology (Stott & Beedler, 2019). They identified a small group of students who utilized comprehension strategies to understand science texts independently, leading to higher success rates in science performance. Unfortunately, most of the students did not have these strategies and could not comprehend the texts independently (Stott & Beedler, 2019). This study highlights the importance of teaching reading comprehension skills for content text because most students cannot independently develop these strategies.

Akbash et al. (2016) provided qualitative and quantitative data highlighting the correlation between reading comprehension and performance in math and science, where high comprehension skills equaled high math and science performance and vice versa with low comprehension skills relating to low math and science performance. These studies show that it is imperative for content area teachers to teach discipline-specific strategies. However, in a study by Casey Paul (2018), data from a professional development course on disciplinary literacy was evaluated. In the teachers' final assignment, they were to create an inquiry-based disciplinary literacy lesson plan. Paul (2018) found that the teachers increased their use of literacy strategies but used generalized reading strategies, not discipline-specific strategies identified by content area experts.

One of the first hurdles in science reading is that the text structure varies significantly from narrative text formats students are more familiar with. In the article Using Science Texts, author Detillion (2021) is a sixth-grade teacher who decides to improve students reading of science texts by directly teaching three common text structures; compare and contrast, cause and effect, and description. The scaffolding supports he used were anchor charts, modeling, and practice, where students had to write examples of the text structures (Detillion, 2021). According to Slough & Rupley (2010), “difficulty in comprehension of science texts can be partially attributed to the high density of unfamiliar vocabulary” (p. 353).

The next hurdle is finding appropriate science texts. In many classrooms, textbooks are the only source of science text. Unfortunately, often these textbooks are years old and no longer contain the most current understandings of science. In a study by Zorana Ercegovac (2003), she highlights the often-under-utilized resource of school librarians and non-textbook science texts:

> What they do not necessarily learn is about the culture of making science, of inventing, communicating personally and in published literature, protecting their ideas and inventions, being rewarded, and working in teams within social and political contexts. In this regard, the following resources are of special importance to the students. The three groups of sources briefly discussed here include information about patents and trademarks, primary sources, and factual data. (p.79)

Ercegovac (2003) encourages science teachers and librarians to form a partnership to use their strengths to improve students’ disciplinary literacy. Another hurdle is ensuring students learn beyond a surface-level understanding of science texts. For example, a study by Tzu-Jun Lin (2014) tested students’ comprehension assisted by a scaffolded argument activity. The scaffolded activities guided students through the argumentative progress. Students had to gather evidence from texts, identify a claim, and synthesize information into a data-based argument to support or reject that claim (Lin, 2014). Students who participated in the scaffolded argument activity obtained a deeper understanding of the content by making more knowledge-based inferences than rote recall of text information (Lin, 2014). Another benefit of this scaffolding strategy is that students also had to evaluate their sources, another essential science literacy skill.

Scaffolding Writing

The recent adoption of new standards like NGSS has made for a push in how science is taught. As a result, more and more experts are pushing for learning by doing and less by teacher-centered activities like lectures. In the following studies by Poock et al. (2007), Sampson et al. (2013), and Slough & Rupley (2010), researchers test the improvement of student writing using strategies that had students participate in hands-on learning activities with an emphasis on laboratory investigations.

First, Poock et al. (2007) tested the Science Writing Heuristic (SWH) approach. SWH approach is based on laboratory investigations being student-centered rather than teacher-centered in the traditional instructor approach (Poock et al., 2007). Teachers acted as facilitators for students to design and conduct their investigations, data collection and analysis, and discussion of concepts. As a result, student understanding of chemistry concepts improved the most when in classrooms with the highest use of SWH, which the researchers also correlated to engagement (Poock et al., 2007). Poock et al. (2007) concluded that SWH increases student engagement in content material, increasing student understanding of the material.

Next, Sampson et al. (2013) tested an argumentative writing protocol, argument-driven inquiry (ADI), for laboratory activities to improve content knowledge and science-specific writing ability. ADI is a teaching model that focuses on science-specific argumentative writing skills while students also learn core science content (Sampson et al., 2013). The ADI model also puts students in a more authentic science experience because students must develop, design, and write their laboratory investigations (Sampson et al., 2013). After implementing the protocol for two semesters in two middle schools and across four science classes, the researchers found that students that participated in more ADI activities had the most growth in their scientific writing skills (Sampson et al., 2013). Sampson et al. (2013) concluded that the greatest strength of ADI is that students learn science content and writing by performing realistic tasks done in the scientific community (e.g., arguing from evidence, transforming data into evidence, or refining a text in peer review).

