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UNLOCKING UNDERSTANDING: ENHANCING SCIENTIFIC LITERACY THROUGH INTERDISCIPLINARY READING STRATEGIES IN HIGH SCHOOL SCIENCE CLASSES

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by
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Abstract

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This study investigated the intersection of literacy instruction and high school science teaching in response to low proficiency levels in these areas and interest in pursuing STEM careers among U.S. high school students. Participants reported using close reading practices combined with inquiry-based science instruction to enhance students' science literacy and reading proficiency. Data were from document analysis, one-on-one interviews, and focus group discussions. Five significant themes showed teachers' journeys from recognizing a problem to implementing new instructional strategies while pursuing knowledge about how to continue growing their craft. The five themes included teacher awareness of students' literacy struggles, the apprehension of high school science teachers to infuse literacy strategies in tandem with inquiry-based science instruction, how academic standards highlighted the connection between science and literacy, effective instructional practices implemented by the teachers, and the role of professional development in refining instructional practices. The findings suggest that interdisciplinary instructional practices like close reading empower high school science teachers to support their students in developing their ability to read and comprehend complex texts while enhancing their scientific knowledge.

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Chapter 1

Introduction

American students ' interest in pursuing science education beyond high school is declining (Fang & Wei, 2010; Lyons, 2006). In 2018, only 20% of all baccalaureate degrees and 8% of associate degrees were conferred in science, technology, math, and engineering (STEM) related fields (National Center for Educational Statistics [NCES], 2020). Furthermore, American students are falling behind their international peers in mastery of scientific knowledge (DeSilver, 2017). Out of the 71 countries that participated in the Programme for International Student Assessment in 2015, an international test of high school students' proficiency in reading, math, and science (NCES, n.d.), American students ranked 24th (DeSilver, 2017). In addition, only 22% of high school seniors demonstrated proficiency in science on the National Assessment of Educational Progress (NAEP, 2022), while almost 40% scored below basic (DeSilver, 2017). These findings allude to the need for science educators to provide instruction that engages students in applying scientific practices and aids in developing their desire to pursue scientific endeavors in the future.

Marincola (2006) attributed the decreasing pursuit of science knowledge to the use of lectures, the increased emphasis on memorization of facts and vocabulary characteristic of science education today, and the diminished role of thinking and problem-solving in science classes. Saunders (2015) also pointed out that instructional time for science has been dramatically reduced to provide additional time for math, reading, and remediation in those subject areas. These teaching practices result from the persistent push for students to perform well on high-stakes tests and the relationship between students' performance on standardized assessments and teacher evaluations (Marincola, 2006; Saunders, 2015). As teachers have become increasingly concerned with ensuring that students pass required state and national standardized assessments, their reliance on student-driven instruction wanes (Marincola, 2006). Researchers have shown that accountability through assessment has led to a 60% decrease in instructional time dedicated to teaching science, further hindering the use of a hands-on approach and a reduction in inquiry-based learning approaches, especially in schools where there is significant pressure for students to perform well on tests (Hayes & Trexler, 2016).

Hands-on, inquiry-based learning—used in combination with direct instruction, teacher modeling, and interaction with informational text—creates a powerful instructional model that facilitates students' ability to recall and comprehend information, referred to as content learning, and their ability to apply strategies for understanding the world around them, referred to as process learning, in the science classroom (Fang & Wei, 2010; Hayes & Trexler, 2016). Teaching students to use close reading strategies when reading informational texts in conjunction with an inquiry-based learning approach to exploring science content can help students become proficient with the science concepts. Students can also become competent with the literacy skills required of scientists and confident in their ability to learn advanced scientific concepts.

The inquiry-based model allows students to experience learning by exploring content in ways other approaches do not (Furtak et al., 2012). Many teachers rely on direct instruction to convey science content without engaging students in the hands-on activities that encourage inquisitiveness as a result of pressure to ensure students perform well on standardized assessments, coupled with a low sense of efficacy regarding their ability to teach inquiry-based science (Fang & Pace, 2013; Gerde et al., 2018; Hayes & Trexler, 2016). By the time students reach high school, many are uninterested in science topics and disengaged in their science classes as a result of the systemic failure to utilize instructional approaches that develop their love of science and their motivation to ask questions about the world around them, seeking innovative answers to real-world problems (Lyons, 2006). In 2012, the Next Generation Science Standards (NGSS, n.d.) were developed to address these concerns and to standardize science instruction in American schools (National Research Council [NRC], 2012). The NGSS requires teachers to decide how to utilize more effective instructional practices that combine inquiry-based learning with direct instruction. The NGSS communicates the expectation that interdisciplinary instruction is implemented to ensure that students read and analyze texts and data, develop clear explanations and construct arguments based on evidence, and effectively communicate information as a regular part of their science instruction.

Interdisciplinary Science Instruction

Interdisciplinary instruction refers to teaching multiple subjects together to maximize instructional time and provide opportunities for students to apply the skills they have learned (McClune et al., 2012). For example, teachers may incorporate reading or writing skills into their regular social studies instruction or use specific mathematical practices when solving equations in a science lab. The teacher's prior knowledge, the influence of the subject matter, professional development, and the collaborative nature of the curriculum development process significantly affect the implementation of interdisciplinary learning (McClune et al., 2012). When interdisciplinary instruction is most effective, there is a synthesis of content and an extension of pedagogy, leading to significantly increased student motivation and a deeper understanding of the presented content (McClune et al., 2012).

The NGSS (n.d.) indicates that students should be able to critically read and comprehend scientific texts and identify their strengths and weaknesses (NRC, 2012). Students must be provided with instruction that increases their ability to evaluate the credibility of sources to make informed decisions. This process includes making judgments about scientific content to determine whether a bias exists and the effect of that bias (McClune et al., 2012). Integrating literacy instruction in the science classroom can support teachers in developing their students' critical literacy skills and become more aware of how media influence the public's perception of information (Alvermann, 2002; Jenkins et al., 2006; McDaniel, 2004).

Inquiry-Based Science and Literacy Instruction

Inquiry-based science instruction is a pedagogical approach in which students use scientific knowledge to ask questions, collect and analyze data, draw conclusions, and communicate their learning about the world (Areepattamannil, 2012; Furtak et al., 2012). The inquiry-based approach has been heralded as the ideal instructional strategy in secondary science classes for many years. The inquiry-based learning model of the 20th century included lessons that began by providing students with facts about science content and following up structured laboratory investigations that would allow the students to explore and experience the content (Krajcik et al., 2014).

A strong correlation exists between student learning and active engagement in classroom activities across all grade levels and content areas (Dyer, 2015). Traditional science education methods, which include lecturing and completing prepared experiments, allow students to explore scientific concepts but fail to adequately provide instruction to develop the skills essential for science literacy. In science, research has shown that guided, inquiry-based, student-centered instruction is a practical approach to increasing student learning (Furtak et al., 2012).

However. the implementation of inquiry-based science instruction can vary significantly from one classroom to the next depending on the teacher's understanding of the approach and the emphasis placed on inquiry-based instruction by school and district administrators (Furtak et al., 2012). Furtak et al. (2012) explained that the implementation of inquiry-based approaches in science ranges from providing students with the freedom to develop questions and design investigations to answer their questions about the topical area being studied with minimal teacher guidance to approaches relying on the teacher to provide the questions and research design that students apply in their investigation of the topic. Inquiry-based learning that features modeling, application, and interactive learning has been shown to significantly positively affect science achievement and interest in science as a content area (Areepattamannil, 2012). This approach increases students' interest in the sciences and increases their science content and process knowledge aligned with the expectations of the NGSS (n.d.; Eunice Kennedy Shriver National Institute of Child Health and Human Development, National Institutes of Health [NIH], & Department of Health and Human Services [DHHS], 2000; Krajcik et al., 2014; NRC, 2012). Regardless of the many benefits purported by supporters of inquiry-based instruction, there are also strong criticisms of the approach.

Critics of inquiry-based science instruction have expressed concern over the limited role of the teacher in providing direct instruction to students throughout the learning process (Furtak et al., 2012; Kirschner et al., 2006; Mayer, 2004). A meta-analysis of inquiry-based science studies that examined the role of the cognitive and social aspects of inquiry-based learning and the role of the teacher in inquiry-based learning showed that student growth is maximized when teachers actively guide but do not dominate the inquiry process instead of relying on a primarily student-driven model (Furtak et al., 2012). Student-led investigations and hands-on activities alone did not bolster students' interest in pursuing careers in science fields, nor did it show adequate gains to meet the average academic competency level shown by other nations on the 2006 administration of the Programme for International Student Assessment (Areepattamannil, 2012). The findings of these studies allude to the understanding that inquiry-based learning approaches are most effective when the teacher serves as a facilitator, supporting and guiding student inquiry through questioning and investigation.

The symbiotic relationship between the scientific content and the interdisciplinary skills necessary for understanding the studied phenomena is essential to inquiry-based instruction (Kern & Bean, 2018). This finding is especially true when teachers implement the NGSS (n.d.) and intend to include a focus on the science and engineering practices and interdisciplinary alignments with the Common Core States Standards (CCSS) for Reading in Science and Technical Subjects (RST). When teachers help students engage in the scientific processes in their studies, such as reading, modeling, and argumentation, inquiry-based learning is enhanced, and life-long learning skills are strengthened. Reading scientific texts critically to bolster inquiry through the analysis, evaluation, and synthesis of information to conclude the world is one-way teachers can help students effectively engage in the inquiry process (Greenleaf & Brown, 2017).

The concept of interdisciplinary teaching is not new. Connecting social studies, art, and science instruction with literacy learning in elementary school has been shown to improve students' reading ability and increase their interest in reading (Fang & Wei, 2010; Kern & Bean, 2018; Palumbo & Sanacore, 2009; Siebert et al., 2016). Researchers have proven that explicit reading strategy instruction and inquiry-based science education are complementary instructional practices, improving students' ability to deeply comprehend science texts and synthesize scientific information across multiple resources (Goldman et al., 2019). By incorporating instructional strategies that support close reading, science teachers may be able to engage students in reading like scientists to increase their scientific content knowledge and further enhance the benefits of the inquiry process.

Problem Statement

Inquiry-based science instruction has been touted as the ultimate solution to increase student interest and improve academic outcomes in the sciences, but these outcomes have yet to materialize fully. Furtak et al. (2012) noted that the implementation of inquiry-based learning in science varies significantly from highly structured experimentation that the teacher strongly guides after a thorough review of the content expounded by a textbook to student-driven experimentation and observation that has limited grounding in the pre-existing knowledge of experts in the field. These differences significantly affect student engagement, interactions with science content, and their interpretation of scientific information (Furtak et al., 2012). Scientists must have highly effective literacy skills to develop, comprehend, explain, and communicate scientific findings (Hand et al., 2003). Practicing analytical reading, argumentation, data analysis, and persuasive writing while navigating science topics as part of learning through inquiry is central to student learning. As a result of the myriad interpretations of instructional best practices in secondary science, reduced instructional time, and diminishing interest in their science classes, Americans are increasingly unprepared to learn advanced science content in higher education and are ill-equipped to be consumers of scientific knowledge as citizens (Marincola, 2006; Saunders, 2015). America's high school students have fallen behind their international peers' understanding of science content. The number of American students choosing to pursue higher education and careers in science fields is declining (DeSilver, 2017; Lyons, 2006; NCES, 2020).

The education system—including preservice and in-service teacher training and the traditional school structure—may contribute to limiting the ability of science teachers to provide appropriate literacy instruction. Insufficient teacher training in instructional practices for literacy in college and through continuing education training for content area teachers, staffing shortages, and the general structure of the traditional high school are some of the potential reasons that high school science teachers do not regularly practice interdisciplinary instruction (Bergman & Morphew, 2015; Cross, 2016; Flinders, 1988; Scott et al., 2018; Shah et al., 2019; Weld & Funk, 2005). In many schools, teachers are isolated by the physical space in which they work, the subject area they are certified to teach, and their desire to maximize their efforts to improve their instruction (Flinders, 1988). The lack of collaboration between colleagues caused by the physical, social, and psychological characteristics of schools increases the solitary nature of the profession. It diminishes the recognition of the benefits of interdisciplinary instruction (Flinders, 1988).

Attempts have been made to remedy the literacy and science crises in America. National efforts to improve reading instruction through public policy have included the Workforce Investment Act of 1998, the Adult Education and Family Literacy Act of 1998, and the No Child Left Behind Act of 2001. These efforts have yielded limited success; American students continue to fall behind their international peers in reading, math, and science, and there is little disagreement that the road to improvement runs through the education system (DeSilver, 2017). Science teachers often overlook the practice of integrating explicit literacy instruction and inquiry-based science due to not receiving adequate training to support the extensive role of reading in science inquiry or from viewing the teaching of reading skills as the responsibility of the reading teacher (Greenleaf & Brown, 2017). The publication of the NGSS explicitly expressed the expectation that science learning would be closely tied to instruction in the practices used by scientists (NRC, 2012).

The NGSS (n.d.) articulated the topics that must be taught by science teachers in America. However, the organization did not make specific recommendations about the pedagogical approaches required for teaching science content aligned with the standards (Eunice Kennedy Shriver National Institute of Child Health and Human Development, NIH, & DHHS, 2000; Krajcik et al., 2014). The exclusion of pedagogical approaches from the standards allows teachers to use their discretion in selecting instructional approaches based on students' academic needs and learning styles (Eunice Kennedy Shriver National Institute of Child Health and Human Development, NIH, & DHHS, 2000). The science and engineering practices incorporated into the NGSS (n.d.) are not instructional strategies. They are skills that students must be taught to use as they grapple with challenging science content. Therefore, teachers are tasked with deciding the pedagogical approaches that best fit their student's needs and providing instruction that seamlessly aligns the disciplinary core ideas (DCIs), cross-cutting concepts, and science and engineering practices. The language-intensive nature of the NGSS standards and performance expectations, coupled with the work of scientists and engineers, calls for secondary science teachers to find ways to support the literacy needs of students to ensure they can successfully engage with each of the three dimensions of science and engineering while continuing to engage them in the exploration of content through hands-on and experiential learning (Drew & Thomas, 2018).

Integrating literacy instruction in content area classes, like science and social studies, has been the research focus for many years. The National Reading Panel (NRP) recommended content area instruction be considered a forum for providing literacy instruction aimed at improving vocabulary and comprehension, in addition to increasing students' content area knowledge (Eunice Kennedy Shriver National Institute of Child Health and Human Development, NIH, & DHHS, 2000). The importance of literacy in science classes is highlighted by the science and engineering practices identified in the K–12 science education framework, in which six practices directly correlate to the CCSS for RST (NRC, 2012). These six essential science and engineering practices may be effectively taught using close reading strategies (NGSS, n.d.).

It is necessary to understand how high school teachers provide instruction in science classes to increase students' self-efficacy and knowledge of the sciences to encourage more students to pursue scientific careers, thereby improving the science proficiency of American students, increasing students' interest in pursuing careers in science fields, and ensuring future generations are fully prepared to consume scientific information. Research on the processes by which teachers make decisions about their pedagogical approaches is necessary to facilitate changes to how high school science instruction is provided.

Purpose of the Study

The purpose of this study was to understand how the knowledge, values, and beliefs of high school science teachers impacted the pedagogical and instructional practices that they use when incorporating interdisciplinary approaches, such as close reading strategies, to teach their science classes to support inquiry-based learning (Frey & Fisher, 2013; Lapp et al., 2013; McConn, 2018). The characteristics of close reading that can be applied in the high school science classroom include the use of rigorous texts, multiple reads of the same text, annotations, and the application of information to real-world situations. Incorporating close reading strategies in science classrooms may provide an effective way for teachers to facilitate student learning through inquiry-based science learning. This interdisciplinary instructional approach, combined with an inquiry-based approach, may engage students in applying many of the fundamental practices that scientists use to make discoveries and communicate their knowledge to others.

This study aimed to identify and describe the influential factors that drove the decision-making process of high school science teachers regarding the use of reading strategies in their classrooms. In addition, the researcher sought to identify how close reading practices, which require students to analyze and evaluate a text through multiple readings to develop a deep understanding of the content, have been applied in coordination with inquiry-based science instruction provided by high school science teachers. Understanding the collaborative efforts of educators who have attempted to integrate a specific pedagogical approach into the curriculum was an important factor in expanding its use and a step toward developing a new best practice for science instruction. It was essential to understand the factors that influenced teachers' decisions about using specific instructional practices to effectuate change in the pedagogical practices used in the classroom.

Many internal and external factors influence teachers as they make decisions regarding the instruction they provide for students. Their beliefs about education and instruction, their personal experiences in school, the beliefs of their colleagues and community regarding school, and their professional learning experiences have a substantial effect on teacher behavior (Argyris, 1990; Clough et al., 2009; Kezar, 2001; Osterman & Kottkamp, 2004). Teachers are more likely to try a new approach if their peers convey a positive experience with the practice; in contrast, the communication of negative experiences can increase resistance and apprehension, making it less likely that teachers will attempt to implement the teaching practice with fidelity (Burke, 2014; Fullan, 2011; Kezar, 2001). In addition to describing the experiences of teachers who have used close reading practices in their high school science classes as part of their approach to interdisciplinary instruction, the current research explored the myriad factors—such as these beliefs, behaviors, and experiences—that influenced the teachers' decisions about incorporating specific literacy practices with their traditional pedagogical approaches in their classes.

Qualitative research was selected as the methodological approach to explore the experiences of science teachers and school administrators integrating literacy-based interdisciplinary instructional practices with inquiry-based science instruction in high school. Qualitative researchers seek to understand a topic and construct knowledge (Stake, 1995). The researcher explored the role of teachers' knowledge, values, and beliefs in implementing close reading strategies in an interdisciplinary approach to teaching science. The study examined the role of curriculum and professional development as mitigating tools in the planning of interdisciplinary instruction. The present study also explored the specific interdisciplinary instructional strategies used to promote effective science instruction in high school science classrooms in a southern New Jersey district.

In this study, qualitative data were collected through interviews, focus groups, and document analysis to understand the experiences of high school science teachers who implemented interdisciplinary instruction through the use of close reading strategies in their classes (Hodder, 2012; Rossman & Rallis, 2017; Rubin & Rubin, 2005). Qualitative interviews and focus groups allow researchers to understand an event they did not experience first-hand, increase knowledge of how others experienced a situation, and compare and contrast multiple perspectives on an experience (Rossman & Rallis, 2017; Rubin & Rubin, 2005). Document analysis can provide information about an event or experience, including the perceptions of those who do not directly participate in a study, critical aspects of the experience that were not communicated through interviews, and nuanced details that may have been viewed as insignificant by others (Hodder, 2012). Document analysis can also confirm or refute the data collected during interviews (Hodder, 2012).

Data were collected to explain how interdisciplinary instructional strategies can be implemented in high school science classes and how high school science teachers collaborated with others to change traditional pedagogical approaches. The goal was to identify the internal and external influences identified by science teachers who have integrated close reading strategies in their classes. Another goal was to understand how the teacher's decision-making process influenced the development of interdisciplinary lessons, the selection of appropriate materials, and the activities designed to engage students in learning high school science content. Scientists, engineers, and students benefit from this practice as they partake in inquiry in the science and engineering fields. Close reading is an interdisciplinary approach that uses strategies that require analytical reading to comprehend complex texts (Frey & Fisher, 2013; Lapp et al., 2013). Interdisciplinary instructional practices like close reading incorporate scientists' critical language and literacy skills while continuing to engage students in inquiry-based learning.

Close reading aims to increase students' reading comprehension and bolster their confidence when tasked with reading complex texts. The essential components of a close reading lesson include using a text at or slightly above the student's grade level, multiple readings, and text annotations (Frey & Fisher, 2013; Lapp et al., 2013; McConn, 2018). A meaningful follow-up task that requires students to apply their learning in real-world situations is another essential component of close reading (Lapp et al., 2013). Close reading teaches students to read analytically to comprehend rigorous materials (Frey & Fisher, 2013; Lapp et al., 2013); using close reading strategies such as multiple intentional readings of the text or annotating a text while reading, students can comprehend the material on a deeper level. Teachers provide support through strategic questioning and discussion approaches, increasing student comprehension. Students benefit from repeated exposure to standard text features and their ability to connect to prior readings and understandings. In addition, students are encouraged to adapt their learning experience by asking questions about the text, identifying unknown vocabulary, and recognizing different perspectives by engaging in content-specific discourse with their peers.

Instructional approaches and structured learning tasks that require students to engage in reading, analyzing, and discussing a complex science text multiple times deepen their understanding of the world by exposing them to multiple viewpoints and help them recognize and potentially develop innovative solutions for real-world problems (Lapp et al., 2013). Close reading provides an opportunity for teachers to engage students in "structured learning experiences that promote creative and critical thinking, provide opportunities for substantial discourse, encourage deep knowledge, and make connections to the world as they know it is critical for these students" (Johnson & Mongo, 2008, p. 2003). Many science texts present challenges for students due to the need to convey complex information, content-specific language, and irregular sentence construction (Lapp et al., 2013). Therefore, close reading can provide a practical approach to teaching students to read, comprehend, and apply knowledge obtained through engaging with science texts.

Research Questions

The purpose of this study was to facilitate a deep understanding of the experiences of high school science teachers who implement interdisciplinary instructional strategies focusing on literacy to support their students in comprehending complex informational text. In case study research, Stake (1981, 1995) contended that developing a limited number of research questions guides the development of data collection protocols and helps provide a focus for the study. In this study, the researcher sought to answer the following questions:

1. How do teacher knowledge, values, and beliefs about interdisciplinary instruction guide their pedagogical and instructional practices?
2. How can close reading strategies be incorporated into the high school science classroom to promote interdisciplinary instruction?
3. From teachers' perspectives, how do curriculum and professional development impact teacher planning for interdisciplinary lessons?

Significance of the Study

The U.S. military pursuits, such as World Wars I and II and the Cold War, increased the push for developing young scientists (National Academies of Sciences, Engineering, and Medicine, 2019). Likewise, legislative acts included the No Child Left Behind Act of 2001 and the Every Student Succeeds Act. The No Child Left Behind Act established a national requirement for student assessment and gave the federal government significantly more control over education. The Every Student Succeeds Act shifted control back to the states while maintaining testing requirements. These acts have had a distinct impact on the goals of science education and the instructional approaches used in American education (Heise, 2021; National Academies of Sciences, Engineering, and Medicine, 2019). Furthermore, the development of national standards for education—namely, the CCSS and the NGSS (n.d.)—has reinforced the importance of developing students' proficiency with informational text and applying literacy skills in science (National Academies of Sciences, Engineering, and Medicine, 2019).

During the early to mid-1900s, science instruction focused on laboratory experiments, which were believed to lead students to understand the nature of science and science content (DeBoer, 1991; National Academies of Sciences, Engineering, and Medicine, 2019). In the 1970s, the first shift from teaching science content to focusing on science literacy occurred (National Academies of Sciences, Engineering, and Medicine, 2019). At the time, science literacy was viewed as understanding the application of science processes in real-world decision-making scenarios (National Academies of Sciences, Engineering, and Medicine, 2019). The ongoing improvement of the human condition relies on the development of scientifically literate citizens and people passionate about using science to address modern issues. Scientific investigations and explorations are at the core of advancements that facilitate economic, medical, political, and environmental improvement (Areepattamannil, 2012; Brito et al., 2012; Marincola, 2006). The findings of this study will provide insight into ways that effective science pedagogy can provide excellent educational opportunities. The findings will contribute to growing Americans' fluency in scientific content and increasing the number of children passionate about science and interested in pursuing careers in STEM fields.

The reliance on reading and writing in science makes it critical for teachers to integrate inquiry-based science instruction with opportunities for students to learn and practice fundamental science literacy skills. Fundamental science literacy skills include the proficiencies needed to read, write, and communicate effectively within the science community (Norris & Phillips, 2009). Scientists and students use common literacy skills to learn about scientific concepts, expand their understanding of the world, communicate information, and make valid arguments using evidence (Hand et al., 2003; NRC, 2000). These literacy skills require sustained practice with scaffolded guidance and support for students to develop automaticity and fluency. Hand et al. (2003) suggested that additional research is necessary to understand the myriad connections between literacy and science and teacher pedagogy's role in developing science literacy.

Researchers should continue investigating opportunities to embed literacy instruction throughout all content areas, including science, in meaningful and effective ways. The findings of this study could have important implications for teachers, K–12 educational leaders, curriculum developers, teacher preparatory programs in college, and professional development consultants. The researcher aimed to contribute to educational research by examining the efforts of high school science teachers as they collaborate with other educators to alter pedagogical approaches to include the integration of interdisciplinary instructional strategies and inquiry-based science instruction. The researcher aimed to analyze the teacher decision-making process to understand the factors that impact change. Another goal was to understand the reasons teachers' chose to use close reading strategies to support their science instruction. Understanding these concepts can help teachers and educational leaders recognize the importance of increasing literacy learning opportunities for students and begin to remedy the growing problem of illiteracy in America while developing students' proficiency and passion for science content.

Finally, the findings of this research have significant ramifications for the researcher as an educational leader and curriculum developer. A deep understanding of the relationship between content areas and instructional practices like close reading and effective science instruction will allow the researcher to provide meaningful guidance, feedback, and support to teachers to improve instruction for all students. In addition, this knowledge will empower high school English teachers to work collaboratively with their science colleagues to develop units of study that increase student proficiency in science and reading while engaging them in meaningful and essential content.

