2019-04-01

A Content Analysis of Scientific Practices in a Fourth-Grade Commercial Literacy Program

Hailey A. Oswald
Brigham Young University

BYU ScholarsArchive Citation

Oswald, Hailey A., "A Content Analysis of Scientific Practices in a Fourth-Grade Commercial Literacy Program" (2019). *All Theses and Dissertations*. 7410.
https://scholarsarchive.byu.edu/etd/7410

A Content Analysis of Scientific Practices in a Fourth-Grade Commercial Literacy Program

Hailey A. Oswald

A thesis submitted to the faculty of
Brigham Young University
in partial fulfillment of the requirements for the degree of

Master of Arts

Leigh Knight Smith, Chair
Ryan Stephen Nixon
Terrell Alan Young

Department of Teacher Education

Brigham Young University

ABSTRACT

A Content Analysis of Scientific Practices in a Fourth-Grade Commercial Literacy Program

Hailey A. Oswald
Department of Teacher Education, BYU
Master of Arts

Increasing science literacy among all students is a longstanding goal of science education. The most recent national attempt to improve science education, and thereby increase science literacy, came in the form of the *Framework for K-12 Science Education* and the *Next Generation Science Standards*, which include 3 dimensions: scientific and engineering practices, crosscutting concepts, and disciplinary core ideas. The purpose of this content analysis was to examine the alignment between 4 of the scientific practices (Asking Questions; Constructing Explanations; Engaging in Argument from Evidence; and Obtaining, Evaluating, and Communicating Information) and a widely used commercial literacy program, *Reading Wonders*, with the goal of beginning an investigation into whether or not general literacy instruction might be useful in developing science literacy. The science texts and their accompanying recommended instruction in 4th grade *Wonders* were coded and analyzed using categories derived from the key features of each scientific practice. Findings showed partial, although most often minimal, alignment between *Wonders* and each of the four practices. Scientific questions were present in *Wonders*, but rarely asked by students. The analyzed texts included some explanations of how or why scientific phenomena occur, but they were rarely supported by evidence. Similarly, in terms of scientific argument, the texts included some opportunities for students to observe claims being made and supported and to make and support their own claims, but these claims were rarely linked to disciplinary core ideas. Finally, *Wonders* offered many opportunities for students to observe and/or engage in Obtaining, Evaluating, and Communicating Information. However, these opportunities mainly involved obtaining information from a single traditional print text and then summarizing it. Teachers who are hoping to use *Wonders* to help students understand scientific practices should be aware that such integration will require additional planning and instruction. Alignment between *Wonders* and these four practices was minimal and rarely authentic to the discipline of science. Future research should continue the investigation this study began, thereby increasing generalizability, by expanding the focus to include other elementary grade levels, as well as other commercial literacy programs.

Keywords: scientific literacy, scientific practices, literacy education, curriculum integration

ACKNOWLEDGEMENTS

First and foremost, I must express gratitude for my family. If they ever doubted that I would finish this project, they hid those doubts well. Their love, support, and confidence in my abilities sustained me and allowed me to keep going, particularly during the many times my own confidence waivered. I could not have done it without them. I would also like to express appreciation for the many friends and coworkers who expressed an interest in my research and were quick to offer words of encouragement, often at times when I needed them most. Finally, I am exceedingly grateful for the patience and kindness of my committee: Leigh Smith, Terry Young, and Ryan Nixon. They read everything I wrote, offered timely and helpful feedback, and continued to work with me even when I took entirely too long to get things done. This is especially true of Leigh, without whose guidance and support I never would have completed this work and earned my degree.

TABLE OF CONTENTS

CHAPTER 1

Introduction

When President Barack Obama described the present as “our generation’s Sputnik moment” in his 2011 State of the Union address, he was speaking of a need to encourage and support U.S. innovation. Part of his administration’s plan for doing this, as he expressed later in the same address, was to reform education and raise standards for teaching and learning, particularly in the areas of science, technology, engineering, and mathematics (Obama, 2011). The promotion of science education was a recurring theme throughout President Obama’s administration. In each State of the Union address, he emphasized the significance of teaching science, along with engineering, technology, and mathematics, in the interest of preparing students for a new economy and a more competitive world (Obama, 2012, 2013, 2014, 2015, 2016).

The need for high quality science education goes beyond helping the United States compete in a global economy, and the push to improve science education in the United States began long before President Obama’s administration. For example, in 1983 the National Commission on Excellence in Education called for major educational reform in their publication, *A Nation at Risk*, because they found that the United States was losing its edge in science and technological innovation. Seven years later, this idea was reiterated with the publication of *Science for All Americans: Project 2061* (American Association for the Advancement of Science [AAAS], 1990), whose authors proposed that improving science literacy, a long-standing goal of science education, was vital not only for the sake of each individual and of the nation, but also for securing the future of the entire world. They described science literacy as having many facets, including understanding how science, mathematics, and technology depend on each other, understanding key scientific concepts and principles, and understanding scientific ways of thinking. More recently, *Rising above the Gathering Storm*, a report prepared by the Committee on Science, Engineering, and Public Policy (2007), further connected science literacy to issues such as national security and quality of life. Together, these messages confirm that science education, along with its ability to create science-literate students, is of vital importance.

The most recent national attempt to improve science education has come in the form of the *Framework for K-12 Science Education* (hereafter referred to as the *Framework*; National Research Council [NRC], 2012) and the *Next Generation Science Standards* (NGSS; NGSS Lead States, 2013). These publications build upon standards-based reform efforts of the past (e.g., *National Science Education Standards*, NRC, 1996), as well as current reform efforts to adopt common standards in other core subjects (e.g., *Common Core State Standards*, National Governors Association Center for Best Practices & Council of Chief State School Officers [NGA Center & CCSSO], 2010). As the conceptual framework upon which the NGSS were developed, the *Framework* is grounded in the most recent science and science education research and focuses more on the individual, as opposed to national security or global competitiveness. It identifies the science knowledge and practices K-12 students need to learn, with the overarching goal of

> ensur[ing] that by the end of 12th grade, *all* students have some appreciation of the beauty and wonder of science; possess sufficient knowledge of science and engineering to engage in public discussions on related issues; are careful consumers of scientific and technological information related to their everyday lives; are able to continue to learn about science outside school; and have the skills to enter careers of their choice, including (but not limited to) careers in science, engineering, and technology. (p.1)

Clearly, the *Framework* emphasizes the need for science education for all students, not only to prepare them for college and/or career, but also to prepare them for everyday life.

In order to accomplish this, the new standards recommend "that science education in grades K-12 be built around three major dimensions" (NRC, 2012, p. 2). These dimensions are (a) scientific and engineering practices, (b) crosscutting concepts, and (c) disciplinary core ideas. Scientific and engineering practices are the practices scientists and engineers engage in as they "investigate and build models and theories about the world and…design and build systems" (p. 30). They also represent how scientists and engineers "engage in scientific inquiry" (p. 41). The crosscutting concepts are ideas that "have application across all domains of science" (NRC, 2012, p. 30). They serve as "an organizational framework for connecting knowledge from the various disciplines into a coherent and scientifically based view of the world" (p. 83). The disciplinary core ideas represent central or fundamental knowledge in four disciplinary areas: "physical sciences; life sciences; earth and space sciences; and engineering, technology, and applications of science" (p. 2). In order for students to achieve the overarching goals articulated in the *Framework*, these dimensions need to be integrated into curriculum, instruction, and assessment (NRC, 2012).