Third, Slough & Rupley (2010) emphasize the importance of student-led investigations supported with teacher scaffolding. According to Slough & Rupley (2010), “scaffolding allows teachers to transfer the responsibility for learning to students gradually and still provide expert guidance” (p. 356).

The key to student-led investigations being successful and engaging is that the focus has a real-world application, the process is similar to the work of actual scientists, and that the scaffolding support is appropriate and slowly removed until independence is reached (Poock et al., 2007, Sampson et al., 2013, Slough & Rupley, 2010).

Another difficulty with understanding science is that it contains many abstract concepts that students may find difficult to connect to their real lives. In two studies by Shultz & Gere (2015) and Schmidt (2013), researchers take two different writing-to-learn approaches to tackle concepts within chemistry and physics. First, Shultz & Gere (2015) tested a writing-to-learn activity where students read the work of historical scientists (e.g., “The Atom and the Molecule” by Gilbert Lewis) then write a summary and comparison of the scientist’s work based on the accepted theories of the time. A vital component of this activity is the peer-review process. The student must share and critique each other’s summaries. Shultz & Gere (2015) found that the descriptive historical texts, summary writing, and peer-review process allowed students to conceptualize Lewis Dot Structures fully.

Schmidt (2013) uses a unique writing-to-learn activity to help students creatively connect physics to their everyday lives. Schmidt (2013) tasked his students to write physics-centered poetry with the goal of "cultivating an internal 'physics voice' that may be useful to them long after the course is completed" (p. 91). As a result, Schmidt (2013) experienced overwhelmingly positive feedback from most students and observed them making more real-world connections to physics concepts.

Theoretical Framework

The theory of scaffolding is a metaphor used by teachers to describe the process of assisting students in order for them to complete tasks that would be unattainable if attempted on their own (Wood et al., 1976). Woods et al. (1976) describe a six-part scaffolding process completed by the teacher: recruiting the students' interest, simplifies and manages the task by limiting degrees of freedom, maintains the students' attention and motivation, marks critical features of the task, controls frustration, and demonstrates when needed. The scaffolding process emphasizes the idea that teaching must not be a one size fits all model, but rather that it must be flexible to meet the needs of the students, which may be on a variety of different academic levels (Brownfield & Wilkinson, 2018). The scaffolding process is often connected to the concept of the zone of proximal development (ZPD) by Vygotsky (1978). ZPD is the idea of a spectrum of what a student can learn with and without assistance and what a student cannot learn even with assistance. Sullivan Palincsar et al. (2017) analyzed a case study of sixth-grade students and their science teacher to study scaffolding in various forms. Within the three analyzed lessons scaffolding support was given by the teacher, curriculum, and mobile device tools. The study found that the quality and richness of the learning depended on implementing a variety of scaffolding strategies with teacher facilitation and peer interaction (Sullivan Palincsar et al., 2017).

This study followed a constructivist paradigm. The goal of this study was to explain how scaffolding can affect students' scientific literacy skills. There was no single reality, but rather the reality was created during this study by interpreting the finding of the effects of scaffolding to improve students' scientific literacy. The relationship between scientific literacy and scaffolding will be interpreted by analyzing student work examples throughout the implementation of scaffolding strategies.

Research Question

What impact does scaffolding have on grade 7-12 students' scientific reading and writing within a rural community setting?

Conclusions

There is ample evidence showing us that teachers need to review and change the way we teach reading and writing within the sciences. Students struggle to go beyond a surface-level understanding of science concepts. Teachers must learn how to teach specific science literacy skills to allow students to gain a deeper level of understanding in science classes. Researchers have seen success and improvements in science comprehension when students are tasked to take on a realistic scientist role where they complete tasks similarly to real world scientists. The challenge many teachers face is that these realistic scientists' tasks do not come naturally to most students. I look to determine if scaffolding can improve students' scientific literacy skills in reading and writing allowing them to perform like real scientists.

CHAPTER 3

METHODS

Introduction

Scientific literacy is a set of specialized reading and writing skills vital to developing students' critical thinking and learning of science content. However, these skills do not come naturally to students and it is imperative that teachers learn the best ways to support student learning of these skills. This study analyzed the effectiveness of scaffolding support to improve scientific literacy skills. The study measured students' abilities to read and write like scientists with different types of scaffolding supports such as modeling, front-loading vocabulary, Socratic questioning, sentence structure framers, or starters.