Definition of Terms

Close Reading: An instructional strategy that requires students to engage in analytically reading complex texts multiple times to understand what the author is communicating deeply and to make connections to their own experiences, beliefs, and other texts (Frey & Fisher, 2013).

Content Area Literacy: The general techniques and approaches intended to support literacy and comprehension across all types of texts (Shanahan & Shanahan, 2012).

Cross-Cutting Concepts: Seven ideas that establish connections between the four disciplinary content areas in science, including patterns, cause and effect, scale, proportion, and quantity, systems and models, energy and matter, structure and function, and stability and change (NRC, 2012).

Derived Science Literacy: Knowledge of scientific concepts and content (Norris & Phillips, 2009).

Disciplinary Core Ideas (DCIs): Four major content areas within the sciences: (a) life science, (b) Earth and space science, (c) physical science, and (d) engineering, technology, and application of the sciences (NRC, 2012).

Disciplinary Literacy: The unique ways reading, writing, and communication are used in specific disciplines such as science or social studies (Shanahan & Shanahan, 2012).

Fundamental Science Literacy: Reading and writing about science content (Norris & Phillips, 2009).

Interdisciplinary Instruction: Instruction that merges information, instructional strategies, and tools from two or more disciplines while anchoring in one primary content area (Klein, 2015).

Literacy: The ability to gather, comprehend, evaluate, and utilize information from a written text (Organisation for Economic Co-operation and Development, n.d.).

Science and Engineering Practices: The general skills that scientists and engineers are required to use to engage in their work, including asking questions and defining problems, developing and using models, planning and carrying out investigations, analyzing and interpreting data, using mathematical and computational thinking, constructing explanations and solutions, engaging in argumentation based on evidence, and obtaining, evaluating, and communicating information (NRC, 2012).

Conclusion

Scientific discovery and innovation have critical roles in modern society. Pursuing scientific knowledge through research is essential to finding cures for diseases, reducing pollution, maximizing alternative energy sources, and finding more effective and efficient ways to solve many challenges today. Unfortunately, American students are underperforming on science assessments compared to their international peers, creating a bleak outlook for the future. The importance of science in the 21st century implores educational researchers to investigate the effectiveness of the pedagogical approaches currently used to teach science in schools, explore other potential instructional strategies to support science instruction, and identify the obstacles preventing teachers from implementing new approaches.

The goal of this qualitative study was to understand the collaborative process by which high school science teachers worked to change traditional instructional approaches, identify the reasons that influenced teachers' implementation of close reading, understand and communicate the ways that high school science teachers use close reading to enhance science instruction, and understand the teacher decision-making process to facilitate change. Integrating literacy into the science classroom allows students to learn and apply reading strategies in a meaningful context to support their development as proficient readers. Improving student literacy must be achieved while providing students with opportunities to apply and enhance their knowledge of the skills used by experts in the field of science. The findings of this study may directly support high school science teachers seeking to integrate literacy into their daily instruction by providing examples of how close reading has been implemented in a similar context. This information can be used to expand the use of close reading in science and other content area classes and improve the overall literacy proficiency of students.

Chapter 2

Literature Review

Authentic, student-driven, and inquiry-based lessons that require students to apply the skills used by scientists, including essential literacy skills, have the potential to increase students' scientific knowledge, develop their ability to apply literacy skills in an array of formats, and empower students to explore ways that science and scientific discovery can remediate real-world problems and improve how the world functions. Exceptional science teachers who provide effective and engaging science instruction are essential to increasing students' interest in pursuing careers in the sciences. The study's findings added to a body of research exploring the factors impacting teachers as they made decisions regarding instructional strategies to accomplish these goals. The findings also filled a gap in the existing research by focusing on teachers' decisions to use specific instructional strategies that encouraged students to engage in close reading behaviors in high school science classrooms.

The literature review for this study begins with a discussion of teaching and pedagogy. Next, traditional science instruction, the NGSS (n.d.), and inquiry-based learning are explained before an overview of the shift from traditional to inquiry-based learning is given. This section is followed by research highlighting the benefits of interdisciplinary instruction and explaining how close reading and inquiry-based science instruction are used as an interdisciplinary instructional approach.

Traditional Science Pedagogy

The approaches used to teach science to American students have changed over time. Changes to the accepted pedagogical approaches are often related to the country's political initiatives and cultural expectations (Cobern & Aikenhead, 1997; DeBoer, 1991; National Academies of Sciences, Engineering, and Medicine, 2019). Politically, legislation and military pursuits have played an essential role in education. Culturally, educational expectations and pedagogical approaches are influenced by how people communicate and their beliefs, attitudes, norms, and world perceptions (Cobern & Aikenhead, 1997; Milne, 2014). These influences have dichotomous effects for the U.S. educational system, some increasing the nation's desire to prioritize science and technological education and others reducing the focus on science education and emphasizing other content areas. The flux created by the nation's political and cultural influences can be observed in the changing instructional practices used in the classroom over time.

The publication of *A Nation at Risk* in the early 1980s profoundly impacted the American education system and the pedagogical approaches used by teachers. This report expressed grave concerns for American schools, citing extremely high levels of adult illiteracy (National Commission on Excellence in Education, 1983). The report indicated that 23 million American adults struggle with literacy-based tasks and 13% of 17-year-olds were functionally illiterate, prompting additional research to be conducted and initiated a movement for educational reform that included developing standards for all content areas, including science, and increasing the focus on scientific-literacy (National Academies of Sciences, Engineering, and Medicine, 2019). Academic standards indicate what students should know and be able to do as they progress through their school years (Hamilton et al., 2008). The standards also provide a benchmark for assessing student performance and holding school districts accountable for students learning (Hamilton et al., 2008).

In 1992, an adult literacy survey reported that 50% of Americans over 15 had limited reading proficiency (Kirsch et al., 2002). These people could locate information in a text and make low-level inferences but struggled with long, complex passages and integrating or synthesizing information (Kirsch et al., 2002). Despite many efforts to improve literacy instruction, these results showed very little progress toward addressing the problem of adult illiteracy in the 1985 Young Adult Literacy Survey (Kirsch et al., 2002).

Throughout the 1980s and 1990s, inquiry-based science instruction sought to develop students' understanding of the scientific process through active learning (NRC, 1996). Inquiry-based learning requires students to utilize their capacity to think critically, identify problems, collaborate with others, and gather information from various sources to understand specific content deeply (Capps & Crawford, 2013). Different competencies, such as critical thinking, problem-solving, collaboration, communication, information, technical, and digital literacies, are essential in the 21st century (Voogt & Roblin, 2012).

Students must be able to gather, process, analyze, and communicate information acquired through various digital sources such as websites, photographs, and blogs (Morrell, 2012). Students must also understand the benefits and drawbacks of the ease of publishing and acquiring information through digital sources and the importance of critically evaluating sources for credibility, bias, and accuracy (Morrell, 2012, 2014). As a result of the improved accessibility of information, students must be taught to apply this information in real-world situations. The ongoing application of these skills increases students' ability to gather and synthesize data from multiple sources, work with others to understand concepts from many perspectives, and build on previously existing knowledge to expand their understanding of the world around them (Capps & Crawford, 2013).

The Role of the Next Generation Science Standards

Since the development of the NGSS (n.d.), instructional practices in science classes have continued to be heavily based on inquiry and investigation. However, a shift toward including instructional practices that blend cross-cutting concepts, science and engineering practices, and DCIs into a seamless curriculum has begun (National Academies of Sciences, Engineering, and Medicine, 2019).

DCIs provide the foundation for content to be taught across grade levels and indicate the cross-cutting concepts that connect the disciplines. Science and engineering practices are the skills scientists use when investigating scientific concepts (NRC, 2012). The DCIs are divided into four domains intended to represent each major science discipline: physical sciences, life sciences, Earth and space science, engineering, technology, and application of science (NRC, 2012). The DCIs were developed to reflect the learning progression from Kindergarten through Grade 12, with each idea becoming increasingly complex as students progress (NRC, 2012). In addition to the DCIs, there are seven cross-cutting concepts related and applied to all of the science disciplines: patterns; cause and effect; scale, proportion, and quantity; systems and system models; energy and matter; structure and function; and stability and change (Krajcik et al., 2014; NRC, 2012). Like the DCIs, cross-cutting concepts are progressive and increase in complexity as students progress through the grades.

Eight science and engineering practices frequently used by scientists and engineers were identified in the framework (NRC, 2012). The recognized science and engineering practices include asking questions and defining problems, developing and using models, planning and carrying out investigations, analyzing and interpreting data, using mathematics and computational thinking, constructing explanations and designing solutions, engaging in argument from evidence, and obtaining, evaluating, and communicating information (NRC, 2012). The practices represent how scientists and engineers learn and communicate information with others in their field (Krajcik et al., 2014). The term *practice* was selected because it serves as a reminder that the skills described must be regularly practiced for students to become fluent and proficient in their application (NRC, 2012). The practices were identified because they are the basis of the work of scientists and engineers and can help students learn critical concepts in the science disciplines. At the same time, they engage in the inquiry process (Krajcik et al., 2014).

By providing continued instruction and practice with these cross-cutting concepts and science and engineering practices, students become fluent in their use, and these concepts help deepen their understanding of the DCIs. The performance expectations for the NGSS (n.d.) integrate the DCIs, practices, and cross-cutting concepts to create cohesive learning goals to guide curriculum development and instruction (Krajcik et al., 2014). Developing students' abilities to apply the scientific process to real-world situations has been a long-standing goal of science education. It is necessary to understand the process by which teachers decide to incorporate interdisciplinary approaches, such as close reading, and the internal and external factors that drive that process to move toward an increasingly interdisciplinary approach to teaching inquiry-based science.

Inquiry-Based Science Instruction: Benefits and Drawbacks

Inquiry-based science instruction is authentic, problem-based learning in which students experiment with concepts and content (Capps & Crawford, 2013). In science classes, inquiry-based learning requires students to develop scientific questions; design and conduct investigations; gather, analyze, and interpret data; use evidence to support arguments; compare findings; and communicate information in an organized and accessible manner (Capps & Crawford, 2013). According to the National Standards for Science Education, inquiry learning involves engaging students in making observations, conducting research using multiple sources, comparing information gathered through research with data collected during experimentation, working with data, generating potential answers to their questions, providing explanations, and making predictions, and communicating the finding with others (NRC, 1996). A single correct answer to the questions that students seek to examine is often elusive when engaging in inquiry-based learning (Heering et al., 2012). Students must use the exploration findings and existing information to draw and support their conclusions.

The use of inquiry in the classroom can vary based on the lesson's goal. Teachers may apply inquiry-based strategies as a mechanism for helping students learn content, or they can establish inquiry as the goal itself, an end in which students learn the nature of science and the scientific process (Levy et al., 2013). Inquiry-based learning presents several challenges for teachers and students based on the purpose of the inquiry. Inquiry as an end goal can be challenging when inconsistencies in the process lead to inaccurate or irreplicable findings (Klahr & Nigam, 2004; Levy et al., 2013). When this occurs, teachers must identify the teachable moment and explore possible explanations for the error by discussing the nature of science (Levy et al., 2013).

Although errors in outcomes present a challenge when inquiry is the end goal, inquiry-based learning faces its own obstacles as a means of gaining content knowledge. Levy et al. (2013) noted that a significant challenge for inquiry-based learning as a means is the recognition that inquiry without reading and researching existing knowledge is inadequate to ensure students learn the required content. Teachers using inquiry to support content learning must balance providing adequate access to prerequisite knowledge while teaching the process of discovery (Kirschner et al., 2006; Levy et al., 2013).

Kirschner et al. (2006) concluded that inquiry-based learning is inadequate for novice and intermediate learners. The researchers explained that inquiry-based learning assumes that students learn best through experience and that challenging students to solve real-world problems leads to effective learning. However, these beliefs counter the current knowledge about how people learn. Human cognitive architecture states that long-term memory, including everything experienced through the senses, is critical to learning and responding in various situations. Solving problems requires a significant amount of long-term memory, making it difficult for new learning to occur (Kirschner et al., 2006). Klahr and Nigam (2004) compared learning through direct instruction versus discovery instruction. According to this study, 77% of students who received direct instruction successfully mastered the content, whereas only 23% of students who received discovery instruction demonstrated content mastery. A meta-analysis of research conducted by Albanese and Mitchell (1993) indicated that medical school students who were instructed through problem-based learning alone had lower scores on teacher-made and standardized exams and spent more time studying than their peers who received direct instruction. These findings, which aligned with the findings of Kirschner et al. (2006) and Klahr and Nigam (2004), showed that direct instruction led to significantly more learning than an unguided discovery approach (Albanese & Mitchell, 1993).

Researchers have used the term *science literacy* in many different ways. Researchers have used it to indicate skills that make scientific concepts, theories, procedures, and findings accessible using written words and numbers (Dubowicz & Schulz, 2014). Other researchers refer to science literacy as having content knowledge, understanding of science practices, and knowledge of the social practices involved in science (National Academies of Sciences, Engineering, and Medicine, 2016). These two definitions of science literacy represent the importance of understanding science and the role science literacy plays in society (Dubowicz & Schulz, 2014). These definitions also demonstrate a significant contrast in understanding science literacy as a fundamental skill and discussing science literacy as indicating a level of content knowledge.

The practices and processes involved in inquiry-based science instruction to learn science content rely on students' ability to apply literacy skills proficiently. The National Standards for Science Education called for inquiry-based instruction that engages students in creating knowledge by applying literacy skills, such as asking questions about the natural world, developing a hypothesis based on prior knowledge and existing scientific research, evaluating relationships between concepts, making logical arguments based on evidence, and drawing conclusions based on observation and evidence that solve real-world problems (NRC, 1996, 2000). Ensuring that these competencies are embedded in the science curriculum and daily instruction is a fundamental task of educators and curriculum developers. These skills are essential in the classroom and are regularly employed by scientists as they engage in investigations to solve problems (NRC, 2000).

Literacy skills are embedded in many stages of the inquiry process. For example, students must ask and answer questions, read and comprehend previously completed scientific studies, compare information from various sources and media types, and communicate information in a cogent manner through writing when engaging in the inquiry process (Pearson et al., 2010). Scientifically literate individuals apply each of these competencies as they develop innovative solutions for real-world problems.

Teaching Fundamental Science Literacy

Instruction that provides opportunities for students to acquire strong fundamental science literacy skills establishes a solid foundation for student-driven, inquiry-based exploration of scientific concepts. The fundamental science literacy skills used by scientists closely align with proficient readers' essential behaviors and abilities. Twenty-first-century literacy instruction focuses on developing a wide range of comprehension skills like interpreting and analyzing information from texts, photos, art, music, speeches, physical observation, and digital mediums (Hand et al., 2003).

In addition, literacy instruction for science classes must include opportunities to enhance students’ communication skills. These skills include speaking, listening, and working collaboratively to understand, synthesize, apply, and innovate using critical subject area content (Hand et al., 2003). Developing and enhancing students' proficiency with these 21st-century literacy skills and providing opportunities for inquiry-based learning supports learning in the science classroom because they enhance fundamental science literacy skills and provide access to derived science literacy knowledge.

The NGSS (n.d.) calls for science teachers at all levels to integrate the literacy skills required of scientists into their classroom instruction. An interdisciplinary instructional approach fulfills this call to action. Mathematical skills are most commonly viewed as being aligned with science disciplines; however, oral and written communications account for an equally significant portion of work done by scientists (Hand et al., 2003). Seamlessly infusing interdisciplinary instruction in high school science classes is essential in providing effective and engaging science lessons that motivate students to learn more by genuinely engaging with content.

Interdisciplinary Instruction Across the Grade Levels

Dana Gioia, chairman of the National Endowment for the Arts from 2003 through 2009, described learning to read as an ongoing process where skills build upon one another and require continual practice to attain mastery (Gioia, 2004). It is sometimes regarded as a simple, easily acquired skill; however, data indicate that many Americans fail to master the skills required for reading and comprehension. Ensuring students read well is a high priority for school districts nationwide (Ristine, 2008). As a result of increasing pressure to raise literacy scores, researchers and educators have sought innovative ways to maximize the time available for students to apply their literacy skills, including taking an interdisciplinary approach in which literacy instruction is fully integrated into other content areas like science, social studies, and math.

Interdisciplinary instruction is a purposeful approach to teaching in which students are expected to apply the skills and knowledge they gain in one academic course to another (Harish et al., 2012). For example, in many content area classes, students are expected to engage in writing, a literacy skill. Interdisciplinary instruction is evident when the teacher provides specific lessons designed to enhance students' ability to write effectively in that discipline. Because of the authentic nature of interdisciplinary instruction, students can practice and enhance their learning skills and see the relevant applications of these skills (Harish et al., 2012; McClune et al., 2012).

The effect of integrating literacy instruction in content area classes has been a focus of research for many years (Eunice Kennedy Shriver National Institute of Child Health and Human Development, NIH, & DHHS, 2000; Fang & Wei, 2010; Gaston et al., 2016; Palumbo & Sanacore, 2009; Vaughn et al., 2013). Many studies and reports have focused on embedding literacy and content area instruction at the elementary and middle school levels. For this study, content area instruction referred to courses like science and social studies in which the focus of learning was traditionally knowledge based, where students learned facts, as opposed to skill based, where students learned to use transferable practices that advanced their learning abilities. The research on interdisciplinary literacy focused on student engagement and motivation, vocabulary acquisition, development of comprehension skills, and improvements in students' reading fluency; these findings show how classes like science and social studies can provide opportunities for teachers to improve students' proficiency in reading. Although studies examine interdisciplinary instruction at all levels, fewer focus on how literacy can be incorporated across the curriculum at the high school level, specifically how the practices associated with close reading are used in the high school science classroom.

Content area instruction that incorporates literacy strategies is recommended as a best practice by the NRP report (Eunice Kennedy Shriver National Institute of Child Health and Human Development, NIH, & DHHS, 2000). The NRP suggested that content area classes should be viewed as an additional forum for providing literacy instruction aimed at improving vocabulary and comprehension, in addition to increasing students' content area knowledge (Eunice Kennedy Shriver National Institute of Child Health and Human Development, NIH, & DHHS, 2000). The findings of Palumbo and Sanacore (2009) supported the NRP report regarding the importance of maximizing time spent on literacy instruction by increasing its use in content-area classes and aligned with Fang and Wei's (2010) quasi-experimental study. The researchers found that students demonstrated higher levels of proficiency in science and improved their general reading ability as a result of receiving instruction in strategies for reading in conjunction with inquiry-based science instruction that reinforces the application of reading strategies. The findings of these studies highlight the many benefits students receive when literacy skills are presented through a wide array of lenses. Researchers have suggested that literacy skills, content knowledge, and student interest in reading are increased because of this practice (Fang & Wei, 2010; Palumbo & Sanacore, 2009).

Beginning in preschool and continuing through the elementary grades, reading instruction focuses on teaching students to read by developing foundational skills such as associating letters and sounds, decoding words, recognizing high-frequency words, and applying knowledge of phonics skills like syllabication and rhyming when reading multisyllabic words in context. Using high-interest, authentic literature and informational texts in science and social studies provides a meaningful and highly engaging canvas for students to practice applying their foundational reading skills. The additional time spent implementing newly acquired reading proficiencies in content area classes strongly affects students' overall proficiency in reading, writing, and communicating (Fang & Wei, 2010; Palumbo & Sanacore, 2009). As students move into the late elementary and middle school years, the focus of instruction shifts toward reading to learn and using literacy skills to increase content knowledge (O'Reilly et al., 2019; Shanahan & Shanahan, 2008).

Middle and high school literacy instruction emphasizes learning and applying comprehension skills like summarizing, paraphrasing, inferring, and synthesizing. Science classes in middle school and high school focus on ensuring students acquire the core content knowledge despite the integration of interdisciplinary literacy learning standards (New Jersey Department of Education, 2019; NGSS, n.d.; O'Reilly et al., 2019; Partnership for Assessment of Readiness for College and Careers [PARCC], 2011; Shanahan & Shanahan, 2008). Literacy instruction at these levels focuses on teaching the specific literacy practices needed within the discipline and content mastery.

Several studies on content area learning and literacy instruction provide evidence that supports the importance of integrating literacy strategies in science and social studies classes. Gaston et al. (2016), Kern and Bean (2018), and Vaughn et al. (2013) evaluated the impact of teaching literacy strategies to middle and high school students. Gaston et al. (2016) found that using literacy strategies, such as the Frayer vocabulary model, word maps, and annotations, supported student engagement, motivation, and academic achievement in a Grade 8 social studies class. Similarly, Vaughn et al. (2013) focused on improving middle school student content knowledge and reading comprehension. They concluded that students who received reading instruction with their content area instruction outperformed their peers who only received content area instruction on the acquisition and comprehension of content, as well as reading comprehension (Vaughn et al., 2013).

At the high school level, Kern and Bean (2018) noted that students who engage in text analysis, listening comprehension activities, note-taking, and genuine class discussion make significant gains. These gains are in content knowledge, critical thinking skills, comprehension, and cultural awareness. The researchers identified disciplinary literacy instruction, culturally responsive teaching, and instruction in the changing mediums of literacy as essential components of literacy development for students (Kern & Bean, 2018). These researchers suggested that an interdisciplinary approach to content area instruction with a strong emphasis on applying literacy skills had many benefits for students. However, no strategies associated with close reading were examined as a specific approach to interdisciplinary instruction.

Integrating Close Reading in Science

The studies above highlight the benefits of integrating literacy strategies to enhance content-area learning and increase reading proficiency. Close reading is a specific approach that science teachers can use to support students' efforts in reading while deepening their understanding of critical science content. Close reading is an instructional strategy teachers implement to increase students' reading comprehension and bolster their confidence when tasked with reading complex texts.

The PARCC (2011) model content framework describes the process of close reading and its importance for students in Grades 3 to 11 by stating:

> Close, analytical reading stresses engaging with a text of sufficient complexity directly and examining meaning thoroughly and methodically, encouraging students to read and reread deliberately. Directing student attention on the text itself empowers students to understand the central ideas and key supporting details. It also enables students to reflect on the meanings of individual words and sentences; the order in which sentences unfold; and the development of ideas over the course of the text, which ultimately leads students to arrive at an understanding of the text as a whole. (para. 2)

Close reading can be applied in any content area (Frey & Fisher, 2013). Many of the NGSS (n.d.) directly connect to a corresponding CCSS for reading. For example, the NGSS for matter and its interactions requires students to demonstrate their ability to cite evidence and provide an explanation of a specific science topic. The standard directly correlates with the CCSS for Reading Science and Technical Texts, which requires students to cite evidence supporting a topic's analysis. Close reading provides an instructional strategy that supports students as they practice responding to text-dependent questions based on information provided in a science or technical passage.

Effective close-reading texts are short, complex, and grade-level appropriate passages (Fang & Pace, 2013; Frey & Fisher, 2013). Characteristics of complex text include vocabulary that is specialized and discipline specific, the use of nouns and verbs in unusual ways to represent processes and objects, often referred to as nominalization, challenging text organization and coherence, sentences and phrases that are dense with noun phrases and content words, and grammatically intricate sentence structure that includes multiple clauses (Fang & Pace, 2013; Fang & Schleppegrell, 2010; Shanahan & Shanahan, 2008). Textbooks used by middle and high school students in content area classes frequently embody many of these characteristics (Fang & Pace, 2013).

In addition to using complex text, a close reading exercise requires that students read and reread the same passage with different purposes in mind each time (Frey & Fisher, 2013). Multiple readings are essential in close reading because new details embedded in a text are revealed with each reading of the passage, deepening the reader's understanding (McConn, 2018). Teachers support students in grasping these details through well-planned, text-dependent questions that guide inquiry and discovery (Fang & Pace, 2013).

Finally, effective close-reading activities engage students in a task that requires applying knowledge gained from reading the complex text (Frey & Fisher, 2013). This process could include applying the information to a project or problem, writing about the text, or participating in a class discussion (Frey & Fisher, 2013). The follow-up close reading activity in a high school science setting might be the development of a scientific experiment. Students use information learned from reading about a science topic to create a plan to test their understanding of a concept. When close reading is used as a follow up after experimentation, students may use the information gathered to compare the outcome of their experiment with the information presented in the text.

Close reading is an ideal instructional approach for high school science teachers to support learners in accessing written information about science content. Many science texts present challenges for students due to the complexity of the information presented and the use of content-specific language and irregular sentence structures (Lapp et al., 2013). The complexity and structure of science textbooks make them ideal close reading material. Essential components of a close read include the use of a text at or slightly above students' grade level, the need to engage in multiple readings for different purposes, and the use of text annotation to assist in comprehension (Frey & Fisher, 2013; Lapp et al., 2013; McConn, 2018).

In addition, having a meaningful follow-up task that requires students to apply their learning in real-world situations is another essential component of close reading (Lapp et al., 2013). Teachers provide support through strategic questioning and discussion approaches. Students benefit from repeated exposure to standard text features and their ability to connect to prior readings and understandings. In addition, students are encouraged to adapt their learning experience by asking questions about the text, identifying unknown vocabulary, and recognizing different perspectives by engaging in content-specific discourse with their peers.