Unfortunately, providing authentic science learning experiences that integrate all three dimensions may present challenges for teachers. One major challenge for elementary teachers is instructional time. The percentage of time devoted to science instruction in elementary classrooms has significantly declined in the past 20 years (Blank, 2013). Highlighting this issue further, a recent study found that only 20% of teachers in grades K-3 and 35% of teachers in grades 4-6 reported teaching science every day or most days, every week (Banilower et al., 2013). This same survey reported that on the days science was taught, the average amount of instructional time spent on science each day in primary elementary grades was 19 minutes and in intermediate grades, 24 minutes. These are relatively small numbers as compared to the average amount of instructional time devoted to reading/language arts instruction, which was between 80 and 90 minutes every day, and the average amount of instructional time devoted to mathematics instruction, which was about 60 minutes every day (Banilower et al., 2013). It is hard to believe that students could develop a cohesive and rich understanding of the disciplinary core ideas through active engagement in science and engineering practices and the application of crosscutting concepts, in such a comparatively small amount of instructional time (see NRC, 2012).

While it has been documented in some cases that spending less time on science is a matter of teacher choice (e.g., Appleton, 2003), in other cases, teachers may have very little choice. Some school districts mandate how much instructional time should be devoted to each subject (McMurrer, 2008), and some school districts mandate what curricula teachers must use for teaching each subject, which then impacts how much time teachers devote to those subjects (Romance & Vitale, 1992). For example, if a teacher is required by his/her district to use the commercial literacy program *Reading Wonders* (McGraw-Hill, 2014) for all English and language arts instruction, then, based on the suggested amount of time listed in the teacher's edition for each lesson, that teacher will spend at least 135 minutes on literacy instruction every day. Considering that an average school day includes between 300 and 360 minutes of instructional time (National Center on Time and Learning, 2011) and that the elementary curriculum generally also includes mathematics, social studies, science, health, art, physical education, music, computers, and any number of assemblies and other events, teachers might perceive a lack of instructional time available for science.

One possible approach for overcoming this challenge is curriculum integration. While ideas of what it means to integrate different classroom subjects vary, it is commonly agreed that making connections between subjects is a good idea (Hall-Kenyon & Smith, 2013). In this study, curriculum integration is defined as an instructional practice that involves making connections across disciplines in meaningful ways, while still keeping the two disciplines identifiably separate, similar to how Lederman and Niess (1997) have defined *interdisciplinary* instruction. Several studies have been conducted to investigate the ease and effectiveness of integrating literacy instruction with science instruction (e.g., Everett & Moyer, 2009; Romance & Vitale, 1992; Worth, Moriarty, & Winokur, 2004). These studies all focused on beginning with authentic, inquiry-based science instruction and then finding ways to connect literacy instruction. Everett and Moyer (2009) did this by suggesting appropriate times for reading science trade books during science instruction, while Romance and Vitale (1992) and Worth et al. (2004) focused more on science literacy as a disciplinary literacy, emphasizing the ways that literacy instruction already naturally exists within science instruction. Unfortunately, as was pointed out previously, many elementary teachers are required to use commercial literacy programs for literacy instruction and are limited in the amount of time they can devote to authentic science instruction. For these teachers, a study that focuses on curriculum integration by looking for evidence of scientific practices within a commercial literacy program might prove helpful.

Statement of Purpose

Examining the possible connections between literacy education and the NGSS crosscutting concepts and scientific practices is a large task, perhaps best accomplished through multiple studies. Therefore, this study only sought to begin an examination of the connections that might be made between literacy education and four of the scientific practices: Asking Questions; Constructing Explanations; Engaging in Argument from Evidence; and Obtaining, Evaluating, and Communicating Information (NGSS Lead States, 2013). Of the eight scientific practices included in NGSS, these four were chosen because of their strong connections to the *Common Core Standards for English/Language Arts* (CCSS for ELA; NGA Center & CCSSO, 2010), and because they represent what Norris and Phillips (2003) refer to as the fundamental sense of scientific literacy, which is essentially the ability to read and write when the content is science.

Keeping in mind the overarching goal of examining whether or not general literacy instruction might support the development of scientific literacy, the purpose of this study was to look for evidence of these four scientific practices within a widely-used commercial literacy program. Commercial literacy programs, also called scripted literacy programs, basal reading programs (Norris et al., 2008), or core reading programs (Brenner & Hiebert, 2010), are designed to be used during literacy instruction. They include texts for students to read, as well as scripts and lesson plans for teachers to follow. The commercial reading program of focus in this study was McGraw-Hill *Reading Wonders* (hereafter referred to as *Wonders*; 2014), which, according to its publishers, was designed in alignment with CCSS for ELA. As early as second grade, CCSS for ELA includes a standard that states that students will be able to "read and comprehend informational texts, including history/social studies, science, and technical texts" (NGA Center & CCSSO, 2010, p. 13). Assuming that *Wonders* is, in fact, aligned with CCSS for ELA, it should promote at least the fundamental aspect of science literacy, and evidence of these four scientific practices would likely be found in the texts marked in the table of contents as having connections to science. *Wonders* was also worth examining because it is currently being used by districts across the United States (McGraw-Hill Communications Team, 2013).

Research Questions

This study sought to answer the following research questions:

- In what ways do the science texts and their accompanying suggested instruction in the McGraw-Hill reading program, *Wonders* (2014), align with the scientific practice of Asking Questions, as described in the *Framework for K-12 Science Education* and *Next Generation Science Standards*?
- In what ways do the science texts and their accompanying suggested instruction in the McGraw-Hill reading program, *Wonders* (2014), align with the scientific practice of Constructing Explanations, as described in the *Framework for K-12 Science Education* and *Next Generation Science Standards*?
- In what ways do the science texts and their accompanying suggested instruction in the McGraw-Hill reading program, *Wonders* (2014), align with the scientific practice of Engaging in Argument from Evidence, as described in the *Framework for K-12 Science Education* and *Next Generation Science Standards*?
- In what ways do the science texts and their accompanying suggested instruction in the McGraw-Hill reading program, *Wonders* (2014), align with the scientific practice of Obtaining, Evaluating, and Communicating Information, as described in the *Framework for K-12 Science Education* and *Next Generation Science Standards*?

CHAPTER 2

Review of Literature

The purpose of this study was to examine how the science texts and their accompanying suggested instruction in the fourth-grade portion of the McGraw-Hill literacy program, *Wonders* (2014), include four of the scientific practices found in the *Next Generation Science Standards* (NGSS; NGSS Lead States, 2013): Asking Questions, Constructing Explanations; Engaging in Argument from Evidence; and Obtaining, Evaluating, and Communicating Information. This literature review will first discuss science literacy. It will then review how science literacy connects to disciplinary literacy and the *Common Core State Standards for English and Language Arts* (CCSS for ELA; National Governors Association, 2010), as well as how understanding and engaging in scientific practices is a necessary part of becoming scientifically literate. Finally, it will address one challenge elementary teachers face in helping their students become science-literate and a possible strategy for facing that challenge.

Science Literacy

According to DeBoer (1991), the term scientific literacy was first used in science education in the late 1950s and later, for many in science education, became the “watchword of the 1970s” (p. 176). Over the last 30 years, the terms science literacy and scientific literacy have been used, sometimes interchangeably, to describe a variety of educational goals and have been defined over and over again by various science education organizations and researchers. While the definitions differ, at least in wording, a closer look at several examples, such as those included below, reveals a few key ideas or themes that remain constant.

When members of the American Association for the Advancement of Science (AAAS, 1990) described science literacy in *Science for All Americans: Project 2061*, they stated:

> The science-literate person is one who is aware that science, mathematics, and technology are interdependent human enterprises with strengths and limitations; understands key concepts and principles of science; is familiar with the natural world and recognizes both its diversity and unity; and uses scientific knowledge and scientific ways of thinking for individual and social purposes. (Introduction, para. 19)

AAAS also published *Benchmarks for Science Literacy* (1993), which offers a progression for achieving science literacy by outlining what students should know and be able to do in science, mathematics, and technology by the end of grades two, five, eight, and twelve.