Research Question

What impact does scaffolding have on grade 7-12 students' scientific reading and writing within a rural community setting?

Research Design

This study utilized the case study approach because multiple sources of student data was analyzed to study the phenomena impact that scaffolding has on scientific literacy skills. Student data samples were collected and analyzed before and after implementing scaffolding strategies. The samples were assessed using the scientific literacy rubric (Miller & Calfee, 2004). Data analysis compared and contrasted the scaffolding strategies and student grade levels.

This study followed a constructivist paradigm. There is no single reality, but rather the reality will be created during this study by interpreting the finding of the effects of scaffolding to improve students' scientific literacy. The relationship between scientific literacy and scaffolding was interpreted by analyzing student work examples throughout the implementation of scaffolding strategies.

Setting

This study occurred in a small rural community school in northwest Minnesota with students in grade(s) 7-12. The school community predominantly consists of crop and livestock farming. According to the 2019 census, the town has a population of 765 with a median age of 39 years, a poverty rate of 16.6%, and an employed population of 302. The school is set within town and houses pre-K through 12th grade. In this school setting, the researcher is the only science teacher for grades 7-12. The researcher has six classes: 7th-grade life science, 8th-grade earth science, 9th-grade physical science, 10th-grade biology, and 11th & 12th grades taking either chemistry or environmental science.

Participants

The study included participants from grades 7-12, so population dynamics will only detail this portion of the school and not include elementary student statistics. The total population for these grades is 101 students. However, only 86 students are currently enrolled in a science course and 41 students provided consent for data collection. The ethnicity dynamics are predominantly white at 83%, with the remaining population equally split at 6% each for Native American, Hispanic, and two or more ethnicities. The gender dynamics have a predominantly male population at 55%, with females at 43% and nonbinary at 2%. The school population consists of 39% receiving free and reduced lunch and 16% special education services.

Sampling

Participants were selected through random purposive sampling. All students within the researcher's science class took part in the scientific literacy tasks. The researcher randomly selected student work samples and performed detailed analysis.

Instrumentation

The instrument used for measuring the dependent variable is a Scientific Literacy Grading Rubric which comes from another scientific literacy study by Miller and Calfee (2004), see Appendix B. This rubric was chosen because it targets common scientific literacy skills present in most scientific inquiry activities. In addition, this rubric provides a consistent method of scoring student work. Grading written work can at times become a subjective process. By utilizing a grading rubric, clear guidelines are set for the teacher, making the process more objective. The use of the rubric also gives student work a score that the researcher used for quantitative data analysis. The researcher organized student rubric scores using an excel spreadsheet to detail the participant and scaffolding support activity that corresponds with each score. The scores were also arranged chronologically to observe score changes over time.

Data Collection

Data was collected from student work samples participating in a scaffolded scientific inquiry lesson. The work samples were scored using the scientific literacy rubric (Miller & Calfee, 2004). Student work samples were scored before implementing scaffolding strategies to gather baseline scores. Further data was collected after implementing each scaffolding strategy and related scientific inquiry activity.

Data Analysis

The researcher calculated mean, median, and mode values for the students' scientific literacy scores for each scaffolded scientific inquiry lesson. These values were tracked chronologically to see if students' scores improve over time, showing a positive correlation with scaffolded activities and increased literacy skills. In addition, the chronological trends and average values were compared with the different grade levels to see if there were differences or similarities among the age groups.

Research Question and System Alignment

The table below (i.e., Table 3.1) provides a description of the alignment between the research question and the methods used in this study to ensure that all variables of the study have been accounted for adequately.

Table 3.1.

Research Question Alignment

Research question	Variables	Design	Instrument	Source
What impact does scaffolding have on grade 7-12 students' writing within a rural community setting?	Dependent: science literacy grading rubric (Miller, 2004) Independent: scaffolding strategies: -modeling -front loading vocabulary	Case study approach	DV: science literacy grading rubric (Miller & Calfee, 2004) IV: scaffolding strategies -modeling -front loading vocabulary -Socratic questioning -sentence starters	Grade 7-12 students Sample size: 41

	-Socratic questioning -sentence starters	Grade level: based on scheduled class period

Procedures

The study occurred over six weeks. First, the researcher collected scientific inquiry student work samples to calculate a baseline for scientific literacy skills before scaffolding supports are put into practice. The researcher then utilized the scaffolding practices daily during instruction for four weeks. The researcher collected one data sample set for each week of instruction from every grade level. In addition, data samples were collected from scientific inquiry activities.