Close reading provides an opportunity for teachers to engage students in "structured learning experiences that promote creative and critical thinking, provide opportunities for substantial discourse, encourage deep knowledge, and make connections to the world as they know it is critical for these students" (Johnson & Mongo, 2008, p. 2003). Teaching that enables students to engage with science texts increases their understanding of their world through multiple viewpoints and helps them recognize and potentially develop innovative solutions for real-world problems (Lapp et al., 2013). Close reading allows students to engage with science content while developing their fundamental science literacy proficiency. Repeated readings of textbooks and research studies that directly align with the inquiry processes students engage in will help students develop a clear understanding of the course material. In addition, continually engaging in close reading allows students to become fluent in specific reading practices that benefit them as individuals and improve their fundamental abilities to work through complex scientific texts. These outcomes relate to the eight science and engineering practices identified in the NGSS (n.d.).

Conceptual Framework

Effective teaching engages students in genuine discussion, inquiry, and opportunities to apply learned information to real-world situations (Brooks, 1999; Marshall, 2013). When students face developing solutions to real-world problems, they must apply the knowledge acquired in several classes, especially literacy skills like reading, researching, summarizing, synthesizing, and communicating. Interdisciplinary instruction requires teachers to go beyond finding superficial relations between content areas to provide instruction that establishes the subject's interdependence (McClune et al., 2012).

The framework for cross-curriculum program development, adapted in Figure 1 for this study, showed how teachers' knowledge, beliefs, and values; the subject-area norms; the established curriculum; and professional development were interrelated in the creation and implementation of practical interdisciplinary lessons (McClune et al., 2012). The left column of Figure 1 focuses on knowledge, values, and beliefs influenced by the subject-matter norms and the teacher as an individual. Subject-matter norms refer to the traditionally accepted teaching practices and established boundaries for a specific discipline like science (McClune et al., 2012). This framework used the teacher to encompass their view of educator roles and their beliefs about their abilities to increase their professional capacity (McClune et al., 2012). Combining subject-matter norms and teachers resulted in understanding teachers' knowledge, values, and beliefs (McClune et al., 2012).

The center column of Figure 1 emphasizes the role of the established curriculum and professional development in teachers’ planning and implementation of specific pedagogical approaches. For this study, the curriculum included the content-area standards, textbooks, scope and sequences, pacing guides, learning opportunities, and assessments developed or selected and approved for use in a school district. Professional development includes any learning opportunities afforded to the teachers to enhance their practice (McClune et al., 2012). This process could include workshops, coaches, or other forms of continuing education intended for teachers. Planning and pedagogy resulted from curriculum and professional development. They are influenced by and reciprocally influence teacher knowledge, values, and beliefs (McClune et al., 2012). Curriculum and professional development significantly impact how teachers plan for instruction and the pedagogical approaches they implement in their classrooms (McClune et al., 2012). Interdisciplinary instruction refers to intentionally combining skills from one discipline to enhance the content of another discipline (Harish et al., 2012; McClune et al., 2012). Engaging in interdisciplinary instruction enhances instruction, synthesizes content, and provides learning opportunities in which students effectively apply skills from one discipline to learn new content from another discipline (McClune et al., 2012).

Figure 1

An Adaptation of the Framework for Cross-Curricular Program Development

Subject-matter norms RQ1		Curriculum RQs 2 & 3		Enriched pedagogy and content synthesis RQ2
Knowledge Beliefs Values RQ1	↔	Planning and Pedagogy RQs 1 & 2	→	Interdisciplinary Instruction RQs 1 & 2 & 3
Teacher RQs 1, 2, & 3		Professional Development RQs 2 & 3		Effective learning opportunities for students RQ2

Note. This adaptation demonstrates the relationship between the critical components of interdisciplinary instructional planning and the research questions (McClune et al., 2012).

The Interdisciplinary Instructional Model as the Research Framework

This study's first two research questions focused on the knowledge, beliefs, and values held by teachers that influenced their pedagogical practices when engaging in interdisciplinary instruction and the role of curriculum and professional development in their use of interdisciplinary instructional practices. The third research question for this study related to the use of close reading promotes effective science instruction in high school classes. The data were used to unpack how teacher knowledge, beliefs, values, curriculum, and professional development impact using interdisciplinary instructional strategies and close reading in high school science classes as an interdisciplinary approach.

Breaking tradition and changing how things are done is a complex but necessary task to ensure that the education system is doing everything possible to create life-long learners and scientifically literate citizens (Burke, 2014). Altering the instructional approaches high school science teachers use to include close reading strategies is an evolutionary change (Burke, 2014). This type of change is not likely to significantly alter the overall vision or mission of the school district. However, it may serve as a small step toward meeting the existing goals of providing an excellent education that supports students in developing readiness skills for success in the 21st century. Changing how things get done, including how instruction is provided in a classroom, requires understanding an organization's culture, norms, beliefs, and traditions (Argyris, 1990; Schein, 2010). Therefore, the interdisciplinary instructional framework, being rooted in prior knowledge and experiences, was an appropriate framework for evaluating how teachers' prior knowledge, previous experiences, and beliefs about how students learn affected teachers' decisions about using interdisciplinary science lessons, instructional strategies incorporated into the lessons, and materials selected for teaching.

High school science teachers who implement close reading as an interdisciplinary approach do so in response to many influencing factors within their classes and the school community. These influences include the teachers' beliefs in the importance of reading to support deep comprehension of a topic, the pedagogical norms of the primary subject area, the curriculum, and professional development (van den Broek, 2010). These factors that influenced teachers' decisions about instruction and pedagogy were explored as they related to the adapted framework for interdisciplinary program development.

Conclusion

Scholars have indicated that although the priority placed on reading in early elementary education has produced some improvement in basic reading proficiency, it has been unable to sufficiently ensure that all Americans can read and understand the complex text as adolescents and adults (Burton, 2018; DeSilver, 2017; NCES, 2019; Shanahan & Shanahan, 2008). Thus, there is more work to be done. The body of literature focusing on content area literacy reviewed for this study identified several positive outcomes, including improved content area knowledge, increased student motivation and engagement, and growth in comprehension and critical thinking skills (Fang & Wei, 2010; Gaston et al., 2016; Kern & Bean, 2018; Vaughn et al., 2013). These studies evaluated various instructional approaches and examined students at different educational stages. They provide evidence of positive outcomes that support continued and expanded research into embedding literacy instruction in content area classes. However, none of the explicitly reviewed studies considered using close reading to support science instruction at the high school level.

It is necessary to continue searching for and identifying instructional practices that ensure all students are proficient in applying traditional and 21st-century literacy skills before they graduate high school. Providing more intentional opportunities for students to apply literacy skills in content-specific classes, like science, may support students in becoming effective readers, writers, and communicators. Close reading encourages students to read with a critical eye independently; examining vocabulary, evaluating sources, considering the author’s purpose and potential bias, making connections within and outside of a text, and understanding the message that the author is trying to communicate (Frey & Fisher, 2013). Understanding how close reading is used in science classes may provide insight into how teachers can help students develop independence and confidence in their ability to explore science content and engage students in authentic, student-driven learning experiences.

Chapter 3

Methods

Scientific research and inquiry are essential for advancing society and addressing many social, economic, environmental, and medical challenges facing the modern world (Areepattamannil, 2012; Brito et al., 2012; Marincola, 2006). Educators play a central role in fueling students' natural curiosity and providing effective and engaging instruction that allows them to conduct research and inquiry projects that can lead to innovative solutions to many of these issues. Research within the education field provides educators with opportunities to reflect on their instructional approach to ensure that students receive the best education possible. The findings of this study help to clarify the understanding of interdisciplinary instructional practices focused on using literacy in the science classroom and how it is used to provide effective instruction that supports both the fundamental science literacy skills, the ability to use reading, writing, speaking, and listening skills to understand and communicate scientific knowledge, and derived science literacy skills, the mastery of science content knowledge (Norris & Phillips, 2009).

Science education should support all students in securing the skills necessary to engage in inquiry throughout their lives. Although not prescribing any specific pedagogical approaches, the framework for K–12 science education and NGSS (n.d.) call for science teachers to seamlessly blend instruction for DCIs with cross-cutting concepts and science and engineering practices (Drew & Thomas, 2018; Krajcik et al., 2014; NRC, 2012). Science and engineering practices include specific literacy skills such as asking questions, analyzing data, constructing arguments, and gathering, synthesizing, and communicating information (Eunice Kennedy Shriver National Institute of Child Health and Human Development, NIH, & DHHS, 2000). This cross-curricular approach to science education exposes students to critical science concepts. It supports the development of the fundamental literacy skills that support the sciences and other disciplines. This study examined how high school science teachers can collaborate with other educators to implement close reading practices. The study was guided by several research questions to identify successful strategies for implementing an interdisciplinary learning approach that includes close reading and inquiry-based science instruction to understand the challenges that arose throughout the process.

Research Questions

Effective and engaging science pedagogy is essential to developing scientifically literate citizens and increasing the number of students seeking careers in science. The purpose of this qualitative research study was to identify how and why teachers implement instructional approaches that infused close reading practices in high school science lessons to complement inquiry-based science instruction. The combination of close reading and inquiry-based science instruction helps students understand how to apply the skills that scientists use regularly and allows them to practice applying them as they explore science concepts. As in all qualitative studies, central research questions were developed to focus the study and guide the data collection process (Creswell & Creswell, 2018; Creswell & Plano Clark, 2017). The central research question for this study sought to understand how teachers' knowledge, values, and beliefs influenced the pedagogical and instructional strategies they applied when engaging in interdisciplinary instruction. Scientists regularly read complex texts, synthesize information from multiple sources, write arguments based on evidence, and communicate in oral and written form

(Hand et al., 2003; NRC, 2000; Norris & Phillips, 2009). As a result, including interdisciplinary instruction to teach students to engage in these practices effectively can support their academic success in the sciences and make the pursuit of a future career in science as a future career more enticing (Norris & Phillips, 2009).

The research questions were also intended to reveal details that explained how the established district curriculum, academic standards, and professional development opportunities impacted how the teachers planned for interdisciplinary instruction and how instructional practices associated with close reading promoted effective science instruction in high school science classes. Understanding these ideas has implications for teachers, curriculum writers, and educational leaders as they make informed decisions about the best pedagogical approaches to meet the needs of students in the 21st century and can improve professional development opportunities for teachers. The following questions guided the focus of this study:

1. How do teacher knowledge, values, and beliefs about interdisciplinary instruction guide their pedagogical and instructional practices?
2. How can close reading strategies be incorporated into the high school science classroom to promote interdisciplinary instruction?
3. From teachers' perspectives, how do curriculum and professional development impact teacher planning for interdisciplinary lessons?

Research Approach

Methodology

Qualitative research was selected as the methodological approach for the study because of the importance of communicating the individual experiences of the participant by integrating close reading strategies and science instruction (Braun & Clarke, 2006; Creswell & Creswell, 2018; Lincoln & Guba, 1985; Sandelowski, 2000). This methodological approach is used to understand and give meaning to a problem, situation, experience, or phenomenon that arises from human behavior or social interactions (Creswell & Creswell, 2018). The researcher explored the experiences of high school science teachers, their understanding of literacy pedagogy, and the strategies by which science teachers united literacy instruction and science content. The study also revealed information about the beliefs, values, and other intervening factors that influenced teachers' decisions to incorporate specific literacy practices like close reading with their traditional pedagogical approaches. Researchers using the qualitative research approach seek to understand a topic and construct knowledge rather than confirm or reject a preconceived theory or belief (Creswell & Creswell, 2018; Stake, 1995). Qualitative research was appropriate in this study because the data were used to describe the experiences of the teachers and administrators participating. In addition, the findings and discussion focused on detailing the processes by which teachers and administrators collaborated to integrate close reading as an interdisciplinary instructional approach into high school science lessons.

Qualitative research requires the researcher to ask open-ended questions, observe participants in the natural setting, synthesize multiple perspectives, gather data through several approaches, generate themes, and draw conclusions about a topic based on these emergent themes (Creswell & Creswell, 2018). The primary data collection methods in the present study were open-ended individual interviews of teachers and administrators, focus group discussions, and document analysis. Open-ended questioning techniques allowed the researcher to explore and create a rich narrative explanation of a topic (Campbell, 2014). Qualitative data are commonly collected through interviews, document interrogation, observations, and questionnaires to assist the researcher in developing a comprehensive understanding of a problem or experience within a specific context (Creswell & Plano Clark, 2017).

The qualitative research approach was selected for this study as it most closely aligned with the purpose and nature of the research. Sandelowski (2000) defined the qualitative descriptive approach as a method of inquiry in which the researcher sought to describe the facts related to an event or phenomenon. The questions asked in a qualitative study seek to identify the who, what, and how involved in the phenomena being studied. This approach allowed the researcher to present a detailed summary of the event and allow the researchers to communicate the information in a vernacular accessible to the practitioner (Sandelowski, 2000). The research questions for this study considered how interdisciplinary instructional strategies are implemented in high school science classrooms, the reasons high school science teachers identified for implementing these strategies, and the professional development opportunities that supported teachers' implementation of interdisciplinary instruction in their science classes. As is typical of the type of questions in a qualitative description approach, these questions were straightforward, and their answers required minimal inference on the researcher's part (Sandelowski, 2000). Additionally, aligning with the qualitative approach, the answers to these questions were of specific interest to educational practitioners such as educational leaders, curriculum writers, and teachers considering integrating interdisciplinary instruction through close reading strategies with science instruction (Sandelowski, 2000).

The data collected must accurately reflect how close reading was used in the high school science classroom to answer the research questions presented in this study fully. The objective of this study was to communicate the experiences of high school science teachers who implemented close reading in their classes, describe the application of close reading strategies in the high school science classroom, understand its purpose, and help practitioners who sought to expand their understanding of the practice (Aksamit et al., 1990). The impact of implementation on student achievement was not evaluated as part of the present study; however, it should be considered an important topic for future research.

This study explored the experiences of high school teachers who implemented close reading strategies in their science classes. The researcher examined how these teachers used close reading strategies to enhance their classroom instruction; identified the factors influencing their decisions to integrate close reading and science instruction; and determined what professional learning opportunities the teachers found most beneficial through individual interviews, focus groups, and document interrogation. The goal of understanding how close reading and inquiry-based science instruction were used as complementary pedagogical approaches did not require the development of a hypothesis or pre-existing theory about the topic (Creswell & Creswell, 2018). Furthermore, the findings of the study did not require future researchers to develop a theory but to provide information that could be used to assist practitioners when making curricular and instructional decisions for the science classrooms in their districts and schools or provide foundational information about close reading in high school science classes that could assist in future research (Sandelowski, 2000). The data collected must accurately reflect how close reading was used in the high school science classroom to answer the research questions presented in this study fully.

Case Studies in Qualitative Research

Case studies are a research approach in which the researcher collects data from multiple sources to develop a more substantial understanding of a particular topic occurring in a bounded context (Merriam, 1998). A bounded context can be defined as an individual, a group, an organization, or a geographical location (Merriam, 1998). Using a case study approach was appropriate for this study because the research aimed to understand the use of close reading strategies as part of an interdisciplinary instructional approach in high school science classes in one southern New Jersey high school during the 2022–2023 school year.

The goal of case study research is to investigate a phenomenon and provide a detailed description of the experience, capturing the intricacies of the participants in the specific context (Merriam, 1998; Stake, 1995; Yin, 2002). Detailed descriptions help readers understand the complexities of the case and enable the transferability of findings to similar contexts (Merriam, 1998). Therefore, collecting and analyzing multiple forms of qualitative data is an effective strategy for identifying themes that can assist in answering research questions (Merriam, 1998).

Data collection for this study included individual interviews and focus group discussions. The interviews and focus group discussions were conducted whenever possible in the school and the teachers' classrooms. Merriam (1998) explained that using multiple data sources supports the researcher in verifying information through triangulation and supports corroboration or clarification of their findings to increase reliability. Therefore, document analysis was included as this study's third qualitative data collection method. A recursive and reflective process of data collection and analysis assists the researcher in interpreting the data and revisiting specific ideas revealed during data collection to ensure saturation and enrich the description of the phenomenon (Merriam, 1998). In this study, the three data collection methods provided opportunities for the researcher to dissect and attribute meaning to ideas shared by the participants and through the documents and revisit those ideas during other data collection opportunities to develop further and clarify the meaning of those ideas and how they related to other ideas that had been shared.

Case studies are often conducted from an emic perspective, with the researcher having a deep knowledge of the phenomenon and the setting (Merriam, 1998). The insider researcher attempting to conduct a case study must separate their role in the setting from their positionality and worldview while delaying concluding until they have been fully submerged in the data available in the research setting (Stake, 1995). It is unreasonable to assume that emic researchers begin a study without preconceived ideas about the topic. Peshkin (1985) suggested that the researcher acknowledge their initial understanding and allow their perspective to morph in response to the collected data. In all research, the researcher must recognize and embrace the complexities of the workplace and seek to understand the phenomenon in question through the multiple perspectives available (Peshkin, 1985).

Worldview and Positionality

The researcher plays a central role in qualitative research, directly interacting with participants, usually on several occasions (Creswell & Creswell, 2018). As a result of the critical role that the researcher plays in collecting and analyzing data prior to concluding the study, the qualitative researcher must remain conscious of and forthcoming about their personal experiences and potential biases that could influence the outcome of a study (Creswell & Creswell, 2018; Rossman & Rallis, 2017). Creswell and Creswell (2018) defined *worldview* as the general way a researcher views knowledge construction and research's role in understanding the world. More directly, a worldview can be understood as a person's beliefs about how knowledge is constructed (Guba & Lincoln, 1994).

In the social constructivism paradigm, researchers seek to understand the world based on the participants' lived experiences (Creswell & Creswell, 2018). The social constructivist worldview espouses that people interpret and assign meaning to the world in response to their prior experiences, core values, and the cultural and historical norms of the society in which they live (Creswell & Creswell, 2018). These experiences and preferences often drive the decision to pursue a specific research topic and how the researcher interprets the data collected (Rossman & Rallis, 2017).

Researchers who ascribe to the social constructivist worldview assume ontological relativism, the belief that the facts about any topic, event, situation, or dilemma are relative to the person experiencing or observing it (Guba & Lincoln, 1994). Perspective is a critical aspect of the social constructivist view. Social constructivists believe that knowledge and understanding are developed due to social interaction, life experiences, history, and cultural norms (Creswell & Creswell, 2018).

As a researcher, I believe it is essential to reflect on my educational philosophy based on my experiences during my 20 years working in public. My beliefs about education are essential to communicate during reflection on my position as the primary researcher in this study. In my previous role as a supervisor of curriculum and instruction, I worked closely with teachers of English and other content areas. In my experiences as an elementary teacher and a reading specialist, I incorporated literacy instruction throughout the day in lessons across the content areas. I found these opportunities for students to engage with literacy in an authentic manner highly beneficial. My students could apply their literacy skills and strategies with greater automaticity and were more prepared to access content from informational text. As a result, I believe that educators in all content areas and across all grade levels are responsible for supporting students in developing and enhancing their literacy proficiency and deepening their content knowledge.

In the social constructivist worldview, personal experiences and background also play an essential role in developing the researcher's perspective. I am a middle-aged White female from a middle-class family. I am an avid and passionate reader. My bachelor's degree is in political science, and my master's is in education. I hold educator certifications as a K–8 teacher, K–12 reading specialist, K–12 supervisor, principal, and superintendent. My teaching experience includes 11 years as an elementary school teacher, 2 of which involved providing intensive literacy interventions for struggling students in Grades 3–5. After completing my master's degree, I advanced to a position supervising the curriculum and instruction for language arts classes ranging from Kindergarten to Grade 12. My love of reading and varying experiences in education have inspired me to pursue research that makes reading more accessible and more applicable to students.

As a former employee of the districts that served as the setting for this research, I assumed an emic (i.e., insider) perspective. The insider, or emic researcher, studies and communicates information from an insider's perspective, having previously established access to and knowledge of the gatekeepers and topical experts within the setting (Creswell & Creswell, 2018). As in this study, some benefits and challenges arise for the emic researcher when engaging in research.

Researching from the emic perspective provides the benefit of relying on preexisting relationships to open doors more quickly. However, the researcher must also know how these relationships influence the participants’ responses (Creswell & Creswell, 2018). Insider researchers face many challenges in seeking solutions to problems or issues within their organizations. These challenges include addressing perceived bias, navigating relationships to ensure the data collected are valid, being aware of assumptions, asking appropriate clarifying questions, and recognizing confidentiality barriers (Coghlan, 2003).

The first challenge they face is looking at the problem from a fresh, unbiased perspective (Coghlan, 2003). Emic researchers are members of the organization that they seek to understand. Therefore, they bring past experiences, assumptions, beliefs, and values that have shaped their organizational behavior (Coghlan, 2003). To avoid biased research, a researcher must remain cognizant of and transparent about their opinions and assumptions and consciously avoid imparting them in the research process (Coghlan, 2003).

Another challenge that emic researchers face is their prior knowledge's effect on the interview process. Insider researchers risk allowing their experience to hinder the probative nature of the interview process. They may assume that they fully understand the perspective of a subject without asking more clarifying questions (Coghlan, 2003). The process of asking follow-up questions allows the researcher to focus on specific events or issues relevant to the interview subject. It can provide critical data to inform future action (Stringer, 2014).

Finally, insiders may experience challenges when obtaining data due to their role within the organization. The data they require may be out of reach due to organizational structure, departmental restrictions, or many other reasons. The researcher should aim to include all stakeholders in the research process to minimize these barriers (Coghlan, 2003). Acknowledging my role as an insider in the research setting, I had to recognize my professional interest in improving literacy and science instruction in my = district and a personal interest in improving education at high schools within the county. Even though I did not directly supervise teachers in the science department, I had to remain cognizant of the influence my role as a curriculum supervisor in the district might have caused. At the other county high schools, I had no prior professional affiliations and limited familiarity with any of the potential participants from the schools.

Research Setting

This research focused on interdisciplinary instruction, such as close reading strategies in high school science classes at a public high school in Southern New Jersey. The Perdue School District is a large district composed of a full-day preschool program, eight K–5 elementary schools, three middle schools, a high school campus, a math and science academy for accelerated students, and an alternative program for middle and high school students. Perdue High School serves approximately 2,500 students of diverse culture and socioeconomic status. Standardized assessment results for this district demonstrate a significant deficiency in high school literacy.

Twenty-two percent of students attending Perdue High School met or exceeded expectations on the New Jersey Student Learning Assessment (NJSLA) during the 2018–2019 school year (New Jersey School Performance Report, 2018). In science, only 14% of these students earned proficient scores (New Jersey School Performance Report, 2018). The teachers have an average of more than 16 years of teaching experience, and more than 90% have more than 4 years of experience (New Jersey School Performance Report, 2018). The student-to-teacher ratio for Purdue High School is 14:1 (New Jersey School Performance Report, 2018).

Table 1

High School Student and Staff Data

School	Student enrollment	% of students proficient in language arts	% of students proficient in science	Avg. years of teaching experience in public schools	4+ years of experience	Teachers in out-of-field placements	Student-to-teacher ratio
Perdue High School	2500	22%	14%	16.1	91.9%	5	14:1

Note. Adapted from New Jersey School Performance Report (2018).

Participants and Sampling

Fifteen teachers were recruited for participation. Purposeful sampling is often used in qualitative research because it helps the researcher identify and select specific cases that are information-rich and varied to provide a comprehensive picture of the event or phenomenon based on the questions posed (Patton, 2002; Sandelowski, 2000). Two purposeful sampling approaches, criterion sampling, and snowball sampling, were used for this study.

First, criterion sampling was used to identify teachers for participation. Criterion sampling was selected as the initial approach to identifying and selecting potential participants for this study. According to Patton (2002), criterion sampling involves establishing standardized participant qualifications. This sampling method is appropriate when a researcher seeks to select participants who possess particular qualifications, such as a specific age or years of experience, that are essential to the study's outcome (Patton, 2002). Setting criteria for selecting participants ensures that the finding reflects the experiences of a specific group of people (Patton, 2002). The criteria established for participation in this study included being assigned as a high school science teacher and experience implementing strategies aligned with close reading in the science classroom. Having 3 or more years of teaching experience was an additional criterion in selecting participants to analyze data about teachers at varying points in their careers regarding their perceptions of implementing close reading strategies in science. The teachers selected through criterion sampling represented similar teachers for this study (Palinkas et al., 2015). School staff lists posted on district websites were used to generate a list of teachers who might have met the criteria for participation in this study. An email was sent to those teachers inviting them to participate in focusing on interdisciplinary instruction using close reading strategies in high school science classrooms.

Once the initial participant group was identified based on the established criteria, snowball sampling was used to identify additional participants and enlarge the sample size. During the initial interviews, participants were asked to share information about other information-rich sources (Patton, 2002). Snowball sampling takes advantage of the recommendations of other participants regarding individuals who may be knowledgeable about a topic and willing to participate in a study (Patton, 2002). Relying on the teachers' recommendations identified through criterion sampling to find additional participants could expand the population available for interview. When used together, criterion and snowball sampling strategies assisted the researcher in identifying and focusing on similar cases and increased the study's trustworthiness (Morse et al., 2002; Palinkas et al., 2015).