The National Research Council (NRC) drew extensively from these two AAAS publications when it created the *National Science Education Standards* (NSES; 1996). A chief goal of the standards was to achieve science literacy for all students. The NSES define science literacy as "knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity. It also includes specific types of abilities" (p. 22). These abilities include, but are not limited to, asking and answering questions; describing, explaining, and predicting natural phenomena; being able to read and analyze information from a variety of scientific texts and engage in social conversations regarding their validity; and posing and evaluating scientific arguments based on evidence. Key similarities between this definition and the definition suggested by the two AAAS publications include the significance of being science-literate for both personal and social reasons, and the idea that science literacy involves not only what students should know, but also what they should be able to do.

Another organization that has explicitly defined science literacy, or scientific literacy, as they have referred to it, is the Organization for Economic Co-operation and Development

(OECD), which created the Programme for International Student Assessment (PISA). PISA is a survey administered every three years to 15-year-old students around the world. Its intent is to test student knowledge and skills in reading, mathematics, science, collaborative problem solving, and financial literacy (OECD, 2016). The main focus of PISA 2015 was scientific literacy, which OECD has defined as:

> The ability to engage with science-related issues, and with the ideas of science, as a reflective citizen. A scientifically literate person is willing to engage in reasoned discourse about science and technology, which requires the competencies to explain phenomena scientifically, evaluate and design scientific enquiry, and interpret data and evidence scientifically. (2016, p. 13)

Similar to the definitions of science literacy already mentioned in the AAAS and NRC publications, this definition's use of the term "reflective citizen" implies that science literacy is important for all students, not only for those planning to pursue further education and/or careers in science-related fields. The assessment aims to measure knowledge and competencies in personal, local/national, and global contexts (OECD, 2016). This definition of science literacy, like the others, includes increasing students' understanding of both science concepts and scientific practices, or skills.

In addition to these organizations' definitions, one can find definitions of science, or scientific, literacy from various science education researchers. For example, Bybee (1995) described three different dimensions of scientific literacy: (a) functional, which involves the ability to read and write scientific passages; (b) conceptual and procedural, which involves understanding of conceptual ideas across fields and disciplines of science as well as understanding and being able to engage in the practices and processes of science; and (c) multidimensional, which includes understanding the nature of science, the history of science, and the role science plays in personal lives and in society. These second two dimensions express ideas similar to those already mentioned in the definitions of science literacy given by organizations, but the first dimension expresses a new idea. It connects science literacy to a traditional definition of general literacy: fluency in reading and writing printed texts (Draper & Siebert, 2010).

Similar to Bybee, Norris and Phillips (2003) offered a definition of what they termed scientific literacy with more than one dimension, or sense. They referred to these senses as the *fundamental* sense of scientific literacy and the *derived* sense of scientific literacy. The fundamental sense is similar to Bybee's (1995) first dimension. It refers to being able to read and write in the context of science. The derived sense involves "being knowledgeable, learned, and educated in science" (p. 224). Norris and Phillips described the relationship between the two senses as intrinsic, saying, "Reading and writing are inextricably linked to the very nature and fabric of science" (p. 226). Both are necessary in science education.

Osborne (2007) agreed with the two-dimensional definition of scientific literacy put forth by Norris and Phillips (2003). He stated that science education requires understanding of "the scientific content…the scientific approach to enquiry…and science as a social enterprise" (p. 177). These are the same ideas that were commonly expressed in the organizations' definitions mentioned previously. In further explaining his own definition of scientific literacy, Osborne (2007) described how interpretation and argumentation are central to scientific inquiry, thus reinforcing the significance of being literate in science in both the fundamental and the derived senses.

Finally, Roberts and Bybee (2014) sought to clarify definitions of science literacy by differentiating between science literacy, which they referred to as Vision I, and scientific literacy, which they referred to as Vision II. Vision I, they argue, refers to literacy within science. It involves “general familiarity and fluency within the discipline, based on mastering a sampling of the language, products, processes, and traditions of science itself (Roberts & Bybee, 2014, p. 546). With Vision I, the main goal of science education is to prepare future scientists and engineers. Vision II involves becoming literate in science with an increased focus on understanding societal issues. With Vision II, the main goal of science education is less about preparing students to study advanced science and more about making students competent outsiders, able to critically read about and discuss science-related issues and to apply scientific understanding in personal, social, and global contexts (Roberts & Bybee, 2014).

The views of science literacy expressed by these researchers, along with common ideas and themes from the other definitions of science literacy described earlier in this section, were used to determine how science literacy would be defined for the purposes of this study. First, science literacy is vital in personal, social, and global contexts, which makes it a necessity for all students (AAAS, 1990; Bybee, 1995; NRC, 1996; OECD, 2016). Second, science literacy requires both the understanding of science concepts and principles and the understanding of scientific processes and practices (AAAS, 1990; Bybee, 1995; Norris & Phillips, 2003; NSES, 1996), which together comprise what Norris and Phillips termed the derived sense of science literacy. Third, science literacy also involves fundamental literacy within the discipline of science. In other words, science literacy requires fluency in the language of science, including being able to read, write, analyze, and interpret scientific texts (Bybee, 1995; Norris & Phillips, 2003; Osborne, 2007).

Disciplinary Literacy and the CCSS for ELA

Given this three-part definition of science literacy, it becomes easier to make connections between the goals of K-12 science education and the goals of K-12 literacy education. Science literacy, particularly in its fundamental sense, might be thought of as a specific type of what literacy educators have recently come to refer to as disciplinary literacy. Shanahan and Shanahan (2014), for example, described disciplinary literacy as “the idea that we should teach specialized ways of reading, understanding, and thinking used in each academic discipline, such as science, history, or literature. Each field has its own ways of using text to create and communicate meaning” (p. 636). This relates to what Gee (2001) described as the “Discourse” of a discipline, which “integrates ways of talking, listening, writing, reading, acting, interacting, believing, valuing, and feeling (and using various objects, symbols, images, tools, and technologies)” (p. 719). Moje (2008) encouraged secondary teachers to “reconceptualize learning in subject areas as a matter of learning the different knowledge and ways of knowing, doing, believing, and *communicating* [emphasis added] that are privileged to those areas” (p. 99). Thus, part of helping students become science-literate involves teaching them to read, write, speak, and think within the Discourse of science.

Reading, Writing, and Speaking and Listening are three of the four strands that make up the CCSS for ELA (NGA Center & CCSSO, 2010). The CCSS, which have been adopted in 41 states, were created to “ensure that all students graduate from high school with the skills and knowledge necessary to succeed in college, career, and life, regardless of where they live” (Council of Chief State School Officers and National Governors Association, 2017, par. 1). These standards include a stronger emphasis on reading and writing informational texts than previous literacy standards, an emphasis which becomes more pronounced as students progress through their K-12 education. Being able to read and comprehend science and technical texts is included in these standards beginning in grade two. The fourth-grade Reading: Informational Texts standards include that students should be able to "explain events, procedures, ideas, or concepts in a historical, *scientific* [emphasis added], or technical text" and interpret information presented quantitatively in charts, graphs, or diagrams (NGA Center & CCSSO, 2010, p. 14). By grade six, disciplinary literacy becomes a major focus. The CCSS for ELA Science and Technical Subjects Standards for grades 6-12 recommend that students should be able to (a) understand and follow procedures in experiments, (b) "determine the meaning of symbols, key terms, and other domain-specific words and phrases," and (c) comprehend multimodal texts, such as charts, diagrams, models and tables (p. 62).