The collected work samples must include at least one scientific literacy task. For example, asking questions, planning and carrying out investigations, obtaining, evaluating, and communicating information. The researcher recorded the scientific inquiry activity and scaffolding practice used for each data sample set. Each sample was scored using the scientific literacy rubric (Miller & Calfee, 2004). During the sixth week of this study, the researcher completed data analysis for all collected data.

Ethical Considerations

Student participants were protected with the requirement of an informed consent letter before being allowed to participate. Since most students are under parental guardianship and the age of 18, informed consent must be completed by their parent or guardian. Privacy was also ensured by removing identifying information and names from all data collection, analysis, and samples.

Conclusions

This chapter discussed the specific details of the methodology for this study including community and student demographics, research design, data analysis, and ethical considerations. A key aspect of this chapter, was the explanation of the scientific literacy rubric which was used to assess data samples (Miller & Calfee, 2004). The following chapters will include an in-depth analysis of the results of this study.

CHAPTER 4

DATA ANALYSIS AND INTERPRETATION

Introduction

The implementation of new science standards has caused a shift in the methods of teaching science. The focus is now on students learning the scientific process rather than a list of scientific facts. However, the problem with this shift is the difficulty of performing various tasks within the scientific process. Each scientific task's foundation is a set of science-specific literacy skills that do not come naturally to most students. This study investigated the impact of scaffolding on students' scientific reading and writing abilities. The researcher utilized four different scaffolding strategies; modeling, sentences starters, front-loading vocabulary, and Socratic questioning. It was hypothesized that scaffolding supports would increase students' scientific reading and writing and success in scientific literacy tasks.

Data Collection

Data were collected from student work samples during scaffolded scientific inquiry lessons. The work samples were scored using the scientific literacy rubric (Miller & Calfee, 2004), a four-point scale. On the four point scale, a score of zero means the work is not scoreable, a score of one is below expectations, a score of two is not yet within expectations, a score of three meets expectations, and a score of four exceeds expectations. Work samples were only given whole value scores. Student work samples were scored before implementing scaffolding strategies to gather baseline scores. Further data was collected after implementing each scaffolding strategy and related scientific inquiry activity.

Results

Research Question: *What impact does scaffolding have on grade 7-12 students' scientific reading and writing within a rural community setting?*

Table 4.1 details the participant data for this study. The researcher asked all students enrolled in a science course in grades 7-12 to participate, a total population of 86 students were invited to take part in the study. The researcher received participation consent from 41 students. The table also details how many participants come from each class and class size. Grade 7 had 9 participants out of 16 students. Grade 8 had 11 participants out of 18 students. Grade 9 had 5 participants out of 13 students. Grade 10 had 8 participants out of 20 students. Grades 11 and 12 were split into different classes, chemistry and environmental science, with no repeated students. Chemistry had 4 participants, 1 senior and 3 juniors, out of 10 students. Environmental science had 4 participants, 1 junior and 3 seniors, out of 9 students.

Table 4.1

Participant Data

	Grade 7	Grade 8	Grade 9	Grade 10	Chemistry grade 11/12	Environmental grade 11/12	Total population
Number of participants	9	11	5	8	4	4	41
Class population	16	18	13	20	10	9	86

Table 4.2 shows the mean, median, and standard deviation values for the students' scores for each scientific literacy task. In this table, the data was not differentiated by grade level, only by scaffolding strategy. The literacy activity before scaffolding had a mean score of 1.89, a median of 2, a mode of 2, and a standard deviation of 0.88. The literacy activity scaffolded by

front-loading vocabulary had a mean score of 2.32, median of 3, mode of 3, and a standard deviation of 1.08. The literacy activity scaffolded by sentence starters had a mean score of 2.54, a median of 3, a mode of 3, and a standard deviation of 0.95. The literacy activity scaffolded by modeling had a mean score of 2.07, a median of 2, a mode of 2, and a standard deviation of 0.98. The literacy activity scaffolded by Socratic questioning had a mean score of 1.98, a median of 2, a mode of 2, and a standard deviation of 1.15.