Data Collection Strategies

In qualitative research, multiple data collection phases are required to present a holistic picture of the activity. The data in this study were collected by observing high school science teachers in their classrooms, interviewing them individually, and, finally, engaging in focus group discussions. Document analysis, interviews, and focus groups allowed the researcher to thoroughly explore literacy-focused interdisciplinary instruction in high school science classes. The researcher could compare the information the study participants provided and ensure the findings are accurately and consistently reported. The qualitative data collected through document analysis, the interview process, and focus group discussions were coded based on the patterns and categories before being used to identify emerging common themes (Creswell & Creswell, 2018).

Document analysis is a process by which a researcher examines, interprets, and gains an understanding of a phenomenon through printed or electronic materials that contain text, images, or a combination of the two formats (Bowen, 2009). Document analysis can provide information about an event or experience, including the perceptions of those who do not directly participate in a study, critical aspects of the experience not communicated through interviews, and nuanced details that may have been considered insignificant during the interview process (Hodder, 2012). The documents provided background and contextual information, assisted in the development of additional questions or a focus for inquiry, supported reaching data saturation, demonstrated the changes made in an organization, and verified findings about the phenomenon studied (Bowen, 2009).

Individual interviews allow a researcher to gain an understanding of an event that they did not experience first-hand. Researchers may increase knowledge of how others experienced a situation while comparing multiple perspectives on an experience (Rubin & Rubin, 2005). Such interviews provide essential support to the researcher in viewing the study topic through the participants' eyes and understanding the external and internal factors that contributed to developing their point of view (King, 2004).

Focus groups are similar to interviews in that the researcher uses them to collect data about the participants’ experiences with a phenomenon (Morgan, 1988). However, focus groups differ from interviews because they are not guided by questions as much as by topics for discussion about which the participants can speak openly (Morgan, 1988). The researcher takes the moderator role during the focus group discussion (Morgan, 1988). Focus groups serve as an ideal forum for supporting the researcher in becoming familiar with the research setting, identifying participants who may provide rich accounts of the phenomenon being studied, and guiding the development of individual interview questions and schedules (Morgan, 1988).

Several benefits emerge from using focus groups, including helping the researcher gather significant information as the participants interact while confirming, refuting, or expanding their experiences (George, 2013; Piercy & Piercy, 2011). Other advantages of focus groups are the time and cost effectiveness of this method, the positive response of participants upon being asked for their input, and the relationships developed between the interviewer and participants (George, 2013; Nestel et al., 2012). One important drawback to using focus groups in qualitative research is the concern regarding the participants' influence on one another in over-reporting, under-reporting, or falsely reporting their experiences (George, 2013; Nestel et al., 2012).

Procedures

Before beginning the data collection process, the researcher submitted a research plan for the present study to the Rowan University Institutional Review Board (IRB) to confirm that all efforts have been made to conduct the study in the most ethical way possible to protect the rights of the participants (Rubin & Rubin, 2005). In addition, permission was sought from all potentially participating school districts. Protecting the identity of the participants, providing information about the researcher, establishing a clear purpose for the study, and explicitly communicating that participation in the study was voluntary were essential components to consider when developing the procedural plan for the study (Rubin & Rubin, 2005). Informed consent letters (Appendix A) that included this information were provided to each participant (Rubin & Rubin, 2005). Pseudonyms were used as participant identifiers in note-taking and reporting procedures. Broad generalizations were drawn about the instructional practices used by the participants in the study across all high school grades and courses (Rubin & Rubin, 2005). Protocols for document interrogation (Appendix B), interviews (Appendix C) and focus group discussion topics (Appendix D) were submitted in a draft form for IRB review; however, the nature of qualitative research and the importance of communicating the participants' beliefs made it essential that the procedures for data collection remained emergent throughout the study (Creswell & Creswell, 2018; Rubin & Rubin, 2005).

The researcher obtained permission from the school district to conduct the study, contact teachers as potential participants, and observe in classrooms. Once permission to engage in research was received, an email invited educators to participate in a study focusing on interdisciplinary instruction on developing literacy skills in science. The email contained the researcher's name, university affiliation, and pertinent information about the researcher's background and the study's purpose. Teachers were asked to respond to the email by answering criterion-based questions about their teaching experience and willingness to participate in the study.

When planning for case study research, experts identify several consistent steps, although the order in which the steps occur differs. The standard stages in case study research include identifying the problem, purpose, and research questions using the literature, defining the bounded context, establishing a research plan, collecting and analyzing the data, and integrating the study findings (Ellinger & McWhorter, 2016). Ellinger (2005) suggested that identifying the problem and establishing a purpose for conducting research are the first phases of case study research. Insider researchers may have a preconceived idea about a problem within a context (Peshkin, 1985).

As a result, reviewing scholarly literature related to the topic was critical in these initial research phases as it allowed the researcher to gather evidence that supported the existence of a problem (Ellinger & McWhorter, 2016). Reviewing scholarly works related to the topic served as a foundation for these processes. The literature helped the researcher confirm the existence of a known problem, clarify the purpose of the study, and develop research questions intended to fill potential gaps in understanding within the research setting (Ellinger & McWhorter, 2016). Once the problem was identified, the researcher selected the bounded context for the study, which could range from an individual in a single setting to multiple groups of individuals across several settings that shared the characteristics being studied (Merriam, 1998). Developing research questions was another beginning step in planning for case study research. During the planning and phase of this study, the researcher identified participants through criterion sampling and secured permission to conduct research in the selected setting.

Following the initial planning phases of case study research, the researcher collected and analyzed data (Ellinger & McWhorter, 2016; Merriam, 1998). During the data collection and analysis, the researcher made observations and collected initial data (Ellinger & McWhorter, 2016). The initial data were analyzed, and generalized ideas were further explored during additional data collection opportunities (Merriam, 1998).

For this study, individual interviews, focus group discussions, and document analysis were the data collection methods. The first method of data collection was document analysis. The researcher collected and analyzed the district high school science curriculum for lessons correlated to the standards for science and engineering practices that aligned with close reading. Lesson plans provided by the participants were also examined. These documents supported the researcher in responding to the third research question, which sought to understand how the curriculum and professional development impacted the teacher's implementation of interdisciplinary instructional approaches. The district curriculum communicated the role of literacy in science instruction and could demonstrate the expectation that an interdisciplinary approach was used to integrate literacy in science classes. The documents were examined to identify the literacy skills required in the content area, the role of literacy in the assessment of student performance, and strategies used for literacy learning (Appendix B). Analyzing documents shared by the participants provided an essential opportunity for the researcher to triangulate and confirm the information provided through other forms of data collection while increasing the validity of the results and reducing the effect of potential researcher bias (Bowen, 2009).

Individual interviews served as the second method of data collection. The interview questions for this study (Appendix C) were developed in an open-ended format to encourage participants to give as many details as possible (Rubin & Rubin, 2005). The interviews for this study were conducted in person, and the participants selected the locations to ensure their comfort. The interviews lasted between 45 minutes and 1 hour.

The data collection occurred in the school and the teachers' classrooms to maintain the bounded setting of the study. The natural setting was the classroom, making it the most desirable location for the interviews. The interviews were audio-recorded when the participant gave written and oral permission. The researcher also took written notes to document anecdotal notes that could help the researcher reflect on the meaning of the responses to interview questions. During the interview, the teachers were asked about their approaches to teaching in the science classroom and the strategies they used to integrate close reading and other literacy practices in their classes. In addition, they were asked about their teaching experiences, their preservice training, the professional learning opportunities they had during their teaching careers, the reasons behind integrating close reading practices in their science classes, and any challenges or barriers that they faced concerning the use of interdisciplinary instruction in their classes. As Rubin and Rubin (2005) recommended, the main and follow-up questions used during the interviews were explicitly designed to investigate the focus of the research question and elicit both depth and details in each response.

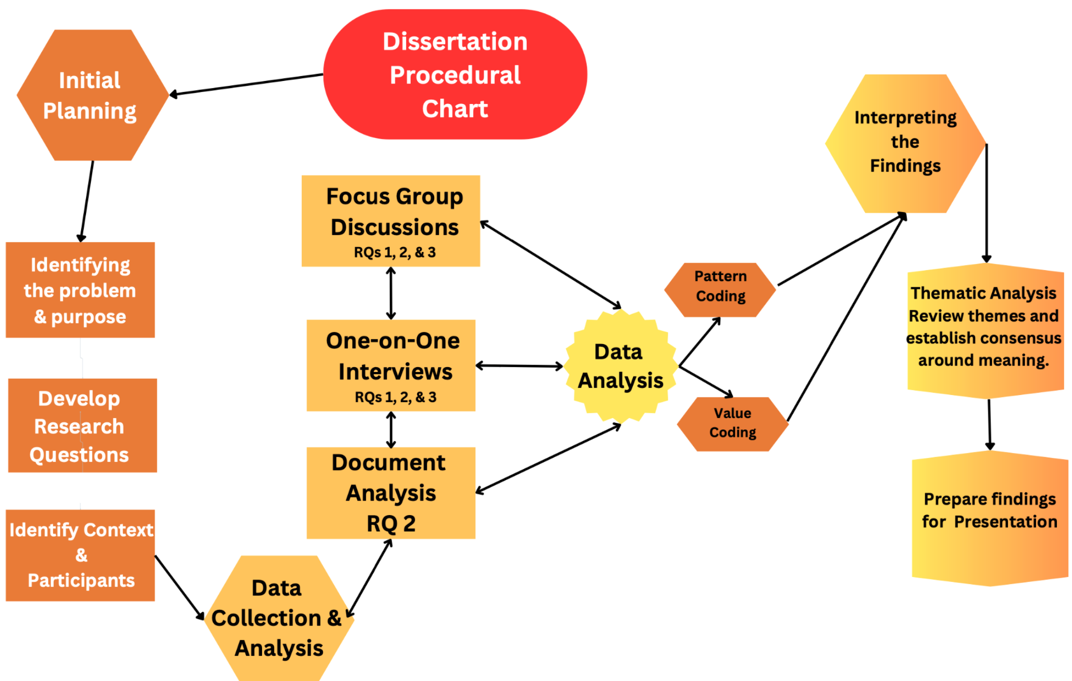
Data analysis is an iterative process in case study research (Merriam, 1998). Throughout the data collection process, the researcher engaged in reflective practices by revisiting the data and the meaning emerging and attempting to confirm, clarify, or expand their understanding to ensure the findings accurately reflect the phenomenon being studied. Focus groups were the final data collection approach used in the confirmation phase of this study (Athens, 2010; Blumer, 1969). The purpose of using focus groups in this study was to serve as an opportunity for the participants to confirm, refute, or expand on data collected through previous methods and discuss the meaning of those pieces of data (Athens, 2010; Blumer, 1969). The themes and codes generated based on the initial data collection methods guided the topics explored through the focus group discussions (Appendix D). The discussion topics included the factors that led the teachers to explore and implement interdisciplinary instruction in their science classes, the process of integrating close reading strategies and inquiry-based science instruction, and the professional learning opportunities that supported their implementation.

Two focus group sessions were held, each lasting approximately 1 hour. Following the focus group protocol, the teachers reviewed and discussed the themes identified by the researcher. The study aimed to verify or clarify those themes to develop the findings. In the final stages of data analysis, the researcher fully transcribed the interviews, revisited and analyzed the documents collected during the exploration phase, and reduced the data through thematic analysis. The researcher followed up with the participants with additional clarifying questions and for more information after the interviews were conducted and transcribed. These follow-up interviews lasted 15 minutes or less.

The interpretation of the data was the final stage in case study research (Ellinger & McWhorter, 2016). Pattern and value coding were used to identify emerging themes in the data. Thematic analysis required the researcher to determine the meaning of the patterns revealed in the data (Braun & Clarke, 2006). It is a common type of analysis used in case study research that can be used effectively by experienced and novice researchers (Merriam, 1998).

Figure 2

Procedural Plan



Data Analysis Strategies

Thematic analysis in qualitative research is a process for identifying, analyzing, and reporting themes found in a dataset (Braun & Clarke, 2006). Though commonly used, thematic analysis is not frequently considered an independent method of data analysis (Braun & Clarke, 2006; Vaismoradi et al., 2013). However, Braun and Clarke (2006) argued that this foundational tool provided enough structure and flexibility for even novice researchers to develop a rich and detailed understanding of the data. The flexibility of thematic analysis allows it to be used with several theoretical frameworks, including the constructionist paradigm in which meaning is given to a phenomenon or event based on personal experiences, norms, values, and social influences (Braun & Clarke, 2006; Creswell & Creswell, 2018; Vaismoradi et al., 2013).

When analyzing data for themes, the researcher identified important information related to the research questions and repeatedly appeared in the dataset (Braun & Clarke, 2006). Before analyzing a dataset using thematic analysis, the researcher must consider several important factors, such as prevalence and keyness (Braun & Clarke, 2006). Prevalence speaks to the number of instances in which the theme is present throughout the dataset (Braun & Clarke, 2006). For a theme to be identified, it must represent a pattern of responses. This pattern could be found within a single data item, across a set of data items, or throughout the entire body of data (Braun & Clarke, 2006). Keyness refers to the importance of information provided concerning the research questions (Braun & Clarke, 2006). Through careful and thorough analysis, the researcher created initial codes, searched for patterns within the dataset, reviewed the patterns to identify themes, refined the themes to create a thematic map, and reported the themes as research findings (Braun & Clarke, 2006; Vaismoradi et al., 2013).

Effectively coding data involved thoroughly reviewing and becoming familiar with the data by creating words or short phrases to summarize information found in the data (Linnenberg & Korsgaard, 2019; Saldaña, 2009). Coding effectively allows researchers to reduce the dataset into a manageable collection of keywords that answer the research questions. However, there are other benefits (Linnenberg & Korsgaard, 2019). Coding requires researchers to engage with the data many times, therefore facilitating the development of a deep understanding of what the data indicate (Linnenberg & Korsgaard, 2019). In addition, coding supported transparency, ensuring that relevant data were shared as examples supporting the findings and their validity and alignment with the research questions (Linnenberg & Korsgaard, 2019). Finally, coding assisted in giving voice to the participants in the study by ensuring that findings accurately reflected the participants' perspectives (Linnenberg & Korsgaard, 2019).

This study used two types of coding: value coding and pattern coding. In this study, value coding was used to identify indicators in the dataset that showed teachers' knowledge, values, and beliefs about interdisciplinary instruction, inquiry-based science, and close reading strategies (Saldaña, 2009). Value coding was intended to reveal the ethos of a community or culture concerning a phenomenon (Saldaña, 2011). For this study, value coding was used to identify data relating to the first research question, which sought to understand how teachers' knowledge, values, and beliefs influenced their pedagogical and instructional decisions when engaging in interdisciplinary instruction. Pattern coding was used to identify parts of the dataset that answer the second and third research questions, which asked about the external influences of curriculum and professional development on their implementation of interdisciplinary lessons and their perceptions about the impact of interdisciplinary instructional strategies on effective science instruction. Pattern coding was the development of connections between the data and research questions that form categories used for analysis (Saldaña, 2009). Using pattern coding, the researcher extrapolated meaning from the data to reveal significant themes and anchored the findings to the research questions (Saldaña, 2009).

Trustworthiness

Quality research must withstand critical evaluation that challenges credibility, reliability, and validity, sometimes called trustworthiness (Aksamit et al., 1990; Lincoln

& Guba, 1985; Morse et al., 2002; Rose & Johnson, 2020). Rose and Johnson (2020) characterized trustworthiness as the quality of the research when evaluated as a whole and included the concepts of reliability and validity in their explanation. Reliability considers the appropriateness of the methods for the study and the consistency and clarity of those processes (Rose & Johnson, 2020). Reliability considers whether another researcher could complete the study again to obtain similar findings. Validity evaluates the relationship between the findings and the data from the perspective of various stakeholders and reality (Rose & Johnson, 2020). Trustworthiness includes the concepts of credibility, transferability, dependability, and confirmability (Aksamit et al., 1990; Lincoln & Guba, 1985).

Credibility refers to the alignment of the researcher's inferences and the intended meaning ascribed by the participants (Aksamit et al., 1990; Lincoln & Guba, 1985; Teddlie & Tashakkori, 2009). A study's credibility can be supported through several purposeful actions on the part of the researcher, including spending a significant amount of time with the participants to reach data saturation, triangulating research sources and methods, and reviewing the findings with the study participants to ensure accuracy (Aksamit et al., 1990; Lincoln & Guba, 1985; Rose & Johnson, 2020). Transferability refers to the ability of interested parties to apply the findings of this study in a similar context (Aksamit et al., 1990; Lincoln & Guba, 1985; Teddlie & Tashakkori, 2009). A thorough and detailed description of the setting provided by the researchers is an essential step in supporting the transferability of the findings (Lincoln & Guba, 1985; Rose & Johnson, 2020). Rose and Johnson (2020) advocated for researchers to include details about the social, political, and economic context in which the study was set. Including these details reinforced the credibility and transferability of the study should other researchers choose to emulate it at a later date.

Dependability questions the process of collecting, analyzing, and interpreting the data. It is the ability to ensure that multiple individuals can consistently agree on the findings (Aksamit et al., 1990; Lincoln & Guba, 1985; Rose & Johnson, 2020; Teddlie & Tashakkori, 2009). Confirmability indicates whether the findings are logical, based on data-driven evidence, and reasonably free of researcher bias (Aksamit et al., 1990; Lincoln & Guba, 1985; Teddlie & Tashakkori, 2009). Internal and external audits of the study are suggested to address a study's dependability and confirmability (Aksamit et al., 1990; Lincoln & Guba, 1985; Rose & Johnson, 2020; Tobin & Begley, 2004). Audits may include a review of the alignment between the research questions and the data, an evaluation of the methods used to collect the data, or an examination of the final report (Aksamit et al., 1990; Lincoln & Guba, 1985; Rose & Johnson, 2020; Tobin & Begley, 2004). The inclusion of a reflexive research journal that provided a record of the researcher's thinking; the evaluation of their positionality; and how their beliefs, values, and experiences influenced their analysis of the data was also crucial in bolstering the dependability and confirmability of the study (Aksamit et al., 1990; Lincoln & Guba, 1985; Rose & Johnson, 2020; Tobin & Begley, 2004; Vaismoradi et al., 2013).

Although establishing trustworthiness was essential (Aksamit et al., 1990; Lincoln & Guba, 1985; Morse et al., 2002; Rose & Johnson, 2020; Sandelowski, 2000; Teddlie & Tashakkori, 2009), Morse et al. (2002) argued that the strategies to evaluate the study were usually left to readers once the study has been completed, leaving no chance for the researcher to make corrections to improve the rigor. Instead, the use of verification strategies applied throughout the research process was suggested (Morse et al., 2002). The researcher's openness to discovery, alignment of the research questions and methods used, appropriate and adequate sampling, iterative data collection and analysis, reflective practices, and logical theory development were the critical components of the verification process (Morse et al., 2002). The research methods employed throughout this study integrated a combination of strategies. The researcher made changes and adjustments during the process, increasing the rigor and providing evidence of trustworthiness for reviewers after the study's completion.

Engaging in practices that ensure trustworthiness was an essential part of this study. Therefore, the researcher's positionality and worldview were discussed, the research questions were carefully crafted to align with the purpose of the study, and multiple data collection methods were selected and used (Morse et al., 2002; Rose & Johnson, 2020). As the study progressed, collaboration with research mentors and peers was necessary to determine whether adjustments to the methods were warranted and consider other perspectives from which the data could be interpreted (Morse et al., 2002; Rose & Johnson, 2020). Member checking was also used; data collected through individual interviews guided the questions used for focus group discussions, allowing the researcher to confirm, negate, or revise their interpretation of the interview data (Morse et al., 2002; Rose & Johnson, 2020).

Conclusion

Reading, writing, and communicating are essential skills for scientists (Hand et al., 2003; NRC, 2000). Teaching that integrates scientific knowledge with the application of literacy practices is critical (Norris & Phillips, 2009). The K–12 science education framework and NGSS (n.d.) established learning standards that included DCIs with cross-cutting concepts and science and engineering practices (Drew & Thomas, 2018; Krajcik et al., 2014; NRC, 2012). These science and engineering practices included many specific literacy skills used when students engaged in close reading (Eunice Kennedy Shriver National Institute of Child Health and Human Development, NIH, & DHHS, 2000). This study aimed to identify close reading practices that high school science teachers used to enhance their science instruction. In addition, this study explored the factors that encouraged high school science teachers to implement close reading practices and the barriers they faced during implementation. Finally, the researcher examined the role of different approaches to professional learning used by teachers when implementing interdisciplinary instructional literacy.

Data were collected through individual interviews, focus group discussions, and document analysis related to integrating close reading strategies in the content area to respond to the research questions. Process and pattern coding were used throughout the data collection period to identify themes represented in the data (Saldaña, 2009). These themes were used to help the researcher interpret the data and generate findings for this study (Braun & Clarke, 2006; Vaismoradi et al., 2013). Reliability, validity, and trustworthiness were addressed, beginning with the statement of the researcher’s worldview and positionality and including purposeful activities such as using multiple approaches for collecting data, seeking guidance from a research mentor and peers, and member checking throughout the data collection period. The goal was to ensure that the themes and findings reflected the participants’ views (Lincoln & Guba, 1985; Morse et al., 2002; Rose & Johnson, 2020).

Social, economic, environmental, and medical advances depended on continued scientific research and inquiry (Areepattamannil, 2012; Brito et al., 2012; Marincola, 2006). To meet this need, educators must provide students with opportunities to advance their knowledge of scientific concepts and the literacy practices that support scientific inquiry (Norris & Phillips, 2009). This study contributes to the research on integrating literacy practices in science education by focusing on how the specific literacy skills associated with close reading can be used with inquiry-based science practice to create an interdisciplinary instructional approach. The goal was to enhance fundamental and derived science literacy.

Chapter 4

Research Findings

American students have struggled to demonstrate proficiency in science on standardized assessments for many years. In addition, there has been a marked decline in the number of students pursuing college degrees in science. These concerns may be attributed to teachers' reliance on traditional pedagogical methods that boost students' foundational knowledge but rely on memorization instead of genuine learning (Furtak et al., 2012). Although these teaching methods may support short-term knowledge building, they fail to provide students with an understanding of learning behaviors that lead to a deep understanding of science concepts. As a result of the myriad interpretations of instructional best practices in secondary science, reduced instructional time, and diminishing interest in their science classes, Americans are increasingly unprepared to learn advanced science content in higher education and are ill-equipped to be consumers of scientific knowledge as citizens (Marincola, 2006; Saunders, 2015).

The ultimate goal of education is to equip students with the ability to learn from the knowledge of others and develop the tools necessary to synthesize existing information with their experiences to create new knowledge. Applying analytical reading, argumentation, data analysis, and persuasive writing while navigating science topics as part of learning through inquiry is central to student learning. Unfortunately, integrating explicit literacy instruction and inquiry-based science is often challenging for science teachers who have inadequate training in instructional practices that support the extensive role of reading in science inquiry or who view the teaching of reading skills as the responsibility of the reading teacher (Greenleaf & Brown, 2017).

This study allowed the researcher to explore how close reading and other interdisciplinary instructional strategies were incorporated into high school science classes to improve academic outcomes and bolster student confidence and interest in the sciences. To accomplish this goal, qualitative research that included interviews, focus group discussions, and document analysis was intentionally selected to facilitate a deep understanding of the experiences of high school science teachers who implement close reading instructional strategies to support their students in comprehending complex informational text. Although each data collection method was chosen because it offered an opportunity to collect new information about interdisciplinary instructional practices, the three methods served as an opportunity for cross-checking, clarifying, and refining how the researcher and the participants could understand interdisciplinary instruction. Information provided during the individual interviews was revisited during the focus group discussions. This process provided a chance for the teachers to reflect on the information that had been previously shared, question the meaning of that information, and challenge the ideas by examining it from different perspectives.

This study chapter contains the findings from analyzing the three data sources: one-on-one interviews, focus group discussion, and curricula and lesson plan documents (Hodder, 2012; Rossman & Rallis, 2017; Rubin & Rubin, 2005). NVivo14 helped the researcher organize and rank the themes from the three data sources. This chapter outlines the research problem and describes the research design, participants, and data collection process. A discussion of procedure analysis follows the study findings. The findings are presented in the form of major themes and subthemes. The chapter ends with a summary of the research findings and introduces the final chapter of the study.

Overview of the Study

For this qualitative study, the researcher collected and analyzed two primary and one set of secondary data sources in this study. A total of 11 teachers participated in this study. The individual interview and focus group discussions had seven teacher participants. The focus group discussion included three teachers and four additional teachers who participated in the interviews. The interviews and the focus group discussions were the primary data sources collected during this study. In addition to the interview and focus group discussions, data were collected from several course curriculum documents and teacher lesson plans. Seven documents were reviewed. After collecting and reviewing the documents, the participants who shared them were briefly revisited for additional context relating to the instructional strategies used to implement their lesson plans.

Participant Demographics

Seven interviews and two focus group discussions were performed for the primary data sources. All the participants were teachers and included males and females. Each participant was a high school science teacher and had experience implementing close reading or strategies aligned with close reading in the science classroom to meet the criteria for the current study. Moreover, they were required to have at least 3 years of teaching experience. The criteria were important because not having the required experience would have meant that the participants could not provide the relevant data for this study, including data about teachers at varying points in their careers regarding their perceptions of implementing close reading strategies in science.