Since the implementation of new literacy standards, some debate has arisen in secondary education concerning who is responsible for teaching disciplinary literacy (Draper, Smith, Hall, & Siebert, 2005). Gee (2001) stated that learning the Discourse of a discipline requires engaging in meaningful practice. This might suggest that the best time and place for learning science literacy occurs during science instruction, as students are participating in investigations and scientific practices. Draper and Siebert (2010) supported this idea when they wrote, "The responsibility to teach adolescents how to read and write discipline-specific texts falls squarely on the shoulders of content-area teachers" (p. 34). Their assertion was based on broad definitions of text and literacy, wherein text is "any representational resource or object that people intentionally imbue with meaning, in the way they create or attend to the object, to achieve a particular purpose" (p. 28). Literacy, then, is being able to "negotiate (e.g., read, view, listen, taste, smell, critique) and create (e.g., write, produce, sing, act, speak) texts in discipline-appropriate ways or in ways that other members of a discipline (e.g., mathematicians, historians, artists) would recognize as 'correct' or 'viable'" (p. 30). These authors were not suggesting that content-area teachers start teaching general literacy strategies or devote more time to reading science textbooks. Instead, secondary science teachers should be teaching students to read, write, and communicate like scientists, in ways and contexts authentic to the discipline.

Some research has shown evidence that explicit literacy instruction along with engaging students in the practices of science has improved students' subject matter knowledge as well as their ability to read science text. For example, Fang and Wei (2010) conducted a study to determine whether or not including explicit literacy instruction in intermediate grade science classrooms would have a significant impact on student attitudes and achievement. Sixth grade students in both the experimental group and the control group were taught science through inquiry. Unlike the control group, however, the students in the experimental group also received explicit literacy instruction each week related to the investigative work they were doing in class. These 20-30 minute reading lessons focused on specific reading strategies, such as predicting, questioning, note taking, and recognizing genre features. Students were also encouraged to read science trade books outside of class that focused on related content. The study found that students who received inquiry-based science instruction infused with that small amount of reading performed better on reading and science assessments at the end of the investigation and had better science grades overall as compared to students who did not receive explicit literacy instruction.

While disciplinary literacy has mainly been a focus in secondary education research, other research suggests that even young children can think like scientists and learn science by doing science (Houseal, Gillis, Helmsing, & Hutchison, 2016). This is perhaps part of the reason that teaching students to read and write scientific texts is included in the elementary CCSS for

ELA. Shanahan and Shanahan (2014) recommend that students in upper elementary grades should read at least 50% informational texts, with a variety of types, modalities, and purposes, and learn to identify differences among them as well as differences between them and literary texts. According to *Literacy in Science*, a report published by the NRC in 2014, literacy in science was included in the new literacy standards not only so that secondary students might better comprehend science texts, but also "to ensure that science retained a meaningful place in elementary grades" (p. 15). All of this suggests a need for studies such as this one, which might help disciplinary literacy become more of a focus in elementary education research.

Connections Between the NGSS and the CCSS for ELA

The adoption of common standards in language arts and mathematics by a large number of states helped to create an opportunity for change in national science standards (NRC, 2012). The NSES (1996) had established a solid foundation in science education standards, but progress in science, as well as a growing body of research on the teaching and learning of science provided cause for revision (NRC, 2014). Thus, not long after the publication of the CCSS, the Carnegie Corporation of New York and the Institute for Advanced Study called for common science standards, and work began. First came the publication of a conceptual framework for these standards, *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (NRC, 2012). Next, based on the *Framework*, came the publication of the *Next Generation Science Standards* (NGSS Lead States, 2013).

The *Framework* and NGSS represent the most recent attempt at improving science education for K-12 students in the United States. Because NGSS was written after the CCSS, its development team was able to work with the CCSS writing team to identify connections between the two standards documents, theoretical connections that had been developed cooperatively over time among researchers in both science and literacy education (e.g., NRC, 2006; NRC, 2007). Connections to specific CCSS standards and objectives are included throughout NGSS and are explained in-depth in accompanying *Appendices L: Connections to CCSS-Mathematics* and *M: Connections to CCSS-Literacy in Science and Technical Subjects* (NGSS Lead States, 2013). For example, a chart included in *Appendix M* suggests a connection between CCSS Reading Anchor Standard Eight, an Integration of Knowledge and Ideas standard, which states that students should be able to “delineate and evaluate the argument and specific claims in a text, including the validity of the reasoning as well as the relevance and sufficiency of the evidence” (NGSS Lead States, 2013, p. 164) and Scientific Practice Seven, which is Engaging in Argument from Evidence (described more thoroughly in a following subsection).

The science standards documents introduce three dimensions that must be “integrated into standards, curriculum, instruction, and assessment” to help K-12 students achieve science literacy (NRC, 2012, p. 2). These dimensions are (a) Scientific and Engineering Practices, which include eight major practices scientists and engineers employ as they investigate the natural world and design and build systems; (b) Crosscutting Concepts, which are seven unifying concepts and processes that have applications across all domains of science; and (c) Disciplinary Core Ideas, which include the science content knowledge students should learn in the domains of life science, physical science, earth and space science, and engineering, technology, and applications of science.

Although meaningful teaching and learning in science and engineering require the combination of all three dimensions (NRC, 2012), this study focused mainly on exploring how aspects of the fundamental sense of science literacy (Norris & Phillips, 2003), meaning reading, writing, speaking, and listening in the context of science, are represented in the scientific practices. This is because education researchers have suggested significant overlap between scientific practices and literacy skills (e.g., Everett & Moyer, 2009; Romance & Vitale, 1992; Worth et al., 2004). Specifically, this study focused on the scientific practices of Asking Questions; Constructing Explanations; Engaging in Argument from Evidence; and Obtaining, Evaluating, and Communicating Information. These four practices were chosen because of their strong connections to the CCSS for ELA. The following subsections will more fully describe these four practices and those connections.

Asking questions. The *Framework* describes "the ability to ask well-defined questions" as "an important component of science literacy" for all students, not only for those planning to become scientists or engineers. Questions are "the engine that drives science and engineering" (NRC, 2012, p.54). In science, the questions students and teachers ask should guide inquiry, seek to refine models or explanations, and/or challenge the premises of arguments (NRC, 2012). This makes asking questions a critical starting point because it leads students into other scientific practices, including investigating and explaining phenomena. In turn, the practices of planning and carrying out investigations and constructing explanations lead to asking even more questions, thus making asking questions an ongoing process (Reiser, Brody, Novak, Tipton, & Adams, 2017).

Viewing NGSS online, one will find that each standard is presented in a table along with its related scientific practice(s), crosscutting concept(s), and disciplinary core idea(s). Connections to CCSS for ELA are included in a separate section at the bottom of the table. One science standard that clearly focuses on the scientific practice of Asking Questions is 4-PS3-3, which requires students to "ask questions and predict outcomes about the changes in energy that occur when objects collide" (NGSS Lead States, 2013, p. 35). The included CCSS for ELA connections are both writing standards. These standards focus on students being able to conduct research projects, recalling and gathering information from a variety of sources in order to investigate a topic. In elementary classrooms, both in reading and in science, asking questions is a vital practice for students as it leads them to investigate various topics and phenomena.

Constructing explanations. According to the *Framework* (NRC, 2012), this scientific practice requires students to be able to construct their own explanations of natural phenomena using accepted theories, models, and evidence, as well as to analyze the explanations of others. McNeill, Berland, and Pelletier (2017) stated, “Explanations focus on a specific question about a phenomenon and construct a how or why account for that phenomenon” (p. 207). They went on to say that engaging in this practice is important for students because it helps them develop a stronger understanding of the natural world and helps them understand how scientists produce knowledge in the real world.

One example found in NGSS that focuses on Constructing Explanations is standard 4-PS3-1: “Use evidence to construct an explanation relating the speed of an object to the energy of that object” (NGSS Lead States, 2013, p. 35). Six related CCSS for ELA standards are listed, including three reading informational text standards and three writing standards. One of these is RI.4.3, which states, “Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text” (NGA Center & CCSSO, 2010, p. 14). The wording of this standard shows a strong connection to the three key elements of a scientific explanation: It (a) answers a question about a phenomenon, (b) explains how or why the phenomenon occurs, and (c) is based on evidence (McNeill et al., 2017).