Table 4.2

Literacy Scores by Scaffolding Strategy

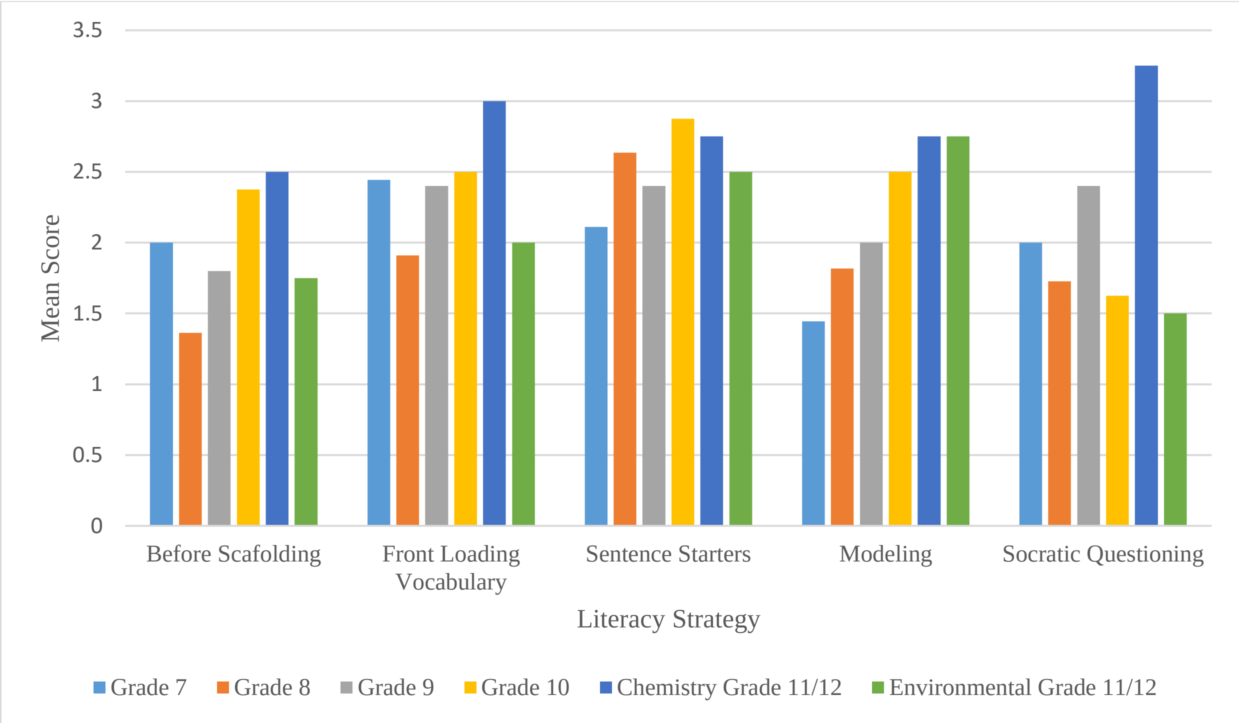
Literacy strategy	Mean	Median	Mode	Standard deviation
Before scaffolding	1.89	2	2	0.88
Front loading vocabulary	2.32	3	3	1.08
Sentence starters	2.54	3	3	0.95
Modeling	2.07	2	2	0.98
Socratic questioning	1.98	2	2	1.15

Figure 4.1 displays the mean literacy activity scores in a bar graph. Both grade level and scaffolding strategy differentiate the data. The collection of bars for the literacy activity before scaffolding shows that most classes had a mean score at or below 2 except for grade 10 and chemistry grade 11/12, scoring near or at 2.5. The collection of bars for the literacy activity scaffolded by front-loading vocabulary had scores at or above 2 except for grade 8, which was slightly below 2, and chemistry grades 11/12 with a score of 3. The collection of bars for the literacy activity scaffolded by sentence starters had scores near or slightly above 2.5 for all classes except for grade 7, which is only slightly above a score of 2. The collection of bars for the literacy activity scaffolded by modeling had a range of mean scores; grades 7 and 8 scored below 2, grade 9 had a score of 2, and grade 10, chemistry grades 11/12, and environmental

grades 11/12 score at over above 2.5. The collection of bars for the literacy activity scaffolded by Socratic questioning shows most classes scoring between 1.5 and 2 except for grade 9 scoring 2.4 and chemistry grades 11/12 scoring 3.25.

Figure 4.1

Literacy Scores by Grade Level and Scaffolding Strategy



Data Analysis.

The results suggest a connection between implementing scaffolding supports and improving students' scientific literacy scores. However, it is inconclusive that scaffolding is the only factor impacting the students' literacy scores. The researcher could not control a range of different factors that could have impacted the data such as age, academic development, content, and small sample size.