The real names of the participants were known to the researcher. However, because participants' anonymity and confidentiality were paramount in this study, using pseudonyms was an important consideration. Therefore, the researcher created pseudonyms for each participant; these were used in place of their real names. The use of pseudonyms was consistent with a qualitative approach. Overall, assigning a pseudonym to each participant helped ensure that their identity was protected. Each of the 11 participants stated they were willing and prepared to engage in the semi-structured interviews or focus group discussion that lasted 45 to 60 minutes.

The participants' ages, genders, ethnicities, years of teaching experience, and pathways to obtaining their teacher certification were diverse. The participants ranged from 28 to 57 years of age and reported their teaching experience as being between 5 and 35 years. Seven teachers reported completing their teacher training in college through an education pathway and obtaining their certifications through the traditional route. However, the remaining four teachers shared that they became teachers through the alternate route after attending college, obtaining a science degree, and working in another field before teaching. There were seven female and four male participants. The self-reported ethnicities included five Caucasian teachers, three Latino teachers, two African American teachers, and one teacher who identified as multiracial. In addition, the teachers’ experiences varied regarding the science courses they taught. Having experience teaching science in Grades 6–12 throughout their careers, the teachers taught anatomy and physiology, biology, chemistry, Earth science, physical science, and physics. Table 2 summarizes information relating to the teachers’ ability to meet the criteria established for participation in this study.

Table 2

Teacher Demographics

Pseudonym	Teaching experience (yrs)	Teacher certification pathway	Science courses taught	Grade-levels taught	Race/ ethnicity	Gender
Mary	23	Traditional	Chemistry	6, 7, 11, 12	Caucasian	F
Sandy	16	Alternate	Biology	7, 8, 9	African American	F
Katherine	35	Traditional	Biology	9-12	Latino	F
Alex	24	Traditional	Biology	6-8, 9, 10	Caucasian	M
Rachael	8	Traditional	Physical Science	9-12	Multiracial	F
Brian	7	Traditional	Physical Science Earth Science	10-12	Caucasian	M
Erica	21	Alternate	Chemistry	11	Latino	F
Michael	7	Traditional	Physics	8, 11-12	African American	M
Tom	13	Alternate	Earth Science	9-10	Caucasian	M
Miriam	10	Alternate	Chemistry	9-12	Caucasian	F
Shaniya	5	Traditional	Anatomy & Physiology	6-8, 10	Latino	F

Data Analysis

Verbatim transcripts of the seven individual interviews and two focus group discussions were analyzed in the NVivo 14 qualitative data analysis software program. The data analysis procedure applied to the data was Braun and Clarke's (2006) inductive, thematic method. The procedure had six steps: (a) familiarization, (b) generation of initial codes, (c) grouping codes, (d) reviewing themes, (e) defining final themes, and (f) producing results (Braun & Clarke, 2006).

The first step of the analysis was familiarization with the data. The data were read and reread in full. The researcher made handwritten notes regarding points of potential analytical interest. Points of interest included repeated ideas, phrases, and keywords, from which codes might be developed in the second step of the analysis.

The second step of the analysis involved generating the initial codes. The researcher clustered into codes different excerpts from the transcripts that expressed similar meanings. Those codes were then labeled with descriptive phrases that indicated the meaning of the data assigned to them. In total, 134 response excerpts were assigned to 32 codes.

The third step of the analysis entailed grouping codes. The researcher grouped codes into themes (Braun & Clarke, 2006). When different codes indicated different aspects of the same broader, overarching idea, the researcher identified them as related and clustered them to form a theme. In total, the 32 initial codes. These codes were revised and limited to 23 codes to eliminate redundancy and then clustered into five major themes. Table 3 includes the pattern and value codes used to develop the major themes.

Table 3

Table of Pattern and Value Codes

Pattern codes, description, & criteria	Value codes, description, & criteria
P1 - Inquiry-based Learning; Hands-on, exploratory activities, labs	V1: Confidence; Data demonstrating teacher & student confidence
P2: NGSS Standards; Examples of the standards in documents & teachers' examples of their impact	V2: Concerns/Fears; Teacher concerns for students & their ability; Teacher fear of repercussions
P3: RST Standards; Examples of the standards in documents & teachers' examples of their impact	V3: Supporting Students; Examples of teachers' desire to support student
P4: Curriculum; Teachers' assessment of the impact of curriculum	V4: Student Proficiency; Teachers' desire to ensure students have proficient skills.
P5: Texts, Passages, & Resources; Examples of reading materials for students.	V5: Life-long learning/CCR; Teachers' desire to help students develop skills
P6: Observations; Teachers' observations of the students.	V6: Frustration/Pressure; Teachers expressing feeling frustrated or pressured
P7: Assessments; Analysis of student results on assessments/tests	V7: Teachers' Passion for Teaching; Ways teachers expressed passion for teaching and learning
P8: Teacher Training; Preservice, workshops, coaching, etc.	V8: Collaboration; Examples of teachers' feeling about collaboration and peer-to-peer learning

Pattern codes, description, & criteria	Value codes, description, & criteria
P9: Chunking; Examples of chunking as a reading strategy.	
P10: Annotating; Examples of annotating as a reading strategy.	
P11: Setting a Purpose; Examples of setting a purpose for reading	
P12: Summarizing and Synthesizing; Examples of summarizing & synthesizing information.	
P13: Lesson Plans; Teachers' assessment of the impact of curriculum	
P14: Administration; Teachers' perceptions about the influence of administration.	
P15: Vocabulary; Building vocabulary as a literacy skill	

The fourth step of the analysis consisted of reviewing the themes. The researcher cross-checked the themes against one another to ensure the ideas they represented did not overlap. The researcher also compared the themes to the original data to ensure they indicated patterns in the participants' responses.

The themes were named and defined in the fifth step of the analysis. These definitions are provided in the findings section of this chapter. All three data sources were thematically analyzed to search for and determine the most common but relevant and meaningful themes across the qualitative primary and secondary data sources. The researcher assigned the themes into major themes and subthemes to categorize and present the established themes. Major themes were the themes with the greatest number of participants and document references per research question. They were also the most significant findings of the research. Finally, subthemes were incorporated. These subthemes were examples of the major themes and provided more refined details.

Presentation of Findings

This section presents the findings from the thematic analysis of the primary and secondary data sources. A subsection is dedicated to each major theme. The study identified the data sources for this theme and discussed the related subthemes. Five major themes emerged from the analysis, in addition to three subthemes.

Table 4 shows the major themes and subthemes. The first major theme was science teachers' awareness of students' literacy struggles. The next major theme communicated science teachers' apprehension about implementing interdisciplinary instruction, especially related to literacy instruction. The third major theme identified in this study was academic standards in science and language arts, which demonstrated the increased emphasis on connecting science and literacy practices through interdisciplinary instruction. The NGSS (n.d.) and the RST standards from the CCSS and the New Jersey Student Learning Standards showed the connection between literacy and science learning and instruction.

In response to the first three major themes, the teachers began changing their pedagogical approaches and sought support for implementing interdisciplinary practices through coaching and workshops. The fourth major theme explained the instructional adjustments that the teachers made to provide the best educational opportunities for their students. The fifth and final major theme focused on the types of support the teachers sought as they adjusted their instructional practices. The major themes demonstrated the teachers' gradual transition from the awareness of the challenges that literacy tasks presented to students and showed how instructional pedagogical approaches were adjusted in response to the teachers' awareness. Data supporting each theme are in the upcoming sections.

Table 4

Major Theme and Corresponding Subthemes

Major themes	Corresponding subthemes
Major Theme 1: Teacher concerns foster self-reflection on practice.	
Major Theme 2: Developing self-efficacy through on-the-job training.	
Major Theme 3: Academic standards bridge science and literacy instruction.	
Major Theme 4: Interdisciplinary resources and approaches that worked	Subtheme 4.1: Setting a purpose for reading Subtheme 4.2: Breaking texts into small chunks. Subtheme 4.3: Annotating and summarizing readings
Major Theme 5: Sustaining changes through instructional coaching and professional development.	

Major Theme 1: Teacher Concerns Foster Self-Reflection on Practice

The first major theme identified from the interviews and focus group discussion analysis revealed that high school science teachers were aware of the challenges their students faced when presented with literacy tasks in the classroom. This awareness motivated the teachers to adjust their instructional practices in response to their struggles. Throughout the data collection process, the participants provided insight into their daily experiences in the classroom and how they became aware of the literacy tasks that presented challenges for their students. Participants vocalized a common concern regarding high school students' wide range of literacy proficiency. The participants relied on their observations of the students in their classes, students' performances on assignments during class, and standardized assessment results shared by district and school administrators. The participants' awareness of the challenge reading presented for their students served as an initial impetus for the changes they made to their pedagogical practices.

The teachers share how their impaired literacy skills impact students' proficiency in communicating their scientific knowledge. The teachers expressed their frustration and concern about students' abilities to read scientific content well. At the beginning of the first focus group discussion, Miriam stated her perception of students' reading ability: "They can't read! How can we expect them to gain knowledge from textbooks that they can't read?" Her statement communicated frustration and concern with students' lack of reading proficiency.

To illustrate the point, Brian shared that having students read aloud gave a clear indication of the challenges the students faced:

> I remember a few years ago, I was teaching a lesson and I asked my students to read out loud. No one volunteered and I got mad. I needed them to participate and they wouldn't. So I picked kids and made them read. While they were reading, it became so obvious that they were struggling. Some of them read so slow and labored it was hard to put the whole idea together. Some of them read so fast they made mistakes, one student even missed an entire paragraph. Some of them mumbled so I had no idea if they were reading it correctly or not. That was the last time I ever forced kids to read out loud. I felt so bad.

Similarly, Shaniya expressed concern about the students and noted how it led to her decision to implement interdisciplinary strategies for reading. She provided additional support for Miriam's and Brian's statements:

> Over the years it's been really clear that the students struggle with the reading and writing tasks in my science classes and it's hard because that makes such a difference in their ability to understand what I'm teaching and respond to open-ended questions. It also makes it hard for them when they have to write up our labs. So that's why I really started teaching reading strategies.

Erica shared a similar observation when discussing classroom instruction and expressed concern about not knowing what she could do to help the students:

> It was always very well known that reading is important in all subject areas. When I first started teaching, I saw that my students struggled with reading but I didn't know what to do about it and neither did the other science teachers. So, we did what we could to help them with reading in science. A lot of times that meant that I just read to them. I didn't know what else to do.

The teachers saw daily the wide-ranging language literacy skills of their students and a growing number of students struggling with reading comprehension, making the acquisition and communication of science knowledge difficult. Their lack of reading skills was concerning and frustrating for the science teachers, as was their perceived inability to help the students improve their reading ability. The teachers shared that they did what they thought would help students understand the science content. However, they recognized it was not effective or adequate, so they began considering better ways to help students read and understand the science content being introduced.

Teachers' observations in their classrooms were further supported by how the students performed on classroom tasks and standardized assessments. The teachers noted that the students also know they struggle with reading. Alex stated, “Now, we have a lot of data and it just confirms what I was seeing.” Expanding upon his comment, Alex added,

> We see what our kids can and can’t do in the classroom all the time. We know they are struggling, particularly with the literacy concepts, but it’s hard to explain that when you don’t have a literacy background. It doesn’t seem to make sense that these kids who are in high school still don’t read well. So I always wondered, is it something I’m doing wrong? Is it the work I'm giving that’s not right for them? Do I expect too much? But now, we are hearing the same concerns across the board and we have the data from the state test and our district benchmarks that are saying the same thing. These students are not reading on grade level.

Sandy shared a time when students openly admitted to avoiding a task that required them to read:

> I remember giving a test one time and the kids did so badly on it. They had to read an article and answer questions. They didn’t have to have any prior knowledge, nothing. It was all right there. And they bombed it. It was so bad. After that, … I had a discussion with the class and asked them to tell me what they read about. And one of the kids said to me, “Miss… I didn’t read it. I tried, but I didn’t get it so I just guessed.” That was really eye-opening for me.

Poor overall performance of their students on assessments also demonstrated the effects of students’ literacy skills on their science learning. This information led the teachers to see it as their duty to find new ways to improve these literacy skills through science teaching. During the focus group discussion, Tom noted that the scores of their students were eye-opening regarding the need to integrate interdisciplinary teachings in their science lessons:

> I think how our students perform on standardized tests plays a big part in it for me. Their scores tell me that they can't really read well. That's really concerning. We're sending these kids off into the world unprepared for life. That does not feel good to me. But also, if they can't read well, how are they going to be successful in science or social studies for that matter?

Mary echoed the importance of assessments, tests, and scores. She described the initial scores as "embarrassing":

> I agree. The tests are a big deal. Since the school is in status, we hear all of the time about the math and ELA scores. But I don't think that is limited to this district. I mean, scores across the state are bad and the science scores are terrible. I mean embarrassing! And if the issue was limited to here, the standards wouldn't have changed and shifted to add the ELA standards and the cross-cutting concepts.

The participants shared that they felt a lot of pressure from school administrators to focus on reading. The emphasis placed on standardized assessment scores motivated several teachers to look for new ways to support students' reading in science. Erica said,

> Honestly, there is constant pressure to increase our math and reading scores on state assessments. I think a lot of the teachers find it frustrating because they think of themselves as scientists, not reading teachers. I completely understand that, but

> I look at it like this: We're all in this together, if the kids can't read and write and communicate, we all fail. The test is the least of my concerns, it's really about helping them become productive adults and maybe even good scientists. They can't do that if they can't read.

Shaniya noted how the scores made her realize that her students were not ready for college or, even more, for jobs in the real world. This realization helped them grasp the need to equip students with the most basic literacy skills and abilities:

> That's true! The test scores are really clear. Our students aren't ready to go to college and be successful. We have to do something about these kids not being prepared for college or to get a job that actually pays them well. We have to give them the fundamental skills they need to do that. Outside of the science content, isn't that why we all became teachers? We want kids to love science, but we want them to be successful in whatever they choose.

School administration clearly emphasized the need for teachers to improve their students' performance on standardized tests actively. As a result, the teachers felt pressured to find new ways of improving their students' literacy skills. The social constructivist worldview suggests that understanding educators' experiences can be challenged and refined in response to or evaluating new information differently. In this study, the participants assigned different values to the emphasis on standardized test scores and their observations regarding their effect on their decisions to implement interdisciplinary instructional practices in their classes.

The contrasting perspectives of the teachers regarding the impact of standardized test results and their knowledge of the struggle students faced with literacy skills were thoroughly parsed during one of the focus group discussions. When discussing standardized testing during interviews, several teachers communicated that the emphasis placed on the outcomes of these tests drove them to change their instructional practices. However, during the focus group discussions, other teachers challenged that idea. The group developed a consensus that the real motivation for the change was recognizing their students were struggling based on what they had observed in their classes. The standardized test scores deepened their conviction to change.

Thematic analysis of the interviews and focus group discussions revealed a significant theme emerging around the problems that science teachers observed surrounding the literacy demands required of students in their classes. The teachers cited students' daily work, classroom assessments, and standardized test results as evidence that the students were struggling in both science and reading. Through a meaningful and collegial debate during focus grouping, the participants agreed that they relied more on their observations than the outcomes of standardized tests. The analyses and discussions in this study made it clear that teachers were acutely aware of their problems with students' literacy skills. Unfortunately, they felt ill-equipped to address these problems through their science teaching.

Major Theme 2: Developing Self-Efficacy Through On-the-Job Training

Teacher self-efficacy is crucial in shaping the implementation of reading instruction in science classes. During the interview and focus group discussions, the teachers communicated that their observations of the students and the analysis of the standardized test scores led them to the acute awareness that students are not reading at the expected level. Although the teachers initially expressed their concerns about students' preparedness for their potential future endeavors, specifically college and career readiness, they conveyed their apprehension about being faced with teaching literacy skills as a part of their science classes. Their apprehension could have presented a barrier to changing their instructional changes to include interdisciplinary instructional strategies, but their recognition of students' struggles outweighed their concerns.

Many participants said they felt ill-equipped to teach the skills necessary to support students in becoming proficient readers. Sandy shared how she tried to help [her students] but believed she lacked the ability and guidance:

> Sometimes I don't even know what they need to improve on in reading to help them in science. I've asked the English teachers for help and they try, but they're busy too. I wish I had more PD [professional development] on the English standards, as funny as that sounds.

Michael echoed the sentiments of his colleagues, who admitted that their students "could not read." He added that at that time, he also lacked the awareness and training on how to help his students: "I was not trained to be a reading teacher. I had to learn that on my own." These statements demonstrated that the teachers strongly felt they lacked the instructional tools to incorporate literacy instruction into their high school science classes as their awareness of students' weak literacy skills grew.

Among other factors, the participants who attended traditional teacher preparation programs contributed to their lack of preparation for their college coursework. They believed their college programs did not adequately prepare them to use interdisciplinary approaches in their classes to improve literacy and science outcomes for the students. The teachers explain how their teacher preparation programs did not do enough to prepare them to address the deficiency in reading for high school students. The teachers explained that their preparation programs emphasized science content class but did not provide adequate support for teaching reading. Alex provided insight into the impact their teacher preparation program had on their confidence in their ability to teach students to read:

> The courses I took in college that were not science content classes were not really focused on interdisciplinary instruction. They were classes about curriculum and planning and science pedagogy, but nothing that taught me how to teach high school kids to read. That was something I had to learn on my own and I still don't feel completely capable. Even after coaching and PD, I feel like I have so much to learn.

According to Mary, the lessons and teachings they had in college were not as helpful as expected:

> The things I learned in college were definitely the least helpful at this level … And the courses I took in college didn't really help with reading skills taught to high school students. And I see the same thing happening today. These kids get out of college and they really don't know how to teach! They know science and are really bright, but their pedagogical background is weak.

Rachael had similar experiences as Mary and Alex, explaining how college did not help her in implementing interdisciplinary lessons:

> I didn't learn anything about close reading in college. Everything I have been able to learn about teaching literacy through science has come from on-the-job training. My classroom is where I have learned the most. I really didn't know anything about what good teaching was when I graduated college.

Many participants commented that their college coursework did not provide adequate focus on how to teach high school students to read and comprehend text. They explained that most coursework focused on the science content, and those courses that did address pedagogy provided insight into lesson planning and inquiry-based science instruction but not the fundamentals of literacy. One implication from this theme is the need for college and university leaders to examine how teacher preparation programs support students in learning to implement literacy-focused interdisciplinary instruction when teaching content-specific courses like science. This focus is significant for secondary education content-specific teacher candidates facing the increasing challenge of supporting the development of high school students' reading and comprehension skills. With only 37% of high school seniors demonstrating proficiency in reading on the 2019 administration of the NAEP (2022), the need for high school teachers to support reading across the disciplines is more significant than ever.

As the present study found, many teachers expressed reluctance to incorporate interdisciplinary practices, especially when addressing literacy skills in science classes. Even though they expressed awareness about the importance of literacy proficiency for college and career readiness, most shared that they felt unprepared to teach reading when teaching science content. Their major concern stemmed from a paucity of interdisciplinary instructional tools and their lack of schooling in literacy instruction while in their teacher-preparation programs. They overwhelmingly shared that their programs, if they did not center on science education, did not afford them ample opportunities to practice integrating literacy-focused interdisciplinary instruction across the curriculum.

The study illuminated how unprepared many teachers feel when teaching high school students, especially when nearly two thirds of graduating seniors read below grade level. The findings call on colleges and universities to re-evaluate and overhaul their teacher-preparation programs to better prepare prospective candidates for teaching in secondary education, especially concerning helping teachers embrace interdisciplinary instruction. Ongoing professional development and support are critical if leaders want to maximize teachers' abilities to support students in developing their literacy practices while genuinely teaching vital science content.

Major Theme 3: Academic Standards Bridge Science and Literacy Instruction

The CCSS, which communicated performance expectations for math and language arts students, was adopted by the State of New Jersey in 2010 (NRC, 2012). Although these standards focused on literacy and mathematics, the standards included the Common Core companion standards from the RST. Four years later, in 2014, the state adopted the NGSS (n.d.). This theme demonstrated how the RST and the NGSS increased awareness of integrating reading and literacy instruction in science classes.

The RST standards, part of the CCSS, call for exposing students to various informational texts. Specifically, the standards call for exposure to texts that focus on scientific and technical subjects at an increasing rate as students progress through school. Therefore, students must read various scientific texts, including articles, journals, and technical manuals. Students must be able to read and comprehend complex material in preparation for the sophisticated scientific literature they will encounter in higher education and their future careers to demonstrate mastery of the standards.

A review of the curriculum documents revealed that the RST was identified as an instructional objective in many units. In addition, the teachers' lesson plans also include these standards, demonstrating their recognition of the connection between literacy and science. For example, the chemistry curriculum document, standard RST.9-10.1 and RST.9-10.2, required students to cite textual evidence to support their analysis of science and technical texts and summarize complex concepts, processes, or information presented in a text, respectively, were found 15 times. More complex standards such as RST.11-12.7, which requires students to integrate information provided by various sources, and RST.11-12.8, which asks students to evaluate the information provided in a science text, were identified five times in the biology curriculum document. In lessons that the participants shared, the RST standards were also identified. For example, in Tom's Earth Science - Tsunamis Lesson Plan, RST.11-12.2, was cited, which called for students to paraphrase complex text in simpler but still accurate terms (Tom, Earth Science - Tsunamis Lesson Plan, pp. 1-2). Michael explained that these lessons "really get to the heart of interdisciplinary instruction in science. The content is the primary focus, but they are continually practicing and improving their reading skills."

Adopting and implementing the RST standards was the first indication that literacy skills had a critical impact on science instruction and proficiency. Throughout the interviews and focus group discussions, the participants shared examples of how the RST standards furthered their awareness of the importance of incorporating literacy instruction into the science classroom. They also showed how they modified their instructional practices in response to these standards. Adopting these standards and their inclusion in the curriculum documents further established the connection between science and literacy. According to Mary, the RST emphasized reading in science, adding how the NGSS (n.d.) reinforced and strengthened the RST. Mary provided examples during the interview:

> It was always very well known that reading is important in all subject areas. When I first started teaching, I saw that my students struggled with reading but I didn't know what to do about it and neither did the other science teachers. We would read to them instead of making them read. We would have them summarize, find the main idea and details, and stuff like that. We focused on the science vocabulary and defining the words …. The RST standards in Common Core made it really clear that reading in science was important. This was the first time we really had to think about how we needed to teach science differently to really hit the literacy standards.

In addition to encouraging the teachers to examine the literacy skills expected of students in their high school science classes, the standards showed other important components of science literacy that were otherwise less obvious. Erica explained how learning about the RST standards motivated her to learn more about what made a text complex and how to help students break down a complex text so they could understand it. She said,

> There was a call for increased text complexity in the Common Core Standards and I really didn't understand what that meant. I thought it was just a saying that we needed to pick things that were harder to read and understand. I never thought about how the task that I was assigning related to text complexity. That was a big change for me, looking at texts in terms of what the students needed to do with

> them. After I learned that, it helped me understand how much scaffolding I could do.

Bringing interdisciplinary skills and demonstrating an important initial connection between literacy and science to the forefront was an important contribution to the RST standards. Despite this benefit, the teachers expressed concern that they did not provide enough guidance about how teachers should make those connections in their classes. By contrast, the NGSS (n.d.) focuses on science content and practices; however, these standards recognize the importance of literacy skills in science education. The NGSS emphasizes eight science and engineering practices, one of which is "Obtaining, Evaluating, and Communicating Information" (para. 1). This practice underscores the importance of students being able to read, write, and communicate scientific information effectively. In addition, students are encouraged to engage in research, evaluate sources of information, and communicate their findings through writing and other means. One example that showed that the NGSS brought a focus to the connection between instruction for science and literacy was communicated by Mary in her interview. Mary explained how, with the NGSS, they started to target the development of children's literacy by warranting that students read from textbooks and other relevant and scholarly sources. She added that the change has been both "good" and "challenging":

> Over the years, there have been a lot more PDs offered that focused on reading in science class .… The RST standards in Common Core made it really clear that reading in science was important. The NGSS just solidified and reinforced that idea. They have really made literacy a much bigger component in my class. The students are reading from the textbook, but we are also incorporating more

> research-based articles and writing so much more. It’s been good, but challenging. The kids have to read things two or three times, we really break articles down into manageable chunks, there is so much vocabulary that they need to know. We really are teaching them how to read and write like scientists and giving them a model of what it looks like.

Sandy furthered how the science standards helped the teachers realize how they should manage and address the literacy issues of their students. With the NGSS (n.d.), teachers can let their students explore using sources that may help them improve their ability to read and understand the data. Sandy narrated the following during the interview:

> The science standards have influenced me a little because the NGSS emphasizes student exploration. Students need to be able to understand and read to succeed in science … The school’s science curriculum follows the NGSS. Our textbook has many case studies, readings, and scientific explanations.