Engaging in argument from evidence. Reasoning and argumentation are a huge part of the Discourse of science. Scientists present and defend their own arguments, and they look for weaknesses or limitations in the arguments of their fellow scientists. Goals included in the *Framework* for this standard require students to do both of those things, as well as to recognize weaknesses in their own arguments and make revisions, and to read critically science texts they might encounter in the media (NRC, 2012). Berland, McNeill, Pelletier, and Krajcik (2017) point out that this scientific practice is important for students because it allows them to be "part of the process of developing new ideas by revising old ones," making them knowledge producers and critical consumers (p. 232). In a classroom setting, it "entails making and supporting claims, evaluating one another's ideas, and working toward reconciling their differences" (p. 231).

A CCSS for ELA standard that most closely relates to this scientific practice is W.4.1, which requires students to "write opinion pieces on topics or texts, supporting a point of view with reasons and information" (NGA Center & CCSSO, 2010, p. 20). While opinion pieces and argumentative writing, as represented in CCSS for ELA, are certainly not the same as scientific arguments (Lee, 2017), the literacy standards do suggest that students' reasons are supposed to be supported by facts and details, which makes this standard similar to the part of scientific argumentation that includes making and supporting a claim. There is also a reading standard related to this scientific practice. RI.4.8 requires students to "explain how an author uses reasons and evidence to support particular points in a text" (NGA Center & CCSSO, 2010, p. 14), which is similar to evaluating one another's ideas. While the CCSS for ELA do not appear to include the third component of scientific argumentation, which is "working toward reconciling their differences" (Berland et al., 2017, p. 231), they do include speaking and listening standards that require students to engage in collaborative conversations (NGA Center & CCSSO, 2010). It is conceivable that such conversations could involve evaluating each other’s arguments and reaching a consensus.

Obtaining, evaluating, and communicating information. The description of this practice in the *Framework* emphasizes that “reading, interpreting, and producing texts are fundamental practices of science in particular, and they constitute at least half of engineers’ and scientists’ total working time” (NRC, 2012, p.74). Science texts contain discipline-specific vocabulary and are structurally different from other texts, which can make them challenging for students to comprehend. According to Bricker, Bell, Van Horne, and Clark (2017), the practice of Obtaining, Evaluating, and Communicating Information “involves students in gathering, critically examining, and using resources to further their collective investigations and sense-making about the natural and designed world” (p. 261). These researchers also address the importance of students engaging in this practice as a part of authentic science activity. Students might evaluate information they have obtained through reading about the investigations of scientists, or through conducting their own investigations. Communicating information might involve documenting their investigative process, recording and interpreting data, or formally sharing the results of their investigations in a written report or presentation.

One clear connection to this scientific practice in CCSS for ELA is writing standard 4.2, which requires students to write informative/explanatory texts. It involves developing a topic with “facts, definitions, concrete details, quotations, or other information and examples” (NGA Center & CCSSO, 2010, p. 20). Mastering this standard also requires the correct use of domain-specific vocabulary. While mastery of this writing standard would require students to learn how to obtain information from multiple sources, determine whether or not those sources are trustworthy, and then communicate their findings in written or oral reports or presentations, it leaves out the part of this scientific practice wherein a person would obtain information from his/her own investigations and observations. Also missing is the component of this scientific practice that involves evaluation of the findings of others.

Science in an Elementary School Setting

Understanding and engaging in the scientific practices, including those just described, is key to developing scientific literacy. *Appendix D: All Standards, All Students* in NGSS states, "Engagement in these practices is also language intensive and requires students to participate in classroom science discourse" (NGSS Lead States, 2013, p. 29), so it demands language learning at the same time it supports science learning. Additionally, the *Framework* and NGSS suggest that providing students with authentic opportunities to participate in the practices of science and engineering to investigate and make sense of crosscutting concepts and disciplinary core ideas can also strengthen student understanding in mathematics (NRC, 2012; NGSS Lead States, 2013).

Unfortunately, facilitating authentic, three-dimensional science learning can be difficult in an elementary setting, in part because science instruction tends to receive less time than language arts and mathematics instruction (Blank, 2013). This has been the case for decades, but was perhaps made worse between 2000 and 2007, when the No Child Left Behind Act required schools to demonstrate adequate yearly progress on standardized literacy and mathematics tests (Griffith & Scharmann, 2008; Jennings & Rentner, 2006). Blank's (2013) study showed that in 2008 elementary teachers devoted about 28 minutes per day to science instruction, while they spent over an hour on math and over two hours on language arts and reading. Also, while most teachers reported teaching language arts and mathematics every day, only 20-35% reported teaching science every day or most days (Banilower et al., 2013).

NGSS suggest that because engagement in the scientific practices has such great potential to strengthen student understanding in literacy and mathematics, devoting extra time to these subjects at the expense of science instruction is unnecessary (NGSS Lead States, 2013). Indeed, Romance and Vitale (1992) provided evidence of this long before the NGSS existed. Recognizing strong overlap between science thinking and process skills and applied literacy skills, they investigated the effect of replacing the district-adopted basal reader with science-content-based reading instruction and in-depth science instruction. The result was that their experimental group performed better than the control group on both reading and science assessments. And yet, 25 years later, many elementary teachers are still using basal reading programs.

Unfortunately, decisions regarding whether or not to use a commercial literacy program for ELA instruction and how much time to devote to each subject are not always made by teachers. Instead, they are often made by school district leaders (McMurrer, 2008). When that is the case, and a teacher finds him/herself with little time for science instruction, curriculum integration may offer a partial solution.

Curriculum Integration: Science and Literacy

In education, there is no single, agreed-upon conceptualization or definition of curriculum integration, as is evidenced by the number of words used when describing it: “interdisciplinary, multidisciplinary, transdisciplinary, thematic, integrated, connected, nested, sequenced, shared, webbed, threaded, immersed, networked, blended, unified, coordinated, and fused” (Czerniak & Johnson, 2014, p. 399). While some researchers (e.g., Beane, 1996; Hall-Kenyon & Smith, 2013) have suggested fairly specific, working definitions of curriculum integration, others have asserted that curriculum integration exists on a continuum, with disciplines being taught in isolation at one end, and the lines between disciplines being blurred during instruction at the other end (e.g., Victor, Kellough, and Tai, 2008). For the purposes of this study, integration was defined as an instructional practice that would fall somewhere in the middle of that continuum, an idea similar to what Lederman and Niess (1997) called *interdisciplinary* instruction. This type of integration makes connections across disciplines in meaningful ways, but the two disciplines remain identifiable. For example, a fourth-grade teacher might plan an integrated lesson wherein students study diagrams of fossils in rock layers and then use the evidence they find to explain how the landscapes represented in those diagrams have changed over time. This activity could help students meet an objective related to 4-ESS1-1 (NGSS Lead States, 2013). If the fourth-grade teacher began the lesson by teaching students about the diagrams themselves and discussing how they contribute to the text as a whole, this activity could also help students meet an objective related to CCSS.ELA-Literacy.RI.4.7 (NGA Center & CCSSO, 2010). Defining integration in this way seemed to compliment the purpose of the study, which was to look for evidence of scientific practices in a commercial literacy program.

As has been evidenced in previous sections of this literature review, examination of the connections between science education and literacy education is not a new idea in educational research. Science literacy, in its fundamental sense, can perhaps be thought of as a specific type of disciplinary literacy, and developing a student's ability to read and write scientific texts is included in the CCSS for ELA (NGA Center & CCSSO, 2010). Research studies examining the ease and effectiveness of integrating science and literacy have already been conducted. For example, as was mentioned previously, Fang and Wei (2010) found that infusing inquiry-based science instruction with even a small amount of reading instruction could lead to improved performance on science and reading achievement tests. Romance and Vitale (1992) also provided evidence that replacing 90 minutes of basal reading instruction and 30 minutes of science instruction with 120 minutes of in-depth, hands-on science instruction that included teaching naturally-imbedded ELA skills, could also lead to higher achievement on standardized science and reading tests.