The connection of scaffolding supports and improving literacy scores was most prevalent in the literacy tasks that utilized scaffolding strategies with the highest amount of support, sentence starters, and front-loading vocabulary. Before scaffolding, the mean score of all grades was 1.89, with a mode of 2. All of the scaffolding strategies saw an increase in the mean values. However, the front-loading vocabulary and sentence starter strategies saw the most significant increases with mean scores of 2.32 and 2.54 and modes of 3. This data supports the research done in studies by Poock et al. (2007), Sampson et al. (2013), and Slough & Rupley (2010), where researchers found improvement in student writing after using scaffolding strategies while students participate in hands-on learning activities such as laboratory investigations. According to Slough & Rupley (2010), "scaffolding allows teachers to transfer the responsibility for learning to students gradually and still provide expert guidance" (p. 356). Since front-loading vocabulary and sentence starters provide the highest levels of scaffolding, it makes sense that student scores would show the most significant improvement. At the same time, the other strategies only saw slight gains in student scores. This could mean that the students participating in the study still have a high level of dependence on the teacher when completing scientific literacy tasks.

When the data were differentiated by grade level and class, more conclusions could be made on the students' ability to complete scientific literacy tasks. For example, the chemistry 11/12 class consistently scored the highest or second-highest for all scientific literacy tasks. Chemistry 11/12 is a college preparatory class with students that generally succeed academically. This class had a mean increase with all scaffolding supports and most notably the greatest gains with the Socratic questioning support, which provides the lowest amount of teacher support. In contrast, the grade 8 class scored the lowest or second-lowest for all literacy tasks except for the task supported by sentence starters which is also a high-level support scaffold. The grade 8 class contains all students of this age and is not differentiated by academic ability. These contrasting results can show how the factor of age, development, and academic skill may have impacted the study.

The researcher could not control a range of different factors that could have impacted the data. As stated above, age, development, and academic skill factors may have impacted the study. For example, in the differentiated grade 11/12 classes, the upper-level chemistry class consistently scored higher than the lower-level environmental science class, a remedial science course predominantly made up of high academic needs special ed students. In the heterogeneous classes, grade 10 consistently and substantially scored higher than grades 7 and 8. Other factors outside the researcher’s control were the content variation in the scientific literacy tasks and samples sizes. None of the scientific literacy tasks were identical, with each class representing a different science content. However, the research tried to implement each strategy similarly. This factor could mean that the content of the activity rather than the scaffolding strategy had a greater impact on the literacy scores. Table 4.1 shows that less than half of the population elected to participate in the study. The class with the greatest participation had 11 students, while two classes only had 4 participants. This small sample size may have also skewed the data because it may not fully represent the total population.

The scientific literacy rubric (Miller & Calfee, 2004) instrumentation tool was an adequate tool for this study. The four-point scale provided a clear and consistent model for grading student work. In this study, the researcher only gave whole point score values. As a result, some student samples were hard to place within one score category because different aspects of the sample showed rubric qualities of different score values. This could have caused an inconsistency or bias in the researchers' scoring of student work. If the study were duplicated, this possible source of error could be accounted for by having multiple people score all student samples and taking the average score for further data analysis.

Conclusion

Based on the results of this study, a connection can be observed between the utilization of scaffolding strategies and students' scientific literacy skills. The results showed that students scored better when completing scientific literacy tasks with higher scaffolding support. However, the researcher has identified other factors such as age, academic development, content, and small sample size that may have impacted the students' literacy scores.

Chapter 5

IMPLICATIONS FOR PRACTICE

Introduction

This study analyzed the impacts of scaffolding on students' scientific literacy skills. The researcher analyzed student work samples before and after providing four different scaffolding support strategies. This study aimed to identify which scaffolding support strategies made the most significant impact on improving students' scientific literacy skills.

The researcher found a connection between scaffolding supports and improving students' literacy skills. The greatest improvements were observed in literacy activities with the highest teacher support scaffolding levels with the sentence starters and front-loading vocabulary strategies. However, the researcher must note that other factors may have impacted the data to conclusively determine the impacts of scaffolding on scientific literacy skills further testing should be completed.