Katherine explained how she has always followed the NGSS (n.d.) as her guideline inside her classroom. Under the NGSS, the three dimensions were also applied, with all three focusing on the development of children’s literacy:

> Well, over the years it's been really clear that the students struggle with the reading and writing tasks in my science classes and it’s hard because that makes such a difference in their ability to understand what I’m teaching and respond to open-ended questions. It also makes it hard for them when they have to write up our labs. So that’s why I really started teaching reading strategies. Now, we have a lot of data and it just confirms what I was seeing. All of that, plus the NGSS

> standards and the push within the school for all teachers to teach literacy makes it so important now.
>
> The Next Generation Science Standards have three domains that encompass science literacy in one form or another. I have always used standards as my guideline for teaching, the Next Generation Science Standards, which have three domains. Within these domains, for example, when we are teaching inquiry learning, words are learned when they are being used. Instead of beginning with a list of vocabulary words, words are learned when we encounter them during a task. The task might be a computer simulation, activity, or a lab. Literacy instruction using today's standards is more cross-curricular. For instance, when I am teaching Biology, I find applications of living systems in not only other areas of science, such as Physical Science, Earth and Space, and Engineering Design, but also Language Arts, History and Mathematics.

The RST and NGSS (n.d.) standards and their inclusion in the district's curriculum supported the teachers in recognizing the connection between literacy skills and science content knowledge. The standards provided a springboard for teachers to explore literacy skills they could teach in their classes. However, the RST and NGSS standards challenged teachers. Although the participants shared that these standards broadened their awareness of the importance of interdisciplinary instruction, they did not provide specific guidance on how to go about teaching students to read. Similarly, the participants stated that they were unsure how much guidance the curriculum documents provided regarding incorporating literacy instruction. Alex admitted that although the standards were present, he still did not have the actual steps and knowledge to implement them: "It definitely includes some of the literacy standards, particularly the RST ones. Otherwise, I don't think there is anything really specific. Like the standards, it tells us what to do, but not really how to do it."

Brian echoed Alex, noting that although the RST and NGSS (n.d.) indicated the need for literacy in the classroom, the instructions were not as clear and explicit as expected:

> I don't know if there is anything in the curriculum or the standards that is really specific about how to incorporate literacy in science. I mean, the RST standards are noted in there and if you really analyze what the curriculum requires students to do, you can pull out the literacy components, but it's not really explicit. I feel like it's more in practical application that you see the literacy components.

The implementation of the standards left the teachers wanting to know more about how best to incorporate literacy instruction into their lessons. Although the standards appeared in all curricular documents and lesson plans, teachers felt unsure of how to implement them. As a result, the teachers felt it was imperative to develop their pedagogical practices regarding literacy needs in science education and identified professional development as a way to do that.

Integrating literacy instruction into science classes was made a priority in New Jersey following the adoption of the CCSS and the NGSS (n.d.). Teachers noted that the reading standards for RST and the emphasis on literacy in the NGSS helped them connect to other standards documents that highlighted the role of literacy in achieving excellence in science. Understanding how the standards supported interdisciplinary instructional strategies helped the teachers feel confident about their decisions to use specific literacy strategies in their high school classes to address the problems faced in the classroom in reaching students.

Major Theme 4: Interdisciplinary Resources and Approaches That Worked

Incorporating an interdisciplinary instructional approach required the teachers to evaluate the course materials, activities, and instructional practices used in their high school science classes. Their awareness of students' struggle in reading and their developing understanding of interdisciplinary instruction led the teachers to make significant changes in their teaching. The teachers were challenged to determine which texts were aligned most closely with the content being taught while also being rigorous. They also learned to restructure the activities within the science lessons to include opportunities to strengthen students’ literacy skills.

The analysis of the interviews, focus group discussions, and the curriculum and lesson plan documents revealed several important considerations for teaching science through an interdisciplinary approach. First, the teachers communicated the importance of identifying appropriate reading material to teach science content and support literacy learning. They explained how they learned to establish a purpose for reading before starting a lesson. Identifying a rigorous text and establishing a purpose for reading are essential components of close reading (Frey & Fisher, 2013). The teachers shared how they taught the students specific strategies that they could use when reading: break passages into smaller, more manageable chunks, annotate the text while reading, summarize each chunk as they read, and use their summaries to help them synthesize concepts across multiple texts or other forms of media. Finally, the teachers explained that their pedagogical approaches and learning strategies were critical for helping their students determine vital concepts or ideas within a text, accurately and concisely explain the gist of a text, and make connections to other passages and real-world experiences. Despite the pathways that each of the participants took as they embarked on their journeys to incorporate interdisciplinary practices in their high school science classes, they all shared that, when planning for lessons, identifying an appropriate text is now the first step they take after determining the lesson objective based on the curriculum.

When recalling their initial experiences identifying appropriate texts, the participants explained that the curriculum was a starting point. However, they had to adjust to ensure their students could successfully read the text and apply the reading skills they were learning. Rachael explained that although the curriculum provided some passages outside the textbook, she needed to find resources to implement and integrate interdisciplinary lessons in her classroom successfully. She noted,

> I just didn't feel like there was enough in the curriculum that wasn't part of the textbook. So I looked for other options. Teachers Pay Teachers has good stuff and I was able to get some close reading stuff from Boston, too. It was online so that was helpful.

Miriam also shared the difficulty she experienced in selecting a text that was rigorous yet accessible for her students. She said, "I think the hardest part for me was picking a text that was challenging, but not so hard the kids turned off from it." Tom echoed this statement:

> Yeah, that was hard for me too. I found some nice articles from NewsELA that had Lexile levels on them. I did some research to try to figure out where my kids should be reading and picked articles that were in that range.

The participants explained that finding the texts was just the first step. It was not always easy, but once they had done that, it was necessary to change their instructional practices to incorporate interdisciplinary instructional practices that taught students how to analyze texts and build meaning for them. They described how they began lessons using the selected texts, breaking the text into smaller chunks, summarizing the readings, and synthesizing information from multiple texts to draw conclusions about science topics. They aimed to enhance student comprehension of complex science texts. Each of these instructional practices is discussed in the following subsection.

Subtheme 4.1: Setting a Purpose for Reading. Once the teachers identified a passage that they believed was appropriate for students' reading level and the course content, they considered how they would engage the students in actively reading the text. Setting a clear purpose for reading the text, similar to how the teachers set a learning objective at the beginning of a lesson, was a common theme communicated by the teachers. During the focus group discussion, Tom explained that he introduced passages by asking the students a question:

> I treat introducing a new passage or something the kids have to read like I would a lesson. We start by asking questions about the topic. If I'm teaching a lesson about plate tectonics, I will ask the students what they already know about plate tectonics, why they believe the plates shift, and so on. If I select a passage for the students to dig more deeply into the topic, I ask a question that I know the passage can help them answer. I'll say something like, I want you to think about this as you're reading today. As the kids read and we discuss the passage, we'll revisit that question.

Erica and Miriam agreed and expanded upon the idea of asking questions to establish a purpose for reading. Erica explained how the students could contribute to setting the purpose for reading once it became part of their routines when reading in her class:

> Whenever I start a lesson, I start with a question. That's the heart of science, asking questions and exploring different ways to find answers. In the beginning of the year, I find myself doing a lot of the work to ask questions, but as the students get used to the process, they start to ask questions themselves. I'll give them something, it could be a picture of something or a table or an article to read. I let them skim it quickly, for maybe a minute, and then I have them talk in groups or with a partner about their immediate reactions. They talk about what the topic is, how it relates to what we've been learning in class, and what they think they might learn from whatever it is that I gave them. We share those ideas as a whole class and then start digging in.

Miriam added,

> I actually do something very similar. I was in Erica's class one day as she was starting a lesson and I kind of stole the idea for myself. I usually ask the students to think about how the resource they have will further their understanding of a topic. What is it that they don't fully understand yet? Sometimes they come up with things that the article isn't going to help them understand. When that happens, it always leads to the kids asking how they're going to get an answer to their question. It almost motivates them and deepens their desire to learn.

The initial purpose for reading varied from identifying key vocabulary words, connecting to the text, and asking questions about what the passage said. For the teachers, setting a purpose provided a focus for the students while they read and encouraged them to read carefully. It also assisted them in encouraging students to read and reread, which supported their comprehension of the science content and enhanced their ability to read the text.

Once teachers became confident in setting a purpose for reading, they expanded their practice by revisiting the purpose for reading and adjusting it throughout the passage. Katherine shared that sometimes the purpose for reading changes or needs to be reestablished while reading a passage:

> I've had a couple of different experiences with using questions to set a purpose for reading. Sometimes, if I start a lesson with a single question, the kids will get so focused on answering that question, they don't get anything else from the article. I've also had times where we've had too many questions from the beginning and it didn't help the kids get the point of what they were reading. I've adapted my practice to be almost an outline format. We start with one question, of course, it's something I know they can answer toward the beginning of whatever we're reading, and as we go on, I have the students add a question or two for the next section. By the end of the passage, they have a pretty well-annotated article and they have gotten a few really key ideas out of what they read.

Research has shown that establishing a purpose for reading and revisiting that purpose at various points during a lesson helps students comprehend what they have read more thoroughly, improves their ability to synthesize the information with their prior knowledge and information they gain from other texts, and allows them to apply their understanding at a later time (Frey & Fisher, 2013). During the interviews and focus group discussions, the teachers discussed how asking questions facilitated setting a purpose for reading, guided students' thinking as they engaged in reading, and sometimes motivated them to seek additional resources to answer their questions about a science topic. Katherine shared that setting a purpose at the beginning of the lesson was not always sufficient to keep her students interested. She found that adding additional questions along the way helped. By asking new questions as the students revealed their understanding of the initial guiding question, they naturally created the habit of breaking the passage down into smaller chunks. This strategy was another key that the teachers discussed.

Subtheme 4.2: Breaking Texts Into Small Chunks. Reading in science classes allowed students to increase their background knowledge before, during, and after participating in hands-on experiments. The participants explained that they needed to use strategies that would make complex texts more accessible to make reading more effective for students, particularly those who struggle with reading. Teaching students how to break texts into smaller chunks was the strategy the science teachers relied on to help students improve their comprehension of the texts.

For many teachers, this strategy was one of the first interdisciplinary strategies they attempted in their classes. Erica recognized that her students struggled with reading texts and information in science. With the help of close reading strategies such as breaking texts, students improved and could understand the texts as compared to before. Erica narrated,

> Students are struggling with reading, especially in science, as many of the resources are written on a higher level and the vocabulary is not common. Using close reading helps our students focus on specific parts of the text with intention. It teaches them to break the text into smaller chunks and into terms they can understand.

Reading informational text allows the reader to learn new things, confirm things they believe to be true about a topic or gather evidence to refute ideas contrary to the readers' beliefs. Mary commented that to improve students' reading comprehension, "I have to find a way for them to understand the text they are reading. We break a lot into small chunks and read over and over." Similarly, Brian explained that chunking texts as part of a close reading approach provided a way for the students to engage with the passage in a meaningful way:

> The texts that are part of our district-approved curriculum are challenging, but I don't think they always give enough information about the topics we are studying. I find myself supplementing with a lot of articles that are more focused on a specific topic. Those come from sources like Scientific American and The National High School Journal of Science. They can be really challenging. The kids don't do well with those articles when I just have them read the whole thing. They either don't get it or they don't do it. Neither is helpful so I do it in class with them in a close reading style. I break it down either one paragraph or one section at a time and we read it and discuss it as we go. They seem to understand it better when I do it that way.

In planning for lessons, the teachers initially identified breaks in the texts, such as the end of a paragraph or a section of the text, as natural, meaningful chunks. Several lesson plans the participants shared revealed examples of where the chunking strategy was used. When discussing a lesson about Tsunamis, Tom shared that he used this article as a model for using reading strategies:

> This article is one of several articles that I give the students when I do this lesson. We do a close read of this article together so they understand what to do when they read the other articles. I have the students read this article one section at a time. The first time through they identify unfamiliar terms and we discuss them as a class. The second time through, I ask them to write a one to two-sentence gist. Finally, they read through the article one more time and highlight anything that they feel like might be evidence to support their explanation about how natural disasters impact human behaviors. After we do this article together, the students spend three days doing the same thing with the other articles before they write their argument.

Breaking passages into smaller, manageable chunks was one of the first strategies the participants attempted to use as they began incorporating interdisciplinary instructional practices in their classes. The participants found this strategy helpful because it made reading challenging passages more manageable and improved students' comprehension and retention of knowledge. Chunking the text began as a product of the teachers' preparation. However, it was later adapted to allow students to break the text up meaningfully based on the purpose established for reading. In addition to being a helpful way to help students better understand what they read, chunking was used to facilitate text annotations and note taking, another critical strategy shared by the participants. The annotations helped students summarize what they read to make connections between articles.

Subtheme 4.3: Annotating and Summarizing Readings. Summarizing and synthesizing information gathered from various sources was consistently embedded in the curriculum documents, lesson plans, and during conversations with the participants. When asking students to annotate and summarize a passage, the teachers explained that they expect students to decipher the most important information communicated clearly and concisely. This process included highlighting essential vocabulary, defining vocabulary in the margins of a text, underlining details, connecting ideas in a text, writing questions for clarification and discussion, or making personal connections to experiences or prior knowledge in the margins. Students were asked to annotate each chunk of the text as they read and utilize their annotations to support them in summarizing what they read concisely. Michael shared that the annotations were the most helpful for the students. Annotations were how his students took notes on what they had read. He explained,

> Before I started requiring students to annotate and summarize the text, I would spend class time having them take specific notes that they could use to study. For some students that was helpful, but others never went back to the notes so they didn't help them much at all. The difference I found between that and having the students annotate is that annotations are truly differentiated. I'm no longer telling students what they need to know and what is important. They are finding that

> themselves. They are taking notes in a way that is meaningful to them. Some still don't study, but because their annotations are personal, they get more out of them.

Sandy shared that her students were unfamiliar with effective note taking at the beginning of the year, so she developed a process for teaching them to annotate effectively. She explained her process:

> I start out by giving them an example of a well-annotated text. Then, when I give them their own passage, I give them specific things to annotate. They have to find so many key vocabulary words or other unfamiliar terms, they have to find so many details in the passage, they have to make a connection to something; it can be a personal connection or a connection to something else we've read, they have to ask a question for each section of the text. I keep it really structured in the beginning. As they get better and more comfortable with annotating, I give them more freedom to make decisions about what annotations they need.

Rachael explained that her students have always struggled with reading and literacy. First, she attempted to have the students summarize but did not provide any structure to how they did that. After a while, she added the process of annotating the text before the students summarized it. This process helped them with finding the main ideas and key details. She stated,

> It was always very well known that reading is important in all subject areas. When I first started teaching, I saw that my students struggled with reading but I didn't know what to do about it and neither did the other science teachers. So, we did what we could to help them with reading in science. We would have them summarize and expect them to find the main idea and details, and stuff like that.

> Some kids were really good at summarizing, but others were still lost. Over the years, there have been a lot more PDs offered that focused on reading in science class. So, we added annotating before summarizing and it's helped a lot of kids. We started annotating by focusing on the science vocabulary and defining the words. Then we had them start underlining and highlighting key details as they read. Once they started to incorporate that information into their summaries, they started to see the value in annotating and summarizing.

Providing a structured approach to note taking through annotating the text gave the teachers confidence that the students were identifying and noting the key points in a text. It also allowed the teachers to ensure that students could summarize the text effectively and were beginning to understand the scientific content more deeply than they would need as they engaged in inquiry.

The importance of annotating a text and its connection to summarizing and synthesizing information was evident in the analyzed lesson plans and curriculum documents. In the district's approved environmental Earth science, biology, and chemistry curricula, literacy practices included asking students to generate verbal and written summaries identified as approved best practices for instruction. The teacher's lesson plans included RST.9-10.2 and RST.11-12.2. These plans allowed students to demonstrate the ability to determine the central ideas and summarize complex concepts, processes, or information presented in a text. These plans were noted and supported by the lesson objectives and assessment strategies. Each of the lesson plans reviewed required the students to submit annotations as part of the assessment criteria for the lesson. The teachers explained that they relied on students' annotations to determine if they understood the discussed content. Just as the annotations were part of the lesson assessment, the students were asked to produce verbal and written summaries of passages and annotate their text for later use. Katherine stated,

> Their annotations tell me a lot about what the students know about the scientific content of the article. When they read a section of the text, they always circle or highlight vocabulary words and write a sentence or two explaining what they think the section was mostly about. If their summaries are accurate, they can use them to synthesize and draw conclusions. When they are able to make the appropriate connections between concepts in the article and draw accurate conclusions, I know they got what they needed from the article and we can move on. If they aren't comprehending the text appropriately, then I know they don't understand the concepts well enough to make the connections and we have to reteach them.

By formatively assessing students' annotations and summaries, the teachers could adapt their lessons to revisit and reteach science concepts their students did not securely master. Once the students could summarize information from a single passage, synthesis of information from multiple sources becomes important. Synthesis, which the teachers explained was challenging for students, could be demonstrated in students' writing and class discussions in which they could communicate ideas from multiple sources and combine them to enhance or alter the current understanding of a topic. Mary and Miriam provided several examples of how their students synthesized information:

> There are a lot of opportunities for students to read and write in my class. One of the biggest things I need students to do is synthesize information from multiple

> sources. They get information from all of these different sources and they have to use it to answer higher-order thinking questions and open-ended responses. It's not about what happened in the research, but why it happened, how it happened, and how they can create an experiment that replicates it.

Miriam agreed that students needed to be effective readers and deeply learn the science content in her science classes. She expected her students to utilize the different close reading tools that they practice: "The kids have to analyze and synthesize information from different sources, they are writing lab reports, we have a few argumentative essays, and I have my kids do a research paper so that requires a lot of literacy skills."

As the teachers explained, annotating complex text, summarizing a passage, and synthesizing information gathered from multiple sources are essential literacy skills that bolster derived science literacy (Norris & Phillips, 2009). These reading skills align with the science and engineering practices identified in the NGSS (n.d.) as best practices of the many specific strategies that students use to deepen their comprehension of an informational text (Eunice Kennedy Shriver National Institute of Child Health and Human Development, NIH, & DHHS, 2000). Selecting appropriate, complex texts to support science instruction is critical to annotating, summarizing, and synthesizing information; the strategies identified by the study participants were effective and practical for application in their high school science classes.

When many students in the classroom struggled with reading and comprehending complex texts, the teachers faced the task of providing strategies that students could use to make the text more accessible and manageable. The participants in this study found that incorporating much-needed literacy skills into their science classes entailed establishing a purpose for reading and revisiting or revising the purpose throughout the lesson, breaking the text down into smaller chunks, annotating the text to support more accurate summarizing the smaller sections of the passage, and practicing synthesizing within a text and across multiple texts. The participants shared that these practices improved students' understanding of scientific concepts.

Major Theme 5: Sustaining Changes Through Instructional Coaching and Professional Development

The fifth major theme highlighted the benefits teachers found in coaching and other professional workshops in their planning and teaching skills for interdisciplinary instruction. Teachers admitted knowing that the students struggled with literacy tasks, feeling unprepared to help them improve their literacy skills, and implementing standards emphasizing the importance of incorporating literacy in science. In response, the teachers sought professional learning opportunities to improve their practices.

In many cases, the teachers shared that attending a district-wide workshop or webinar session that focused on implementing reading strategies across content areas provided their first step toward teaching using interdisciplinary instructional approaches. Sandy explained that interdisciplinary instruction and teaching reading in science began to make more sense after she attended a workshop provided by the instructional coach and a few other teachers:

> They had given a PD that was interesting so me and a couple of my colleagues decided to try it. Some didn't keep going with it, but some of us did. The PD was really the first formal training that broke down teaching reading to make it more

> like teaching science. There are specific steps to follow and things to look for. It made teaching reading more manageable for me.

Katherine shared that the training program she found most helpful was sheltered instruction. She explained that she learned about sheltered instruction practices at a series of workshops provided by the district for teachers with an English as a Second Language certificate. She said, "Most teachers find that techniques learned in the Sheltered Instruction Training have been useful. The Sheltered Instruction Training has helped not only ESL students but students at all levels of learning."

Sandy also noted that her motivation to incorporate interdisciplinary instruction in her science class came from a workshop she attended. She said,

> I started looking for ways to help them with their vocabulary and some of my colleagues in the language arts department were talking to me about close reading. I didn't really know much about it. I went to a workshop that the district offered and learned about it there. I don't know if I'm doing it perfectly, but the close reading strategies that I think I'm using allowed me to see where students needed support and meet them where they were to learn the science content.

Sandy mentioned that after her initial introduction to interdisciplinary instructional approaches through the district workshop, she signed up and attended a webinar to learn how to use close reading in her classroom. She found the webinar helpful. However, she lamented the lack of time to collaborate with her colleagues in the English department, noting how their expertise in this area would benefit her instruction.

Meanwhile, Rachael used workshops and other personal resources to help her implement interdisciplinary instructional practices in her classroom: "I found a couple webinars, I found pre-made lessons that I used, and articles. The workshops that weren't specific to science weren't all that helpful. It was hard to make the connection." As a result, the teachers continued to implement strategies aligned with interdisciplinary instructional approaches to the best of their abilities. They sought additional support to enhance their practice in other ways, especially peer coaching and collaboration.

All participants noted how the opportunity to observe and learn from their peers and receive coaching helped them greatly. According to Mary, the most beneficial learning experiences were job-embedded and provided by district colleagues with experience planning and implementing interdisciplinary lessons. Several of her colleagues echoed her sentiments about coaching. Erica said,

> I like the workshops that we had in the district and observing my colleagues has been so helpful. I'd say that has been the best thing …. I just think we spend a lot of money bringing in presenters and we have so many great teachers in the district who can present just as well and relate to what's happening in our classes with our students.

Furthermore, similar to Mary and Erica's statements and experiences, Alex noted the value and helpfulness of coaching: "The coaching has, by far, been the most helpful! I don't know how receptive all of the teachers are to it, but it has been amazing for me. It's like having someone model best practices all of the time." Rachael had similar experiences to Mary and Alex, explaining how coaching and modeling improved her competence and confidence:

> Like I said before, we had PD on reading across the curriculum and then we had a specific PD on close reading and that's how I got interested in how I could use it

> in my classes. I worked with the coach a few times and we planned together. I tried a couple of times on my own and it was terrible. Then she came in and modeled it for me and then I did it again with her help. It went better. It's still hard for me on my own though.
>
> I had the coach come in and model it for me and then co-teach it with me several times until I started getting better at it and feeling more confident.

Rachael continued about how she found coaching the most helpful and effective way for her to use interdisciplinary instructional practices in her class:

> I used the coach when I started planning my own lessons. Without that, I wouldn't have kept going …. Our coach is really good. I know not everyone loves her but she knows what she's talking about so you have to respect that. The coaching sessions were tailored to exactly what I was teaching. Almost like a work session.

Cross-curricular academic teams have been shown to benefit teachers by improving their understanding of content and pedagogy (Reed & Groth, 2009). This finding aligned with this study; when possible, coaching and learning from colleagues were frequently identified as the most effective forms of professional learning they experienced. The fifth major theme highlighted the importance of coaching and professional workshops in enhancing teachers' pedagogical skills, particularly in interdisciplinary instruction. Teachers recognized the need to address students' literacy struggles and sought opportunities to improve their practice.

Colleagues' job-embedded learning experiences and workshops within the district were deemed most beneficial, surpassing traditional college training. Coaching sessions allowed teachers to observe best practices and receive tailored support, significantly improving their competence and confidence. Workshops focused on close reading and sheltered instruction were particularly helpful, offering specific strategies for teaching literacy in science classes. Teachers emphasized the value of collaboration with peers and instructional coaches, acknowledging the need for ongoing support to implement interdisciplinary instruction effectively. Despite challenges, teachers remained committed to refining their skills and incorporating interdisciplinary practices in their classrooms, leveraging available resources and seeking further professional development opportunities.

Conclusion

The purpose of this study was to facilitate a deep understanding of the experiences of high school science teachers who implemented interdisciplinary instructional strategies to support their students in comprehending complex informational text. The analyses of the three data sources (e.g., interviews, focus group discussions, and the analysis of curriculum documents and lesson plans) supported identifying themes. After completing the focus group discussions and analyzing the lesson plans, three follow-up interviews were conducted to provide details and additional context to the findings.

Five major themes and three subthemes emerged from the analyzed data. Chapter 4 explained the five major themes and three subthemes derived from the primary and secondary data sources through thematic analyses. The themes traced the teachers' transition from awareness of the challenges students faced when presented with reading tasks and the teachers' uncertainty about their ability to provide literacy instruction in their science classes to their adjustments to instruction methods due to the implementation.

The first major theme focused on teacher awareness of their students' struggle when given a task that required them to read and comprehend complex text. The teachers discussed their classroom observations of students’ reactions to reading tasks and students’ work quality on assignments that required them to read. The teachers also shared that the state assessment results for language arts, which were communicated to them by school and district administrators, furthered their understanding of the significant problem of diminishing reading proficiency. Unfortunately, the teachers felt ill-equipped to support literacy instruction in their science classes.

The second major theme in this study was the apprehension that the science teachers felt about integrating literacy instruction in their science classes. The teachers explained that they did not believe that they were trained to be reading teachers, and their perceived inability to support their students was a source of frustration for them. Although this issue could have presented a formidable barrier, the teacher chose to learn how they could support their students through interdisciplinary instructional practices. The CCSS and the NGSS (n.d.) served as justification for their decision.