Because such evidence of the effectiveness of integration exists, conducting research that investigates the connections between commercial reading programs, which many elementary teachers continue to rely upon (Norris et al., 2008), and the three dimensions of science learning (NRC, 2012; NGSS Lead States, 2013) is worthwhile. This study contributed to that research which has shown that (a) more recently published basal readers include more science content than those published before the turn of the century (Anthony, 2009), and (b) current commercial reading programs include enough accurate science content and the right genres to help students learn to read scientific texts (Norris et al., 2008). These studies both focused on making connections to science content knowledge within reading instruction. In contrast, this study focused on the possibilities of making connections to scientific practices within reading instruction.

CHAPTER 3

Methods

The purpose of this study was to describe how four of the scientific practices (NRC, 2012), those that seem most closely associated with literacy, are included in a widely used, elementary-level literacy program. Specifically, it sought to answer four research questions, all focused on describing the ways in which the science texts and their accompanying suggested instruction in the McGraw-Hill reading program, *Wonders* (2014), align with the scientific practices of Asking Questions; Constructing Explanations; Engaging in Argument from Evidence; and Obtaining, Evaluating, and Communicating Information, as described in the *Framework for K-12 Science Education* and *Next Generation Science Standards*. The following sections will discuss the research design and procedures.

Research Design

To address the research question, this study employed qualitative content analysis. Stemler (2001) defined content analysis as “a systematic, replicable technique for compressing many words of text into fewer content categories based on explicit rules of coding” (p. 1), and expressed that it is particularly useful for sifting through large quantities of data and for determining the focus of an individual, group, or institution. Krippendorff (2004) stated that content analysts “examine data, printed matter, images, or sounds—texts—in order to understand what they meant to people, what they enable or prevent, and what the information conveyed by them does” (p. xviii). He differentiated qualitative approaches from quantitative approaches, explaining that qualitative approaches require close reading of relatively small quantities of text and might involve rearticulating and/or reinterpreting those texts (Krippendorff, 2004).

Other researchers have offered further explanation of qualitative content analysis. Sandelowski (2000), for example, referred to it as "qualitative description" and described it as offering a comprehensive summary, with more inferencing than traditional quantitative content analysis. Hsieh and Shannon (2005) defined it as "a research method for the subjective interpretation of the content of text data through the systematic classification process of coding and identifying themes or patterns" (p. 1278). Similarly, Zhang and Wildemuth (2009) asserted that it "goes beyond merely counting words or extracting objective content from texts to examine meanings, themes and patterns that may be manifest or latent in a particular text" (p.1). It emphasizes description, rather than numbers and statistics (Sandelowski, 2000; Zhang & Wildemuth, 2009), and has been described as being "especially amenable to obtaining straight and largely unadorned answers to questions of special relevance to practitioners and policy makers" (Sandelowski, 2000, p. 337). In essence, these scholars suggest that qualitative content analysis allows the researcher to describe and summarize data in a meaningful way, using themes and patterns within the data to make inferences and answer questions. That made it a good fit for this study because it provided a way to describe and summarize texts in McGraw-Hill *Wonders* such that teachers will be able to see if the program might be useful in helping their students achieve higher levels of science literacy, as well as general literacy.

Data Source

The data for this study were taken from *Wonders*, a comprehensive K-6 literacy program published by McGraw-Hill (2014), which is, according to the publishers, designed to align with the *Common Core State Standards for English and Language Arts* (NGA Center & CCSSO, 2010). The fourth-grade version of *Wonders*, which is the specific data set that was analyzed for this research, includes a teacher's edition for each of its six instructional units and two student texts: a reading/writing workshop textbook and a literature anthology. Each unit is designed to take six weeks of instructional time. The teacher's edition includes a unit overview and suggested lesson plans for each week that include instruction in phonics/decoding, vocabulary, fluency, comprehension, writing, grammar, and spelling. It also includes ideas for differentiating instruction and providing support for English Language Learners. These lesson plans include objectives taken directly from CCSS for ELA (NGA Center & CCSSO, 2010). They outline what teachers should do and say throughout the lesson and include the related student texts and worksheets (McGraw-Hill, 2014).

Because the purpose of this study was to determine in what ways the fourth-grade version of *Wonders* might include certain scientific practices (NRC, 2012), data analysis focused on explicitly-labeled science texts from the reading/writing workshop textbook and literature anthology, as well as the accompanying lesson plan pages for those texts, which are found in the teacher's editions. In the fourth-grade *Wonders* reading/writing workshop textbook, ten weeks are identified as focusing on science. While the majority of the texts students will read during those weeks are labeled as either expository or narrative nonfiction, several other genres are also listed, including science fiction, myths, biography, and procedural texts. Data for this study consisted of 40 student texts and their accompanying lesson plans included in the ten weeks of instruction, which means analysis focused on 394 pages, or about 35 percent of the fourth-grade program for whole group instruction. (McGraw-Hill, 2014).

Data Analysis

This study utilized a summative approach to content analysis (Hsieh & Shannon, 2005). Similar to quantitative content analysis, it began with an attempt to determine frequency of words and ideas related to the four scientific practices included in the research questions. It also included latent content analysis, an approach that relies more on interpretation and focuses on meanings, themes, and patterns (Zhang & Wildemuth, 2009). Goals included being systematic, but not rigid (Altheide, 1987); identifying frequencies and analyzing data simultaneously (Sandelowski, 2000); and keeping all inferences grounded in data (Zhang & Wildemuth, 2009).

Trustworthiness. Several requirements have been suggested to ensure the trustworthiness of qualitative content analysis. A reliable study must show credibility, stability, and reproducibility (Graneheim & Lundman, 2004; Hsieh & Shannon, 2005; Zhang & Wildemuth, 2009). *Credibility* deals with how well the data source, collection, and analysis address the intended focus of the research (Graneheim & Lundman, 2004, Zhang & Wildemuth, 2009). It was achieved in this study by clearly defining rules for coding, with guidance and support from science and literacy education experts. *Stability* and *reproducibility* relate directly to the coding process. Stability refers to a researcher's tendency to re-code data in the same way over an extended period of time (Busch et al., 2017), and reproducibility, similar to inter-rater reliability, refers to the tendency of a group of researchers to define categories and code data in the same way as each other (Busch et al., 2017; Stemler, 2001). To ensure stability, the researcher selected a sample to code at the beginning of data analysis, and then again toward the end, addressing discrepancies as needed. To ensure reproducibility, the primary researcher and an expert in elementary science education used the rules and procedures for coding to code a few different sample texts. They then compared results, finding that they had matched 90% of the time, and resolved any disagreements before the primary researcher completed the rest of the data analysis.

In a qualitative content analysis, data are analyzed in a series of steps or phases. Altheide (1987) described the process as reflexive and highly interactive for the researcher. It should be systematic and replicable, with data analysis and interpretation happening throughout the process. The following sections describe phases for data analysis in this study.

Phase I: Establish coding categories. The first step in data analysis for this study involved creating codes for a priori coding categories. These are categories established by the researcher beforehand, based on existing research or theory (Stemler, 2001). In this study, the a priori categories were derived from four of the eight scientific practices included in the *Framework* and NGSS: (a) Asking Questions; (b) Constructing Explanations; (c) Engaging in Argument from Evidence; and (d) Obtaining, Evaluating, and Communicating Information (NGSS Lead States, 2013; NRC, 2012). The a priori coding categories established for this study focused on key elements of each scientific practice. For example, key elements of the scientific practice of Asking Questions include that the questions should be explanatory in nature, guide student inquiry, and be asked by both teachers and students (Reiser et al., 2017). A detailed description of each a priori coding category, along with examples representative of what may be found in the text and rules for coding, is included in Appendix A.