Action Plan

Based on this study, the researcher will continue to practice scaffolding supports for scientific literacy tasks. This research has identified an academic need for this group of students, which would be supported by continued teacher support and intervention. However, the teacher may implement different scaffolding supports from the ones conducted in this study or utilize various strategies to meet the needs of select students. For example, the chemistry class saw the most significant improvement with the Socratic questioning scaffolding strategy, while most other classes had no improvement in scores with this strategy. While with the 7th and 8th-grade classes, the researcher may increase the level of scaffolding and provide more direct instruction on how to complete scientific literacy tasks. This variation will help support the students' varying needs and consider their zones of proximal development suited to their age and level of academic development.

While conducting this study, the researcher also identified different factors such as age, academic development, content, and small sample size that may have impacted the data. The researcher should conduct further studies on each factor to identify their impact on students' scientific literacy skills. This analysis may be best served by conducting longitudinal data analysis. Since the researcher teaches all students grades 7-12, she can analyze their progress over an extended period. The researcher can also analyze grade groups such as the 7th grade class of 2021-2022 with the 7th grade class of 2022-2023. This longitudinal practice would also help the researcher reflect on her teaching practices and help make improvements for the future.

Although the data did not show significant gains in the students' scores based on the scientific literacy rubric (Miller & Calfee, 2004), the researcher has observed notable improvements in the students' scientific writing. For example, the 10th graders recently completed a scientific debate activity where they needed to conduct research and prepare a ten-minute speech. As a collective group, the students did remarkably better on this assignment than in previous years. Other classes have also shown general improvements in their writing abilities. These skills are not limited to the science classroom and will only benefit the students in other writing applications, whether academic, extracurricular, or in everyday life situations.

This study has also heightened the researcher's awareness of the need for pedagogical changes in science education. Incoming new standards call for teaching science content by process rather than strictly teaching students to memorize a set of scientific facts. The researcher has identified and implemented a new curriculum for grades 7-12, which has its foundations in this pedagogical change. The researcher is now working with administration and elementary teachers to understand this change in the standards and find a curriculum to fit these needs.

Plan for Sharing

The researcher will share this study with the other teachers and administration in the district. First, the researcher will present the data to administration during her final observation evaluation meeting. The teacher will emphasize the value of this process and the reflection on her teaching practices. Next, the researcher plans to present her findings during the end of school professional development workshops. This would allow other teachers to reflect on the information and possibly implement new teaching practices in the following year. This data may be most impactful for the elementary teachers because they have science teaching as part of their curriculum. However, there are no other science teachers for grades 7-12 in the district; the scaffolding aspect of this study can be utilized in other content areas. At this time, the researcher does not plan to share this research outside of the district due to the varying factors that may have impacted the data analysis. After conducting a year or two of longitudinal data analysis, the researcher may be willing to share at other levels.

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APPENDIX A

Informed Consent Letter

October 21, 2021

408 Main Ave W

Twin Valley, MN 56584

Dear Parent or Guardian,

Your child(ren) has been invited to participate in a study to see if the utilization of scaffolding will improve their overall scientific literacy, the ability to perform science specific reading and writing tasks.

Your child(ren) was selected because he/she/they is/are in my regular education classroom. If you decide to participate, please understand that your child(ren) will be asked to do the following, and these are typical classroom activities that involve no risk to your child(ren).

1. Your child(ren) will be doing learning activities that will target scientific reading and writing. I will be providing different levels of support to help improve their scientific literacy and foster independence.
2. I will analyze the students' work samples at different intervals throughout the study to measure the changes in their scientific literacy skills.

Although Principal Dustin Flaten has granted me permission to conduct this study, since this information is being used to help me complete my master's degree at Minnesota State University Moorhead, I need to have parental consent to use this information in my final paper that I am required to do as part of my degree. If I didn't need this information to complete my master's degree, I would be conducting this same type of research in my normal everyday lessons and I would not need signatures. If you sign this form, you are giving me consent to use the information that I gather. All information that is used will be confidential, no names will be used. Please also note, that your child(ren) can choose to not participate at any time without any consequences.

Please feel free to ask any questions you have regarding this study. You may contact me by email hunters@nce.k12.mn.us or you may also contact my adviser, Kristen Carlson by email kristen.carlson@mnstate.edu.

You will be offered a copy of this form to keep. You are making a decision whether or not to participate. Your signature indicates that you have read the information provided above and have decided to participate. You may withdraw at any time without prejudice after signing this form should you choose to discontinue participation in this study.