The third major theme was the connection between literacy and science instruction in the CCSS and the NGSS (n.d.). These standards demonstrated the connection between literacy and science instruction. The CCSS included the RST companion standards for literacy, which identified specific reading behaviors needed to comprehend science text. Similarly, the NGSS identified science and engineering practices requiring students to research, identify evidence in texts, draw conclusions, and synthesize information. Though these standards were not explicit in telling teachers how to integrate literacy and science, they highlighted the vital connection between the disciplines. They established the expectation that students would demonstrate proficiency in literacy skills in their science classes.

The fourth major theme explained the literacy practices that the teachers implemented. Before any instructional changes could be made, the teachers explained that they had to learn to identify appropriate texts for their students. Once the appropriate text was selected, the teachers began slowly trying new teaching strategies like identifying the purpose for reading, breaking the text into chunks, teaching students to annotate the text, and summarizing and synthesizing the information from the passage. Not all teachers reported implementing these strategies in the same order. However, most of their lessons evolved to follow this sequence. The teachers sought opportunities to learn about and refine their use of interdisciplinary instructional practices to make these changes.

The fifth theme of this study explains the mediums through which the teachers received professional learning and the approaches most effective for them. Workshops, webinars, independent study, peer shadowing, and coaching were the most widely used approaches to professional learning. The teachers found collaborative, peer-led professional learning opportunities to be the most helpful. They explained that these opportunities allowed them to understand the application of interdisciplinary instructional practice with their students.

The data analysis led to the development of five themes that showed the similarities and differences between the teachers' experiences along their journey of incorporating interdisciplinary instructional approaches in their high school science classes. Strong literacy skills are essential for students to attain mastery of the scientific concepts taught throughout their high school careers and to continue to expand their knowledge of the world around them (Hand et al., 2003; NRC, 2000). By engaging in interdisciplinary instruction in high school science classes, teachers can support their students' learning and motivation to learn throughout their lives (McClune et al., 2012). The fifth and final chapter discusses the themes concerning the literature, connects the themes to the research questions, includes implications for educational leaders and teachers, and explores topics that may be considered for further research. Finally, the research concludes with the recommendations and implications of the study based on the findings.

Chapter 5

Discussion, Implications, and Recommendations

Researchers have established that inquiry-based learning through hands-on, engaging experiences positively impacts learning, especially in science classes (Dyer, 2015; Furtak et al., 2012). However, a lack of a clear structure for partaking of inquiry-based instruction has led to inconsistent results in students' academic achievement (Furtak et al., 2012). When inquiry-based instruction is structured to provide opportunities for students to increase their background knowledge, a rich learning experience is available (Frey & Fisher, 2013; Furtak et al., 2012). These statements suggest a significant need for changes in the instructional approaches used in American classrooms. Science instructors should engage students in applying scientific practices to spark curiosity and lead to the desire to pursue scientific endeavors in the future. However, instructors must still provide students with the tools to comprehend science content deeply. Those tools include developing students' abilities to read and comprehend complex scientific and technical texts.

The percentage of students who demonstrate proficiency on various high school science assessments is low. Direct instruction, reduced instructional time, and the lack of engaging inquiry-based instruction—the result of school districts struggling to help students meet expectations on standardized tests in language arts and math—are contributing factors to the low level of student proficiency (Hayes & Trexler, 2016; Marincola, 2006; Saunders, 2015). Not only do these factors impact students' ability to master the science content, but they also result in reducing student interest in science topics and their motivation to engage in meaningful inquiry (Lyons, 2006). Many science teachers have sought ways to overcome students' academic challenges in their science classes by implementing interdisciplinary instructional strategies. Using interdisciplinary instructional strategies creates a synthesis between content areas, like science and literacy, deepening students' understanding of the content, and their success can motivate them to continue to pursue knowledge in that subject area (McClune et al., 2012).

The purpose of this qualitative study was to develop an understanding of how the knowledge and beliefs of high school science teachers impacted the pedagogical and instructional practices they used when incorporating interdisciplinary approaches to teach their science classes to support inquiry-based learning (Frey & Fisher, 2013; Lapp et al., 2013; McConn, 2018). The content area standards, curriculum, and professional development opportunities must be considered. It is important to understand teachers' journeys in implementing interdisciplinary instructional strategies in their classes, their recognition of the problem, and their beliefs about their ability to support students effectively (McClune et al., 2012).

Three data collection methods were used in this study over 5 months. First, individual interviews with high school science teachers were conducted. Seven individuals participated in the interview process. Two focus group discussions were also held to further engage educators in a discussion of using interdisciplinary instructional practices in the high school science classroom. A total of 11 teachers participated in the study in some capacity. Finally, document analysis provided the final method of data collection. Curriculum documents and teacher lesson plans were included in the document analysis.

This chapter includes a discussion of major findings related to the literature on interdisciplinary instruction and its implications. The study may be valuable for teachers, elementary and secondary educational leaders, curriculum developers, teacher preparatory programs in college, and professional development consultants. The chapter concludes with a discussion of the limitations of the study, areas for future research, and a summary.

Interpretation of the Findings

This chapter section focuses on the connection between the themes, the existing scholarly literature on interdisciplinary instruction in high school science classes, and the research questions. The section begins with a brief review of the five major themes showing the experience of high school science teachers who implement interdisciplinary instructional strategies in their classes. Then, each theme is discussed concerning the literature and the research questions.

Summary of the Major Themes

Five major themes emerged from the analysis of the interviews, the focus group discussion, and document interrogation. These themes were organized in a way that helps to explain how teachers experienced their journey toward implementing interdisciplinary instructional strategies focusing on literacy instruction in their science classes. The first theme demonstrated how high school science teachers became increasingly aware of their students' difficulties when given a reading task. This awareness resulted from observing students’ behavior when confronted with a reading task and their academic performance on classroom assignments and standardized tests. The second major theme explained how, regardless of their awareness of the problem, the high school science teachers did not feel adequately prepared by their preservice education programs to address the issue. Many teachers noted that their college courses focused extensively on deeply understanding the science content but did little to support them in learning how to implement the best instructional practices, especially regarding teaching students to read in high school. The third major theme revolved around the development and adoption of the CCSS, specifically the standards for RST standards and the NGSS (n.d.). The teachers indicated that the adoption of the standards and their incorporation into the district curricula made it clear that there was an essential connection between literacy skills and science instruction. One concern that the teachers noted was that although the standards established the expectation that literacy skills would be incorporated in science classes, they failed to provide specific guidance on how that goal would be accomplished. The fourth theme focused on the instructional practices the teachers implemented as they refined their practice of using interdisciplinary instruction. The first task that the teachers faced was finding appropriate texts and content while being accessible to students. Once a fitting text was identified, the primary strategies included setting a purpose for reading at the beginning and throughout the passage, breaking the text down into more manageable chunks to improve comprehension, and using annotation as a note-taking tool that facilitated students' ability to summarize and synthesize information from one or more passages. The fifth and final theme was the impact of professional learning opportunities through workshops, coaching, and other independent activities.

Major Theme 1: Teacher Concerns Foster Self-Reflection on Practice. The teachers who participated in this study explained how their classroom observations and assignments revealed that their students struggle to apply their literacy skills when reading science texts. Their observations align with the data regarding student proficiency in science across the state and country. In 2015 and 2019, only 22% of American high school seniors earned a proficient or higher score on the NAEP (2022) science assessment (DeSilver, 2017). Similar results were seen on the NJSLA for Science (NJSLA-S) in 2019. On the NJSLA-S assessment in 2019, only 27.3% of all 11th graders met the expectation for proficiency. In 2023, there was little improvement, with only 27.9% of 11th graders earning a proficient score (O'Dea, 2023).

The teachers also cited an increased focus on standardized assessments in reading and the communication that their students underperformed on these assessments as another indicator of their students' lack of proficiency. Marincola (2006) and Hayes and Trexler (2016) noted increased pressure for students to meet or exceed state and national standardized assessment expectations. These studies demonstrated the connection between the pressure to perform well on these tests and the decreased use of hands-on inquiry-based instructional practices in all content areas. The teacher participants in this study explained how their awareness of how the students performed on their language arts and science assessments impacted their instructional decisions. The teachers began to recognize the need to broaden their support for literacy skills as it directly impacted students' understanding of science.

Major Theme 2: Developing Self-Efficacy Through On-the-Job Training. Science teachers who implement interdisciplinary approaches at the high school level do so in response to many influencing factors within their classes and the school community. The primary influence is the teachers' identification of a deficit in reading proficiency within the student population or their recognition of the importance of reading to increase student comprehension of a topic (van den Broek, 2010). Although the teachers who participated in this study were aware that their students struggled to master the science content and were significantly behind in reading, they shared that they lacked confidence in their ability to remediate the problem. This issue was a significant concern expressed by the participants. Implementing interdisciplinary instructional practices that focus on improving literacy and synthesizing that literacy instruction with inquiry-based science has been historically avoided by science teachers because they have not received appropriate training and do not feel prepared to use these practices effectively (Greenleaf & Brown, 2017).

Some teachers became certified through the alternate route due to a college degree in science. Their only opportunities to learn about interdisciplinary instructional strategies came from professional development. The participants who had attended teacher preparation programs explained that their education focused extensively on their content. Those who recalled classes that taught pedagogy asserted that those classes helped them understand the curriculum and how to write lesson plans effectively but did not teach them to address students who struggled with reading skills. In their practice, the teachers felt that they would benefit from understanding how to identify why students struggled with reading, having additional knowledge of the academic standards, specifically the English standards, and a wider repertoire of strategies for supporting their students.

Research has shown that historically, there was an insufficient focus during teacher preservice training on instructional practices for literacy, especially for students majoring in secondary education (Bergman & Morphew, 2015; Scott et al., 2018; Weld &

Funk, 2005). The participants in this study who received undergraduate degrees in education expressed that they did not believe that their teacher preparation programs taught them how to implement interdisciplinary instruction in their high school science classes. However, these teachers identified a challenge that their students were facing, sought training in various mediums to learn how they could help, and embraced the opportunity to implement instructional practices for literacy in their classes.

Major Theme 3: Academic Standards Bridge Science and Literacy Instruction. Close reading and other approaches to literacy instruction are usually reserved for English and language arts classes; however, the CCSS, RST, and the NGSS (n.d.) emphasized the importance of teaching literacy across all disciplines (Krajcik et al., 2014). The RST focused on ensuring that students graduate high school with a solid foundation of fundamental science literacy and the skills needed to read and write effectively in science (Norris & Phillips, 2009). In contrast, the NGSS (n.d.) highlighted the importance of derived science literacy, which required students to deeply understand science concepts and content (Norris & Phillips, 2009). Within the NGSS (n.d.), however, the importance of developing fundamental science literacy is also evident.

In this study, the participants asserted that the RST and NGSS (n.d.) standards had an essential effect on implementing interdisciplinary instructional strategies to incorporate literacy in their classes. The decision to change their instructional practices was no longer a matter of choice but a requirement established by the standards in their curriculum documents. Reviewing the curriculum documents for chemistry, biology, environmental Earth science, and physics revealed many citations for the RST standards across the high school grade-level bands. Most frequently, the curriculum documents cited RST Standards 1 and 2, requiring students to cite textual evidence and summarize complex concepts, processes, or information. RST Standards 7 and 8, which required students to evaluate and synthesize ideas from multiple sources, were also cited in each document. The teacher evaluation of lesson plans provided evidence that the standards are being taught and the level of rigor associated with the lesson.

The goal of achieving derived science literacy is accomplished through meeting the standards associated with the DCIs and cross-cutting concepts of the NGSS (n.d.; NRC, 2012; Norris & Phillips, 2009). The science and engineering practices of the NGSS (n.d.) require students to master the skills and practices used by scientists (NRC, 2012). Mastery of these skills is necessary to attain fundamental science literacy (NRC, 2012; Norris & Phillips, 2009). Four of the eight science and engineering practices identified in the NGSS (n.d.) are closely aligned with the RST standards found in the curriculum documents and lesson plans provided by the participants. These science and engineering practices are analyzing and interpreting data; constructing explanations and designing solutions; engaging in argument from evidence; and obtaining, evaluating, and communicating information (NRC, 2012).

Major Theme 4: Interdisciplinary Resources and Approaches That Worked. The analysis of the interviews, focus group discussion, and documents revealed essential changes to the pedagogical approaches used by the teachers because of their knowledge of the challenges their students faced and the importance of supporting them in mastering the academic standards. As the teachers attempted to shift their instruction to include interdisciplinary instructional practices, they explained that they first had to understand how to select an appropriate text. As they stated, the text had to be rigorous yet accessible and aligned to the science content being taught. When teachers implement close reading as an interdisciplinary instructional strategy, they must select a complex text that is at or slightly above students' grade levels (Frey & Fisher, 2013; Lapp et al., 2013; McConn, 2018).

Once the appropriate text was selected, the teachers learned to communicate the purpose of reading the article or text to the students. Eventually, they helped them establish their purpose for reading a text. According to the participants, this process was accomplished by asking guiding questions at the beginning of the lesson, encouraging students to discuss their preexisting beliefs about the text topic, and encouraging them to be curious about what they might learn. Strategic questioning is a metacognitive strategy essential in comprehending a text and critical to close reading (Lapp et al., 2013).

The teachers later refined their practice of setting a purpose at the beginning of the text to revisit setting a purpose throughout the text. As one purpose was accomplished, a new target was set. They also began to support their students by chunking the text into smaller parts. The teachers explained that this strategy made the text more accessible and less overwhelming for students. Chunking the text also supported their comprehension by allowing them to process the information more quickly (Marzano, 2007).

Annotations and summarizing the text were also important behaviors that teachers modeled, practiced with the students, and required the students to apply when reading independently. Students could highlight or underline important words or ideas in the text that would help them access that information later and make connections to other texts or real-world experiences such as classroom experiments and labs. Gaston et al. (2016) and

Kern and Bean (2018) found that note-taking practices like annotating texts significantly improve reading comprehension and retention of information. As a result, practicing these strategies in high school science classes supports fundamental science literacy and deepens science literacy (Norris & Phillips, 2009).

The participants' fundamental changes to their pedagogical strategies included identifying the “right” text, establishing and revisiting the purpose for reading, and chunking, annotating, and summarizing texts to improve comprehension. These interdisciplinary instructional approaches are key strategies used in a close reading lesson. Close reading strategies provide a structured learning experience that promotes critical thinking and deep comprehension (Johnson & Mongo, 2008, p. 2003). The teachers explained that they did not simultaneously implement all of these changes to their pedagogy. As they learned more and more about interdisciplinary instruction and practiced each step, they combined them in their lessons to truly implement a close reading approach in their science classes. Close reading strategies become a powerful interdisciplinary instructional tool when used in science classrooms.

Major Theme 5: Sustaining Changes Through Instructional Coaching and Professional Development. The teachers sought professional development in various forms to refine their craft and become more fluent in each instructional practice they tried to use in their classes to implement interdisciplinary instructional approaches best. Some sought support through traditional workshops, while others sought support through webinars, coaching, or peer shadowing. The teacher explained that they felt compelled to learn how to integrate literacy instruction with their inquiry-based science instruction so that their students could succeed. Professional development provides an essential opportunity for teachers to hone their practices and access these opportunities, significantly influencing their willingness to try new approaches (McClune et al., 2012; van den Broek, 2010).

One concern that the teachers shared regarding workshops for literacy strategies was the lack of focus on how literacy instruction could be blended with inquiry-based science instruction. They explained that the workshops they attended often focused on using these strategies in English or social studies classes. That made it difficult for the teacher to envision the application in their classes. However, when they could take the knowledge they gained from the workshops, collaborate with their coach and colleagues, and plan for meaningful instruction in their classes, they could see the benefit of interdisciplinary strategies for their students.

Research shows that coaching and peer collaboration are generally well received by teachers, especially when coaching is nonhierarchical (Ben-Peretz et al., 2018; Ivanova et al., 2022). Of all the ways the teachers could learn more about interdisciplinary instructional strategies, they expressed the most satisfaction with receiving coaching in their classroom. They also expressed a desire for increased opportunities to learn from their colleagues. Peer coaching accepted a nonthreatening, supportive, and often self-motivated form of professional learning (Lu, 2010).

As individual themes, the findings of this study provided insight into the experiences of high school science teachers who embarked on integrating literacy instruction into their science classes through interdisciplinary instructional strategies. When blended, they create a story of their journey, exploring the highs and lows the teachers confronted along the way. From awareness and recognition of a problem to making minor changes to their instructional approach to seeking opportunities to deepen their understanding of interdisciplinary instruction, the participants shared their experiences so that others would benefit from the lessons they learned.

Answering the Research Questions

Suppose educators hope to impact students' lives positively by ensuring they graduate high school capable of reading, writing, communicating proficiently, and understanding a broad range of science concepts. In that case, educators must continue to seek an understanding of the instructional practices that can support students in accomplishing this goal. Equally important to identifying instructional best practices is seeking to learn how to support teachers using new practices.

The following sections provide answers to the research questions of this study. The purpose of this study was to deepen educators' understanding of the knowledge and experiences of teachers who implemented interdisciplinary instructional practices focusing on literacy instruction, like close reading, in high school science classrooms.

Research Question 1. How do teacher knowledge and beliefs about interdisciplinary instruction guide their pedagogical and instructional practices? The first research question sought to understand why teachers began their journey toward incorporating literacy instruction into science classes. The interviews and focus group discussion showed that the participants believed that students needed to learn the science content, and they communicated their understanding of the complementary relationship between being an effective reader and learning content in science classes. Before engaging in specific instructional practices for literacy, the teacher expected their students to read and write, develop arguments and support their positions with evidence from their experiments and the texts, and analyze and synthesize data presented in many formats. The onus to change their instructional repertoires to include explicit literacy instruction came as they recognized their students' struggle with literacy.

The teachers had observed their students shy away from engaging in tasks that required them to read. At times, the students outright refused to participate. At first, this issue may have been interpreted as students being defiant; however, students’ scores on high-stakes standardized tests confirmed that they struggled to read and comprehend text at their grade levels. This reason was the first significant one that the teacher identified as their reason to change.

After teachers recognized their students' struggle, they adopted the CCSS, specifically the companion standards for RST, and the NGSS (n.d.). These standards were used to draw connections between science instruction and literacy proficiency. The standards require students to analyze and interpret data accurately; construct explanations and design solutions; and obtain, evaluate, and communicate information (Drew & Thomas, 2018; Krajcik et al., 2014; NRC, 2012). Students must summarize and synthesize information from complex sources, evaluate the validity and bias of a source, and communicate their understanding effectively. These goals require students to understand science literature and content deeply while making connections between ideas presented through different modalities. Accomplishing any of these expectations is impossible without being supported by a strong foundation in literacy and reading comprehension skills.

The outcomes of this study suggest that recognition of the need for change was the most crucial factor that led teachers to implement interdisciplinary instructional practices like close reading in their high school science classes. The participants explained that they observed their students struggling with reading in the classroom and were aware of the standardized test results indicating that many students did not have proficient literacy skills. Teacher self-efficacy and perseverance also played an important role. The teachers' lack of self-efficacy for explicitly teaching literacy skills in science was a potential barrier. The teachers viewed themselves as science specialists. Their preservice education emphasized the importance of knowing the content. The lack of knowledge in this area was a source of frustration for the teachers, but they did not let this challenge prevent them from seeking ways to support their students, and they soon began to rethink their instructional model.

Research Question 2. How can close reading strategies be incorporated into the high school science classroom to promote interdisciplinary instruction? Close reading utilizes instructional practices that can be applied in any content area (Frey & Fisher, 2013). The structure of a close reading lesson allows students to gain background knowledge about a topic that can help them be more successful when engaging in inquiry-based learning (Johnson & Mongo, 2008). The findings of this study reveal several instructional practices aligned with close reading that can be seamlessly integrated with science lessons for high school students.

First, the participants discussed the importance of identifying the "right" text for the lesson. The teachers explained the importance of finding a text that was appropriately complex and near or at grade level while providing access to the appropriate content for the lesson. In close reading, text selection is significant. An appropriate text for close reading will have content-specific vocabulary terms, challenging text organizations, and sentences with complex or irregular structure (Fang & Pace, 2013; Fang & Schleppegrell, 2010; Shanahan & Shanahan, 2008). This challenge was the first that the teachers reported when they began using interdisciplinary literacy strategies in their classes. To make the text accessible for students, the participants assisted them in chunking the text into more manageable and meaningful sections. Many times, the chunks were naturally established based on the text structure. Other times, the passages were divided into paragraphs.

Next, the teachers shared how they set a purpose for reading. Close reading is reading for a purpose (Frey & Fisher, 2013). The participants communicated how they began by modeling how they established a purpose for reading. After modeling, the teachers encouraged the students to brainstorm questions about the topic before reading to establish a clear purpose. Although the teachers started modeling the process of establishing a purpose at the beginning of the text, the practice was expanded to include revisiting and re-establishing a purpose during reading when appropriate. In close reading, engaging and rereading a text for different purposes is essential (Frey & Fisher, 2013; Lapp et al., 2013; McConn, 2018).

Another close reading strategy embraced by the participants was annotating and summarizing the text. The participants explained how they had previously allowed the students to take unstructured notes. However, they eventually taught them to annotate the text in the margins, underline and highlight key words or phrases, and summarize each chunk. The teachers believed that these annotations helped the students better understand the text and supported them when synthesizing information from multiple sources.

The findings showed that the participants implemented close reading practices in their high school science classes by incrementally increasing the number and complexity of the literacy strategies they used in their classes. Research shows that incorporating specific literacy strategies supports student engagement and comprehension (Gaston et al., 2016). The participants in this study expressed their belief that their experience with integrating interdisciplinary instructional strategies would benefit their students. As a result of their initial experience, they sought support through professional development, collaboration, and coaching to refine their practice. They expressed that they believed they would continue honing their skills and implementing literacy instructional practices in their science classes.

Research Question 3. From teachers' perspectives, how do curriculum and professional development impact teacher planning for interdisciplinary lessons? The CCSS for RST and the NGSS (n.d.) significantly impacted the participants' decisions to implement literacy-focused instruction in their science classrooms. The adoption of these standards underscored the connection between literacy and science. The participants in this study explained that while the curriculum referred to the RST and NGSS standards, they did not feel it adequately addressed how teachers should provide literacy instruction in their classrooms. As Krajcik et al. (2014) explained, the NGSS was developed to serve as a guide for curriculum development. From the teachers' perspective, the standards and the curriculum established the outcome but did not explain or provide a pathway for teachers to help their students reach that goal. The teachers explained that the curriculum noted the standards but did not provide explicit ways for the teachers to implement the interdisciplinary instructional strategies required to help students meet the standard.

Professional development directly affected the implementation of interdisciplinary instructional strategies for the teacher participants of this study. They referred to coaching, peer shadowing, workshops, and reading professional literature as the forms of professional development they could use to improve their teaching ability using interdisciplinary instructional literacy strategies in their science classes. McClune et al. (2012) demonstrated that professional development and the collaborative development of curriculum have a salient effect on implementing interdisciplinary instructional practices. The findings in this study suggested that the professional development that the teachers could attend had a more significant impact on how they planned for and implemented interdisciplinary lessons than the curriculum.

Reflection on Conceptual Framework

The adapted framework for cross-curricular program development identifies the factors that must be considered when evaluating the implementation of interdisciplinary instructional strategies (McClune et al., 2012). The first column of the framework, as shown in Figure 1 in Chapter 2, includes the teacher's self-efficacy and the traditional instructional approaches that impact their knowledge, values, and beliefs about their role as educators. The center column focuses on external factors that impact teachers' planning and pedagogy, including curriculum and professional development. The third column of the framework includes the outcome of interdisciplinary instruction, which can improve pedagogy and academic outcomes for students by synthesizing content and skills. The framework establishes the reciprocal relationship between the first two columns, indicating that the factors in each column can affect the other components. This study provided evidence that supports this framework.

Subject-matter norms, knowledge, beliefs, and values, and the teacher aligned with the findings used to answer the first research question, which sought to understand how teachers' knowledge and beliefs about interdisciplinary instruction impacted their pedagogy. The findings demonstrated that the teachers' knowledge about the difficulty students have with reading tasks, their beliefs about the connection between science and literacy, and the value they place on ensuring they have provided the best education possible for their students served as the foundation for their decision to begin implementing interdisciplinary instructional strategies like close reading in their classes.

Adopting the RST and NGSS (n.d.) standards reinforced the teacher's beliefs in the connection between literacy and science. Their inclusion in the curricula demonstrated the expectation that students would be able to use their literacy skills to learn science content. These findings represented "curriculum" within the middle column of Figure 1. Although neither the curricula nor the standards provided the teachers with explicit directions about how literacy should be integrated into science instruction, the importance of the connection was communicated.

Professional development provided a starting point for the teachers and a guide to improve their practices. Although McClune et al. (2012) found that both curricula and professional development had a significant impact on the teachers' pedagogical choices, the findings of this study suggest that professional development played a more significant role in effectuating change in this situation. The teachers' observations and beliefs about instruction, the standards and curricula, and the professional learning opportunities provided the foundation for changes in their approach to planning and pedagogy. The interplay between the concepts guided the answers to the second and third research questions, which examined how teachers' pedagogy changed and the effect that professional development, the curriculum, and the standards had on the implemented changes.