Phase II: Create coding procedures. Once a priori coding categories were established, they were used to create a coding form that would allow the researcher to systematically read and code the data, keeping track of the presence of scientific practices using recording units. Recording units are “units that are distinguished for separate description, transcription, recording, or coding” (Krippendorff, 2004, p. 99). Content analysts use them to “capture meaningful variations” and “obtain reliable accounts of larger units of texts” (p. 100). Recording units in this study were units of meaning, which might have included words, phrases, sentences, or other representations, such as charts or pictures, that explicitly or implicitly relate to one of the scientific practice categories. A coding form can be found in Appendix B. The first two columns of the form allowed the researcher to indicate the book from which each unit came (i.e., teacher's edition, reading/writing workshop textbook, or literature anthology) and describe specifically where it is located in the text (e.g., page and paragraph numbers). The remaining columns were for marking which elements of each practice were present.

Phase III: Code a sample of the text. Because the analysis used in this study was interpretive, and therefore potentially subject to bias, this phase was meant to strengthen the credibility or trustworthiness (Shenton, 2004) of the study by using a process that has been called "reproducibility" (Stemler, 2001). It involves establishing a scheme where the text being analyzed will be coded the same by different people. The researcher and a science education expert used the rules for coding to analyze a representative sample of the text. They then compared analyses and discussed any areas of discrepancy, repeating this procedure until they reached consensus.

Phase IV: Read and code all of the text. During this phase, the primary researcher carefully and systematically read each identified science text in fourth-grade *Wonders*, highlighting and coding instances that related to or showed evidence of the scientific practices, as described in Appendix A. Each of these highlighted instances was then reread and recorded on the coding form. Instances where the text provided students with an opportunity to observe elements of the scientific practices were marked with an 'O' in the appropriate column on the coding form. Instances where the text suggested the teacher ask students to engage in a scientific practice were marked with an 'E'. This step was significant because true understanding of scientific practices, a key component of science literacy, cannot be achieved by only observing those practices. Students must engage in the practices themselves (NRC, 2012).

Throughout the coding process, categories were modified and added as needed, to ensure that they were mutually exclusive and exhaustive (Stemler, 2001). The original code SP1B, meant to indicate instances when both teachers and students were involved in asking questions, was eliminated. Instead, in an attempt to more accurately represent the data, questions asked by teachers were marked with a 'T' on the coding form; questions asked by students were marked with an 'S'; and questions within the student text were marked with an 'I'. Additionally, because the coding process revealed a great deal of overlap between the categories indicated by the codes SP6Q and SP6HW, these two categories were combined and all coded as SP6Q. This code was used to indicate any instances in which explanations were present in the text that answered a question about a phenomenon, perhaps including how or why it occurs. Finally, the a priori category related to Communicating Information was split into two categories, SP8CV and SP8CW, in order to differentiate between verbal and written forms of communication. These categories and changes are more fully explained in Appendix C and are summarized in Table 1, which is included with all other tables in Appendix D.

Phase V: Analyze the results of the coding process. The final phase in data analysis involved determining frequency and drawing conclusions. The researcher used the coding sheet to determine how many times each key element of each scientific practice appeared in each of the *Wonders* science texts and its accompanying lesson plans. If all of the key elements were present in a text, the scientific practice was considered fully represented in that text. If one or more key elements were missing, the practice was considered only partially present or not at all present. These numbers could then be compared across the texts labeled as science texts in *Wonders* to gain insight into whether or not some science texts aligned with the scientific practices better than others. Identifying if a scientific practice was fully, partially, or not at all present in each *Wonders* science text would help the researcher better describe in what ways the reading program aligns with scientific practices overall.

Limitations

Focusing on one grade level of a single commercial reading program limits the scope of the study's findings. While this examination might be representative of the program, the findings lack generalizability across all grade levels, particularly the primary grades. Also, findings are likely not representative of all commercial literacy programs.

The Researcher

Because qualitative content analysis relies so much on interpretation, it is impossible for a researcher's analysis to not be influenced by his or her perspective and personal history (Graneheim & Lundman, 2004). With this in mind, it is necessary to describe the parts of my personal history that might influence my interpretations throughout the course of this study.

I hold a bachelor's degree in elementary education and am currently working toward a master's degree in teacher education, with an emphasis in STEM (science, technology, engineering, and mathematics). I have completed all of the coursework for my master's program, including classes focused on best practices in teaching the STEM subjects.

I have taught at an elementary level for the last eleven years—mostly in fifth grade, currently in fourth. Though I remember very little of my own elementary science education being inquiry-based, my experiences in learning how to teach science have led me to see the value of inquiry-based instruction. They have also helped me acquire the tools and instructional practices needed for engaging my students in inquiry-based science learning. Throughout my career, I have had varying levels of freedom to plan and teach my own units and lessons in reading, mathematics, and science. Some years I have been told to follow district-approved textbooks and curriculum materials closely. Other years I have experienced more flexibility.

CHAPTER 4

Findings

This qualitative content analysis was conducted in order to describe ways in which the explicitly-labeled science texts and their accompanying suggested instruction in the fourth grade version of the McGraw-Hill reading program, *Wonders* (2014), align with the scientific practices of Asking Questions; Constructing Explanations; Engaging in Argument from Evidence; and Obtaining, Evaluating, and Communicating Information, as described in the *Framework for K-12 Science Education* (NRC, 2012) and *Next Generation Science Standards* (NGSS Lead States, 2013). The findings of this study, separated by scientific practice, are discussed in the following sections.

Asking Questions

Reiser et al. (2017) suggested that there are three key features to the scientific practice of Asking Questions. Two of these features relate to the nature of the questions themselves. First, in order to be considered scientific, questions should be explanatory, meaning that they get at how and why a phenomenon occurs. Second, they should guide student inquiry by helping identify what needs to be investigated about a phenomenon. An example of an explanatory question might be, “Why don’t the planets and other objects fly off into space away from the sun?” (McGraw-Hill, 2014, Unit 4, Week 4, p. T217F). An example of a question that has the potential to guide student inquiry might be, “Which skater will travel farther when released down the ramp?” (McGraw-Hill, 2014, Unit 1, Week 4, p. T217O).

Findings related to the scientific practice of Asking Questions are summarized in Table 2. Of the 123 scientific questions included in the portions of *Wonders* that were the focus of this study, 97 (78.86%) were explanatory in nature, and 26 (21.14%) had the potential to lead to scientific investigation. In Table 2, data are separated by unit and week. Only those weeks of each unit that were labeled “science” were included in this study. Of those weeks, the fifth week of Unit 3, the third week of Unit 4, and the third week of Unit 6 did not contain any explanatory questions. The fourth week of Unit 2 and the third week of Unit 4 did not include any questions that had potential to lead to scientific investigations. This means that the third week of Unit 4 contained no scientific questions, and, therefore, does not even partially align with the scientific practice of Asking Questions. The weeks containing the most scientific questions were Unit 1, Week 4 (44 questions) and Unit 4, Week 4 (21 questions), suggesting that the content included in these two weeks may show the most alignment with the scientific practice of Asking Questions.

The third key feature of Asking Questions described by Reiser et al. (2017) focuses on who asks the questions. In a classroom setting, the role of asking questions is critical for both teachers and students. As is shown in Table 2, overall, the majority (95.93%) of scientific questions asked in the *Wonders* texts analyzed for this study are either teacher questions (50.41%) or in-text questions (45.53%). In-text questions are those printed in student texts, either the reading/writing workshop textbook or the literature anthology. In all of the analyzed content, students were encouraged to ask scientific questions only five times (4.07%). Interestingly, the two weeks mentioned previously that included the most scientific questions (Unit 1, Week 4 and Unit 4, Week 4) were two of only three weeks in *Wonders* during which students were encouraged to ask scientific questions. This provides additional support for the previous assertion that the instructional content during these two weeks perhaps shows the majority of the alignment with the scientific practice of Asking Questions.