X ______________________________
Signature of Parent/ Guardian

X ______________________________
Date

X ______________________________
Signature of Investigator

X ______________________________
Date

APPENDIX B

Science Literacy Rubric		
Score	Description	Criteria
4	Exceeds expectations	• Commanding use of key terms with very few or no errors • Connections between concepts are well developed • Concepts presented demonstrate understanding at the analysis, synthesis, or evaluation levels; reflect transformation of content beyond that provided in the text/activity by the student • Further examples and extensions are provided and illustrate excellent comprehension
3	Meets expectations	• Sufficient use of key terms to illustrate comprehension; majority of key terms used accurately • Connections between concepts are beginning, although they may be limited to the applications provided in the text/activities
2	Not yet within expectations	• Relatively few key terms present; or a majority of the key terms present are used inaccurately • Connections between concepts not present; or generally incorrect
1	Below expectations	• No examples from text or activities present (text/activities not referenced) • However, paper is scorable
NC	Not scorable	• Unrelated, unintelligible, or length not sufficient to score • Copied from board or another student

(Miller & Calfee, 2004)

APPENDIX C

Institutional Review Board

MINNESOTA STATE UNIVERSITY MOORHEAD

DATE:	January 28, 2022
TO:	Kristen Carlson, Principal Investigator Hunter Schow, Co-investigator
FROM:	Dr. Robert Nava, Chair Minnesota State University Moorhead IRB
ACTION:	**APPROVED**
PROJECT TITLE:	[1865366-1] Improving Disciplinary Literacy in the Science Classroom with Scaffolding
SUBMISSION TYPE:	New Project
APPROVAL DATE:	January 28, 2022
EXPIRATION DATE:	
REVIEW TYPE:	Exempt Review

Thank you for your submission of New Project materials for this project. The Minnesota State University Moorhead IRB has APPROVED your submission. This approval is based on an appropriate risk/benefit ratio and a project design wherein the risks have been minimized. All research must be conducted in accordance with this approved submission.

This submission has received Exempt Review based on the applicable federal regulation.

Please remember that informed consent is a process beginning with a description of the project and insurance of participant understanding followed by a signed consent form. Informed consent must continue throughout the project via a dialogue between the researcher and research participant. Federal regulations require that each participant receives a copy of the consent document.

Please note that any revision to previously approved materials must be approved by this committee prior to initiation. Please use the appropriate revision forms for this procedure.

All UNANTICIPATED PROBLEMS involving risks to subjects or others and SERIOUS and UNEXPECTED adverse events must be reported promptly to the Minnesota State University Moorhead IRB. Please use the appropriate reporting forms for this procedure. All FDA and sponsor reporting requirements should also be followed.

All NON-COMPLIANCE issues or COMPLAINTS regarding this project must be reported promptly to the Minnesota State University Moorhead IRB.

This project has been determined to be a project. Based on the risks, this project requires continuing review by this committee on an annual basis. Please use the appropriate forms for this procedure. Your documentation for continuing review must be received with sufficient time for review and continued approval before the expiration date of .

Please note that all research records must be retained for a minimum of three years after the completion of the project.

If you have any questions, please contact the Minnesota State University Moorhead IRB. Please include your project title and reference number in all correspondence with this committee.

This letter has been issued in accordance with all applicable regulations, and a copy is retained within Minnesota State University Moorhead's records.

APPENDIX D

NORMAN COUNTY EAST
SCHOOL DISTRICT #2215

Dustin Flaten, High School Principal
P.O. BOX 420
TWIN VALLEY, MN 56584-0420
PHONE: (218) 584-5151 FAX (218) 584-5170

January 14, 2022

To whom it may concern,

This letter is to grant Hunter Schow permission to conduct an action research study at Norman County East School during the 2021-2022 academic year. I understand that this study poses no risk to those persons involved or to the Norman County East School District. I also understand that all information received will be kept confidential and will only be used for the purposes of this study.

Sincerely,

Dustin Flaten

Principal, Norman County East School

APPENDIX E

Method of Assent

I will explain to my students, “I’m currently finishing my Master’s degree at MSUM. Part of that program is to conduct my own research study. I’ve chosen to research how to better help students read and write in science class. I’ve sent letters home to your families asking if it was okay for you all to participate. If your parents/guardians signed the consent letter, they’ve said it is okay for you to participate in this study. However, you also have a choice on whether to participate or not. Your job in this study is to only participate in class as you normally would. My job is to try different teaching strategies to better help you learn. I want to find the best way for you all to read and write better in science class. If you choose to not participate there will be no consequences to your grade, our relationship, or you normal school routine. Do you have any questions?”