All of the elements within the adapted framework for cross-curricular program development impacted the interpretation of the findings of this study. As the framework suggested, these concepts served as the basis for examining how teachers enriched pedagogy, synthesized content, and sought to improve student outcomes in literacy and science. The framework shows that an interdisciplinary innovation arises from the dynamic relationship between curriculum development and professional growth, wherein teachers' expertise, values, and viewpoints in their respective content areas influence and are influenced by their interactions, ultimately shaping the innovation (McClune et al., 2012). The results of this study exemplify that dynamic relationship.

Leadership and Researcher Reflection

Researchers who assume the social constructivist worldview believe meaning is made based on prior experiences and knowledge and their core values (Creswell & Creswell, 2018). The researcher's interpretation of their experiences and beliefs often contribute to their decision to pursue a specific research topic (Rossman & Rallis, 2017). This worldview is reflected in the effect that my past experiences as an educator and my beliefs about the importance of literacy skills directly influenced my selection of this research topic.

Literacy-focused interdisciplinary instruction in high school science closely aligns with why I became an educator. As a young adult completing my undergraduate education, I became acutely aware of the challenges children face growing up, and I wanted to do something to change that. I became a teacher searching for a way to bring change to the lives of children. My passion for reading fueled my love of teaching children to read and encouraging them to read things with which they were passionate. Many of my kindergarten and first-grade students were fascinated by scientific concepts. They loved reading about it, talking about it, and engaging in explorations and experiments. When I became a supervisor, I noticed that my love of reading and my students' enthusiasm for science had diminished. It was not fun; it was just hard.

In addition to influencing the selection of the topic of this research, evidence of the social constructivist paradigm was evident at multiple points throughout the study. There were several times when my understanding of the implementation of interdisciplinary instruction was challenged due to the information communicated by the participants. Before engaging in this study, I believed that high school content area teachers knew that their students did not have proficient literacy skills and did not have experience with explicit teacher reading strategies. However, I was unaware of how frustrated this made them feel. Listening to the participants share their concerns about their perceived inability to provide effective literacy instruction during the interviews and focus group discussions expanded my understanding of why they resisted using interdisciplinary instructional strategies. It was not a lack of desire to support students' literacy development or genuine inability that created a barrier but their lack of confidence that stood in the way. Their apprehension initially prevented them from taking the chance to try something new. When a preponderance of evidence suggested that connecting literacy skills and science instruction was necessary and appropriate, they took a chance. They began to change their mindset and their practices slowly.

Change is necessary but often not embraced. The resistance to change can be reduced by taking an evolutionary approach, making minor adjustments over time until the final result substantially differs from where it began (Burke, 2014). In this study, there was a limited number of participants for many reasons, including the limited number of participants meeting the established criteria for participation. In the district where this study was conducted, most high school science teachers reported using some form of interdisciplinary instructional approach to integrate literacy and science. They were all at different levels of implementation and confident in their practices.

Evolutionary change allows for diversity in the rate and intensity of a change. In my experience as a teacher and educational leader, evolutionary changes are the ones that have longevity. I hope that interdisciplinary instruction that focuses on using literacy skills to comprehend science content deeply continues to evolve and spread over time for the benefit of all students.

When embarking on this study, I hoped the findings would provide me, as a content area supervisor, with insight into why teachers begin implementing interdisciplinary approaches in their classes. Several teachers used close reading strategies in their science classes, and I believe their efforts would benefit student growth in science and literacy. I hoped to share what I learned in this study with the science supervisor and communicate their experiences with other teachers who were more reluctant to try a different approach in their science classes. Although I am now working in a different capacity as an educational consultant, the findings of this study remain relevant to my career. In my new role, I can share these findings with a much more comprehensive range of teachers as I work in districts nationwide. As I review student results on standardized assessments and benchmarks, I am often asked how to change outcomes. The findings of this study will be a significant part of that conversation.

Implications for Practice

Implications for School Leaders

Engaging in educational research aims to facilitate change to improve the school experience for students and improve academic outcomes. The findings of this study have implications for many aspects of education, including educational leadership, curriculum development, and teacher practice. Educational leaders such as superintendents, curriculum directors, supervisors, Board of Education members, and teacher leaders are essential in effectuating school changes. This study, which focuses on using interdisciplinary instructional practices like close reading to integrate literacy skills in high school science classes, could have several implications for educational leadership.

First, education leaders need to prioritize and support the implementation of interdisciplinary instructional practices that focus on literacy instruction in high school science classes. This study demonstrates that high school science teachers are aware of the need to improve students' achievement in reading while continuing to expand their understanding of science concepts. Support for practices like close reading from educational leaders will encourage teachers to continue or begin to seek opportunities to use interdisciplinary instructional strategies in their classes, hopefully improving literacy skills and increasing comprehension of scientific concepts.

Next, in supporting the initiative of integrating literacy and science instruction, educational leaders should consider providing teachers with access to professional learning that will equip them with the necessary skills to effectively integrate literacy into their instruction. Based on the findings of this study, job-embedded professional learning sessions that utilize a collaborative, peer-supported model are preferred. Finding opportunities to engage in job-embedded professional development presents several challenges, including finding the time within full schedules and limited funding to support professional learning. Therefore, it is suggested that educational leaders consider a scaffolded approach to provide job-embedded professional learning. Districts may consider implementing monthly professional learning communities. Regularly scheduled professional learning communities support improvements in teacher practice and increased use of evidence-based instructional strategies, like interdisciplinary instructional practices (DuFour et al., 2016; Vescio et al., 2008). Once regular professional learning communities are established, more frequent, voluntary, and required professional learning communities may be added. In an ideal world, teachers would meet weekly, or even daily, when possible, within work hours to explore interdisciplinary instructional practices collaboratively.

In addition to providing all staff with professional development that focuses on integrating interdisciplinary instructional practices for literacy in high school science, educational leaders may consider identifying a targeted group of staff members to serve as curriculum leaders. These curriculum leaders would benefit from additional, more intense training in effectively integrating literacy instruction in science. This intense training would provide the knowledge and skills necessary to develop curricula for literacy instruction in science. It would also be beneficial to provide the curriculum leaders with time to support their colleagues in a coach-like role to assist with developing lesson plans and with fidelity in implementing interdisciplinary strategies. As the findings from this study and prior research have shown, coaching and peer collaboration are compelling and effective ways to support teachers to try new things (Ben-Peretz et al., 2018; Ivanova et al., 2022; Lu, 2010).

In addition to having implications for professional learning opportunities for in-service teachers, this study reveals the need for educational leaders at colleges and universities, especially those responsible for developing teacher education programs and curricula, to evaluate opportunities for candidates seeking a career as a science teacher to take courses focusing on engaging in interdisciplinary instructional practices for reading in high school science classes. As the participants who studied to be science teachers during college reported, undergraduate students are required to take very few courses that help them develop a deep understanding of instructional strategies that support the reading skills needed to succeed in science classes. Enacting programmatic changes that add or remove courses that students are currently taking is difficult. As an initial step toward supporting secondary education teacher candidates in expanding their knowledge and increasing their efficacy in teaching reading skills, colleges should consider reviewing the topics within their required course curricula and adding multiple lessons focusing on teaching reading skills as part of an interdisciplinary approach to science. In the future, requiring additional courses that support content-area teachers in strengthening their ability to teach reading to high school students would benefit the teacher candidates and their future students.

Furthermore, educational leaders must consider how resources are allocated and consider reallocation to ensure time is provided to improve and enhance the curriculum, plan for professional development, and purchase books, scholarly literature, and other materials necessary for teachers. Curriculum writing is time-consuming and requires a team of experts to develop a high-quality curriculum collaboratively. Teachers need access to texts that are closely aligned with the science content and available at various levels to support readers with different proficiency levels. These texts might include books, scholarly magazines, or digital databases. Finally, professional development resources for teachers might include workshops, additional time to collaborate with or shadow colleagues, books, or webinars. Collaboration is a well-received form of professional learning, and collaboration between science and language arts departments is crucial for the success of interdisciplinary instructional practices. Educational leaders may consider ways to facilitate regular communication and collaboration between teachers from different disciplines.

The need for professional development is not limited to teachers. Educational leaders at all levels, especially those evaluating teacher performance, must be well-versed in appropriate interdisciplinary instructional strategies to ensure they are being implemented with fidelity and provide feedback and support for teachers throughout the year. Policymakers may even consider ways to reflect the importance of integrating literacy skills into science and other subject areas as part of the teacher and school evaluation process.

Finally, educational leaders at all levels must encourage and support ongoing research that evaluates the effectiveness of interdisciplinary instructional practices in improving literacy skills and science understanding. Future studies could take the form of action research led by classroom teachers to measure the academic impact of interdisciplinary instruction on high school students. The results of such a study could inform future decision-making and adjustments to instructional practices.

In summary, the study's implications for educational leaders and policymakers involve a holistic approach to educational leadership, encompassing teacher development, curriculum design, resource allocation, collaboration, community engagement, and policy advocacy to effectively implement and sustain interdisciplinary instructional practices in high school science classes.

Implications for Teachers

The participants in this study shared their experience with implementing an interdisciplinary instructional approach to integrate literacy skills in high school science classes. This study can have several implications for teachers and their practice. First, the importance of text selection was communication throughout the study. Identifying literacy skills that are key to science content mastery was examined. Equally importantly, the study has provided evidence of the need for ongoing professional development and encouraged increased cross-content collaboration. These findings each have important implications for teacher practice.

The importance of text selection was a recurring theme of this study. As such, teachers must begin evaluating the texts currently part of their instructional plans to determine if they are appropriate for the lesson and their students. Teachers should seek guidance and support to select the best possible instructional materials for integrating literacy into science. Finally, teachers must remember to identify texts that meet the needs of their diverse learners. Text selection must consider reading level, language proficiency, required accommodations, and learning styles.

This study reveals several essential literacy skills that students need to be successful. First, students need to be able to read and comprehend complex texts. They must synthesize information from multiple texts and other mediums and apply their understanding of the content in real-world contexts. They also need to be able to communicate their understanding. To support these goals, the participants in this study engaged their students in lessons that included close reading strategies like reading rigorous text, chunking the passage, annotating while reading, summarizing each chunk, and synthesizing the chunks to establish the gist of the entire passage. These strategies serve as the starting point for integrating literacy and science instruction. Identifying the specific literacy skills scientists use will provide opportunities for further study and expanded integration.

This study demonstrated the importance of professional development in learning to use new teaching approaches. Teachers must embrace professional development opportunities and maximize the potential benefits of these sessions. Collaboration with colleagues, coaching, and peer shadowing can provide mutually beneficial learning opportunities where each teacher is the expert and the learner. These professional collaborations could include sharing resources, providing guidance when lesson plans, developing shared assessments, or reviewing curriculum and sharing feedback with curriculum development leaders.

Text selection, identifying critical literacy skills, opportunities for professional learning, and the implications for practice discussed above are part of an iterative process that ensures continuous improvement and refinement of the integrated instructional model. It emphasizes the need for a holistic and collaborative approach to professional development, lesson planning, and curriculum development that prioritizes scientific content and literacy skill development.

Recommendations for Future Research

The findings in this study provide an understanding of how teachers have implemented interdisciplinary instructional practices in their high school science classes, from their awareness of the challenges their students faced to the professional development they sought to hone their craft. It is intended to help practitioners identify instructional strategies that support student literacy growth and mastery of science content. There are several recommendations for future research in interdisciplinary instruction related to high school science classes. The first three recommendations for research focus on instructional practices and learner outcomes. The final two recommendations suggest research to evaluate opportunities to support teachers implementing interdisciplinary instructional models in their classrooms. The following is the list of suggestions:

1. It is suggested that future researchers consider engaging in classroom observations to document the implementation of interdisciplinary instructional strategies that focus on literacy in high school science classrooms. The participants in this study helped to identify several practices that they have integrated into their science lessons. As their practices become more refined, there is potential for additional literacy-focused instructional strategies to be added to their repertoire. Furthermore, a more extensive participant base may suggest additional instructional practices in high school science classes. Finally, using classroom observations as a data collection method will allow

the researcher to confirm the instructional strategies that were self-reported by the participants.

2. Implementing an interdisciplinary instructional model in high school science classes aims to improve student academic outcomes in both literacy and science. It is recommended that future research be conducted to evaluate the impact of interdisciplinary instructional strategies on student achievement, specifically in science and reading comprehension. This study may examine the long-term effects of implementing interdisciplinary instructional strategies focusing on literacy in science classes by tracking a cohort of students from middle school through high school graduation. A standardized assessment, like the NAEP or NJSLA for ELA and Science, would provide insight into the effect on students' reading and science achievement.
3. Explore how interdisciplinary instructional practices impact students from diverse backgrounds, including those with varying literacy skills, English language learners, and students with different socioeconomic statuses. Understanding equity considerations is crucial for effective implementation. Evaluate the perception of students regarding the effectiveness and benefits of interdisciplinary instructional practices. Qualitative research may provide valuable insights into learners' attitudes, experiences, and challenges.
4. After identifying the most effective approaches for teaching through interdisciplinary instruction, research should consider the best ways to support teachers in learning and mastering these techniques. Future research is recommended to explore the impact of preservice education programs for

content-specific secondary teacher candidates and in-service professional development programs on implementing interdisciplinary instructional strategies that focus on literacy in high school science classrooms. The findings of this study and prior research suggest that collaborative and peer-led professional learning opportunities are the most well-received and effective (Ben-Peretz et al., 2018; Ivanova et al., 2022). Research could seek to identify additional opportunities for teachers and teacher candidates to shadow and observe science and English teachers with a focus on interdisciplinary approaches.

This list is not exhaustive of the opportunities available for future research; however, it represents topics for studies that may expand the understanding of the importance, feasibility, and impact of integrating literacy instructional strategies in high school science classes.

Limitations of the Study

Sampling concerns and social barriers were identified as potential limitations for this study. This study focused on implementing interdisciplinary instructional strategies in high school science classes in a southern New Jersey county. As a result of restrictions stemming from the COVID-19 school closures and subsequent protocols, access to teachers in several districts was denied, and the study was completed in a single school district. As such, a limited sample size resulted from the research setting and the criteria established for participation in the study. The limited sample size could impede the transferability of the study results to other contexts. Replicating this study in other districts would minimize this limitation's impact and increase the results' reliability.

In addition to concerns regarding the sample size, it was anticipated that the researcher's role as a district administrator might have caused some social barriers, including the reluctance of some teachers to participate in the study or to respond disingenuously for fear of repercussions. This limitation was somewhat mitigated due to the researcher's career change during the data collection process. Other potential social barriers identified included teachers' hesitancy to share their pedagogical approaches due to receiving negative feedback from their colleagues or pressure from their collective bargaining units. To address these potential limitations, the identities of the teachers who agreed to participate in this study were anonymous, meetings were at the teachers' choice of location, and the researcher's purpose for observing specific classrooms remained undisclosed.

Conclusion

This chapter provided a discussion about the findings of this study on the implementation of literacy-based interdisciplinary instructional strategies in high school science classes. The chapter began with a brief overview of the five major themes derived from the interviews, focus-group discussions, and document analysis data collected in this qualitative study. The research questions developed for this study were answered based on these findings. Next, connections to the conceptual framework and implications for educational leaders and teachers were identified. Finally, opportunities for future research were communicated.

This study revealed the experiences of high school science teachers who implemented close reading interdisciplinary instruction in their classrooms. The findings demonstrated the importance of supporting the development of students' literacy proficiency in their high school science classes. Many studies have focused on using interdisciplinary instructional strategies in elementary and middle school classes. Those studies have found that interdisciplinary instruction provides opportunities for the application of students' skills, further develops student proficiency in using their skills, improves student fluency, and deepens comprehension (Eunice Kennedy Shriver National Institute of Child Health and Human Development, NIH, & DHHS, 2000; Fang & Wei, 2010; Gaston et al., 2016; Palumbo & Sanacore, 2009; Vaughn et al., 2013). These findings suggest that incorporating literacy instruction into high school science is even more critical.

The results of this study suggest that teachers' knowledge, values, and beliefs about integrating literacy instruction are essential to initiating change. The participants in this study explained that their observations of the challenges their students faced, the concerning assessment scores that school administrators shared, and their belief in the connection between effective literacy skills and science proficiency led them to begin considering ways to teach using an interdisciplinary approach. The participants explored various approaches to integrating literacy in their classes. The most frequently identified approaches were reading complex texts, setting a purpose for reading, chunking the text, and annotating and summarizing data. Close reading embraces these techniques to facilitate a deep understanding of content (Fang & Pace, 2013; Fang & Schleppegrell, 2010; Frey & Fisher, 2013; PARCC, 2011; Shanahan & Shanahan, 2008). Finally, the findings indicated that although professional development and curriculum impact teachers as they plan for instruction, professional development significantly affects the changes they implement.

An adapted version of the framework for cross-curricular program development was incorporated into this study to guide the evaluation of data relating to teachers' prior knowledge, experiences, and beliefs about how students learn and their implementation of interdisciplinary science lessons. McClune et al. (2012) constructed the framework to demonstrate the reciprocal relationship between internal and external factors as they mutually impact the implementation of interdisciplinary instructional practices. This study's findings reflected the expected impact of teacher self-efficacy, knowledge, beliefs, values, and subject-matter norms and curriculum and professional development effect on the use of cross-curricular instructional strategies (McClune et al., 2012). The findings of this study slightly differed based on the inconsistent effect that the curriculum had on teachers participating in this study. Further research is needed to determine if this limited impact of curriculum on teacher implementation of multidimensional instructional strategies is widespread or a phenomenon related to the research setting.

The implications of this study are wide-reaching, impacting policy-makers, educational leaders, and teachers alike. Policymakers like the board of education members are encouraged to consider ways that schools can be evaluated to account for students' academic achievement in science, such as in math and language arts. Educational leaders may use the results of this research to reallocate resources to allow for additional materials and professional learning focused on interdisciplinary instruction, to plan for curricular revision, and to encourage action research that focuses on how student achievement is impacted by interdisciplinary instruction. Perhaps most importantly, it demonstrates that educational leaders can validate and support the use of literacy approaches in science—and cross-discipline—thereby encouraging teachers to explore new approaches to supporting all students in learning science and reading.

Finally, the implications of this study for teachers are clear: teachers must cultivate their knowledge of identifying appropriate instructional materials and strategies that support students' learning. The findings from this study underscore the need for teachers to identify the myriad of opportunities to learn about interdisciplinary instructional strategies and be willing to seek input from and, in turn, provide input to their colleagues when appropriate. This study gave an overall look at high school science teachers' experiences practicing close reading instructional strategies used in their practicum in the classroom as part of their effort to use interdisciplinary instructional strategies to increase science literacy. Teachers elected to change their instructional practices due to their perception of student needs.

In addition, teachers had ample support to alter their practices from state and national science assessment data. Only 35% of U.S. high school students demonstrated proficiency on the NAEP (2022) science assessment in 2019, and less than 30% of high school students taking the NAEP and the NJSLA science could be considered proficient on their last administration in 2019. Similarly, the NAEP Nation's Report Card gives the average reading score given to students who participated in the assessment in 2019 as 285, which was the lowest average score on the NAEP reading assessment since 1992 and 17 points below the cut score for science literacy proficiency. Based on their observations, teachers began incorporating literacy-instructional strategies to interrupt this declining student achievement trajectory.

Although they started with low self-efficacy in implementing interdisciplinary instructional practices, professional development, and social support from their peers assisted them in feeling more confident and bolstered their confidence in employing these practices with students. Educators desire all students to engage in learning, an experience that sparks an interest and helps them acquire the skills needed to become lifelong learners. In high school science classrooms, implementing interdisciplinary instructional literacy strategies allows educators to support developing literacy skills within science disciplines while learning about science content.

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Appendix A

Informed Consent

Qualitative Research Study
Informed Consent for Interviews or Interviews with Record Reviews
(Expedited Review with identifiers)

Please read this consent document carefully before you decide to participate in this study.

You are invited to participate in a research study about understanding how the self-efficacy of middle school social studies teachers translates into pedagogical approaches that support students who struggle to read and write. This study is being conducted by researchers in the Department of Education at Rowan University. The Principal Investigator of the study is ____________________.

Participation in this study is voluntary. If you agree to participate in this study, you would be interviewed for about 45 minutes. The anticipated number of participants in the study is 5-8.

The study includes the collection of data from records or documents, individual interview(s), and participation in a focus group discussion(s). Your identity will be kept confidential to the extent provided by law. Your information will be assigned a code number that is unique to this study. No one other than the researcher will know whether you participated in the study. Study findings will be presented only in summary form and your name will not be used in any report or publications.

Participating in this study may not benefit you directly, but it will help us learn about the use of interdisciplinary instructional practices in high school science classes to support literacy and science knowledge acquisition. *Your participation in this study is completely voluntary*. *The choice to not participate in this study will have no effect on any services or benefits you are currently receiving*. You may skip any questions you don't want to answer and withdraw from the study at any time without consequences.

If you have any questions about this study, please contact Nancy Hollenweger, 856-498-9625. If you have questions about your rights as a research participant, please contact the Rowan University SOM IRB Office at (856) 566-2712 or Rowan University Glassboro/CMSRU IRB at 856-256-4078.

YOU WILL BE GIVEN A COPY OF THIS FORM WHETHER OR NOT YOU AGREE TO PARTICIPATE.

Social and Behavioral IRB Research Agreement

I have read the procedure described above. I voluntarily agree to participate in the procedure and **I have received a copy of this description.**

Name (Printed) ____

Signature: ____________________________________

Appendix B

Document Interrogation Protocol

The documents will be interrogated to identify the literacy skills required in the content area, the role of literacy in the assessment of student performance, and strategies utilized for literacy learning

1. What is the document or artifact?
2. Who authored the artifact?
3. Who is the intended audience for this artifact?
4. What is the purpose of this artifact?
    1. What does the purpose of the artifact reveal about literacy in science?
    2. What does the purpose of this artifact reveal about close reading in science?

2. What does the artifact communicate about the literacy skills required in science?
3. How does the artifact reveal the role of literacy in the assessment of student performance in science?
4. How does the artifact communicate strategies for literacy learning?
5. What does the artifact communicate about reading pedagogy in the content area?
6. How does the artifact communicate opportunities for teachers to enhance their literacy pedagogy within their content area?
7. How does the artifact communicate resources that support reading pedagogy?
8. How does the artifact communicate support for students who are struggling with literacy in the content areas?

Appendix C

Interview Protocol

1. Tell me about how you believe students learn best.
2. When you hear the term interdisciplinary instruction, what do you think about?
3. In what ways do you believe that using interdisciplinary instruction in science helps students learn?
4. From your perspective, how has the emphasis on literacy instruction in science changed since you began teaching?
5. In what ways do you think that the Next Generation Science Standards have increased your need to incorporate literacy instruction in your classroom?
6. What motivated you to incorporate interdisciplinary instruction in your science class?
7. What motivated you to incorporate close reading strategies in your science class?
8. What academic or professional learning experiences have you had that helped you implement close reading strategies? (College courses, professional development, professional reading, etc.)
9. What feedback have you received from your students regarding the implementation of close reading in your classroom?
10. What do you believe that your students' work samples would reveal about the use of close reading strategies as part of an interdisciplinary approach to instruction?
11. How do you believe that your students' outcomes have changed as a result of incorporating close reading in your science classes?

Appendix D

Focus Group Discussion Protocol

Welcome:

My name is Nancy Hollenweger. I am conducting research for my dissertation in Education Leadership through Rowan University. Our topic for today's discussion is close reading in high school science classrooms.

Guidelines:

- *Confidentiality* – As per the non-disclosure form, please respect the confidentiality of your peers. The moderator will only be sharing the information anonymously with relevant staff members.
- Please use first names only.
- *Be respectful* - There are no right or wrong answers, only differing points of view.
- You don't need to agree with others, but you must listen respectfully as others share their views.
- Be polite - The focus group discussion will be recorded (audio only) and so please make sure that only one person speaks at a time.
- My role as moderator will be to guide the discussion but I encourage you to talk to each other.

Topics:

- Review general commonalities identified during document interrogation.
- Review commonalities revealed during interviews.
- Discuss the meaning that can be ascribed to these commonalities.
- Additional professional learning opportunities that would be helpful to support interdisciplinary instruction in high school science classes.

Guiding Questions:

1. Let's start by talking about some of the commonalities that I noticed as I reviewed the curriculum, textbooks, and professional development records.
    a. One thing that stood out to me what _____.

        i. How do you believe this impacts your use of interdisciplinary instruction in the classroom?

2. Next, I would like you to share your thoughts on some ideas that were mentioned repeatedly when I spoke with each of you during the individual interviews.
    a. One thing that was mentioned on several occasions was _________.
        i. Why do you think that is the case?
        ii. How do you believe that relates to interdisciplinary instruction and/or close reading?
3. Based on what we've discussed today, what are some of the biggest "take-aways" that really speak to your beliefs about the use of interdisciplinary instruction and close reading practices in science?
4. During the interviews, we discussed professional development. Many teachers noted that ______ and _____ were the primary forms of professional learning that they received in interdisciplinary instruction and close reading. Are there any other types of PD that you participated in to learn about these instructional approaches?
    a. Which were most beneficial?
    b. Which were least beneficial?
5. What further professional development opportunities do you need to integrate interdisciplinary instruction?