Constructing Explanations

As a practice, developing theories and constructing explanations is at the core of the discipline of science. It is what scientists do to make sense of the world (McNeill et al., 2017). Scientific explanations should "focus on a specific question about a phenomenon and construct a how or why account for that phenomenon" (p. 207). They must also be based on evidence, something that can be observed, modeled, measured, or demonstrated. Engaging in this practice will provide students with a stronger understanding of the natural world, help them understand how knowledge is produced in science, deepen their understanding of science concepts, allow them to see that scientific understandings are revisable and continually changing, and, finally, increase their science literacy and 21st-century skills (McNeill et al., 2017).

With all of this in mind, this study sought to discover in what ways the scientific practice of Constructing Explanations might be present in *Wonders*. These findings are recorded as frequencies in Table 3. Once again, data were organized according to the weeks of each unit in which they would occur. Here it is important to note that each week in *Wonders* focuses on a specific literary genre, such as expository, narrative nonfiction, or biography, and includes at least three texts of that genre for students to read. These genres are also included in Table 3. During data analysis, each instance in *Wonders* that could be considered an explanation that answered a question about a phenomenon or explained how or why a phenomenon occurred (e.g., a passage explaining what causes earthquakes) was coded SP6Q. The numbers of instances by week are recorded in the table under the heading 'Explanations.' The columns to the right then indicate the number and percent of these explanations that were based on evidence. This is important because the practice of Constructing Explanations can only be considered fully present if explanations are present *and* based on evidence.

Data analysis revealed that students reading *Wonders* would have opportunities to read explanations that answered questions about scientific phenomena 68 times. Of those 68 times, only eight (11.76%) were accompanied by concrete evidence. Those eight scientific explanations were included in what was labeled as a narrative nonfiction text during Week 4 of Unit 1. In the text, which was written in the style of a comic book, and, therefore, not an authentic science text, a super scientist explained principles related to force and motion at an amusement park and then at a skate park. Each time he explained a concept, he supported his explanation with a demonstration (McGraw-Hill, 2014). The explanations related to various scientific phenomena included throughout the other weeks and units were all stated as fact, with no mention of any evidence to support them. For example, Week 3 of Unit 1 included 11 descriptions of scientific phenomena, but none of them were based on evidence. The main student texts were expository texts that briefly explained how and why avalanches, volcanic eruptions, and earthquakes occur, but none of them offered any description of how scientists developed those explanations or what evidence they have to support them. Without that evidence, the practice of Constructing Explanations is not fully or appropriately represented, which means that reading the explanations would not help students understand how knowledge is produced in science or that scientific understanding is continually changing based on new data (evidence).

Table 3 also displays how often it seemed students were being asked to construct their own explanations in *Wonders*, thus engaging in the scientific practice themselves, as suggested in the *Framework* (NRC, 2012). Although this may appear to have happened 26 times, in only eight of these instances (30.77%) were students instructed to include evidence from the text to support their explanations. Notably, these instances did not engage students in the scientific practice of Constructing Explanations because the evidence they were asked to provide did not need to be something that could be observed, measured, or demonstrated. Rather, these instances simply engaged the students in the reading comprehension practice of summarizing. For example, when students were instructed to “explain what happens to rocks during weathering” (McGraw-Hill, 2014, p. T146), they were encouraged to reread the text to find out what happens and then paraphrase. In no instances were students encouraged to look at other sources, make their own observations, create their own models, or, preferably, to conduct their own investigations to collect data that would help them support their explanations of scientific concepts. In other words, while students were asked to describe scientific phenomena, nowhere were they truly asked to construct scientific explanations of phenomena.

Engaging in Argument from Evidence

The practice of Engaging in Argument from Evidence involves students in “making and supporting claims, evaluating one another’s ideas, and working toward reconciling their differences” (Berland et al., 2017, p. 231). Though definitely not the same (Lee, 2017), it is in some ways similar to CCSS for ELA standard W.4.1, which requires students to “write opinion pieces on topics or texts, supporting a point of view with reasons and information” (NGA Center & CCSSO, 2010, p. 20). As Lee (2017) described it, “Whether in an ELA or a science context, the CCSS maintain that the work of constructing an argument involves, at most basic, providing some form of evidence to support a claim” (p. 95). For that reason, it is perhaps not surprising that analysis of *Wonders* showed several instances in which students might observe others making claims and supporting them with evidence, or might, themselves, be asked to make claims and support them with evidence. The number of times this happened throughout the analyzed weeks and units is recorded in Table 4.

Unlike arguments in an ELA context, in addition to being supported by observable, measurable evidence, a scientific argument must also be related to a disciplinary core idea (DCI) or involve constructing knowledge about scientific content (Berland et al., 2017). Therefore, Table 4 also shows how often, in terms of number of instances and percentages, the claims that were made and supported could be linked to specific science concepts or DCIs from NGSS (NGSS Lead States, 2013). Note that more often than not (85.95%), claims that were made and supported could not be directly linked to any specific science concept or DCI, and therefore do not align fully with the scientific practice of Engaging in Argument from Evidence. The main exception was a narrative nonfiction text in Unit 6, Week 3. In this text the citizens of a town hold a town meeting to discuss the need for finding renewable energy sources. Their claims (e.g., If we build windmills and ride bikes, we will not need oil tankers to come anymore.) can all be related to NGSS 4.ESS.3, which involves students in understanding that energy and fuels come from natural resources (NGSS Lead States, 2013).

Notably, two key features of Engaging in Argument from Evidence were rarely found in the data: evaluating one another's ideas and working toward reconciling differences. Opportunities for students to observe or engage in evaluating one another's ideas were present a total of 11 times throughout the analyzed texts, mainly at the end of the weeks when accompanying lesson ideas involved students in conducting their own small research projects and then presenting their findings to the class. For example, at the end of Unit 4, Week 4, teachers were instructed to have students present their findings and "encourage discussion, asking students to comment on similarities and differences among the ideas discussed" (McGraw-Hill, 2014, p. T221). Additionally, students were asked to make and support claims, evaluate each other's claims, *and* reconcile their differences only one time in the analyzed portions of *Wonders*. This occurred in Week 5 of Unit 3, as part of the suggested instruction following the reading of a persuasive article. Students were to engage in a debate involving the pros and cons of growing genetically modified corn. Though not related to a specific DCI in the elementary standards of NGSS, this example does include science content, and, therefore, provides the only instance in *Wonders* in which the practice of Engaging in Argument from Evidence is fully represented.

Obtaining, Evaluating, and Communicating Information

The final scientific practice of focus in this study was Obtaining, Evaluating, and Communicating Information. It has been suggested that scientists devote half of their time to this practice (Bricker et al., 2017). Perhaps not surprisingly, this practice shows the most overlap with the CCSS for ELA and suggests the need for all students to learn to read, interpret, and create science texts. Table 5 shows the number of times students were given opportunities to observe or engage in the three different components of this practice. Opportunities for communicating information verbally were counted separately from those for communicating in writing. This was done, in part, because of the scientific practice’s clear connection to writing standard 4.2 in CCSS for ELA, which requires students to write informative/explanatory texts (NGA Center & CCSSO, 2010).

As Table 5 shows, opportunities for students to engage in the practice of Obtaining, Evaluating, and Communicating Information outnumbered opportunities for them to observe the practice. Most of the observation opportunities were present in the form of the teacher modeling the practice of obtaining information from a single text and then communicating it by paraphrasing verbally, taking notes, and/or writing a summary. Unit 5, Week 3 offered a more unique opportunity for observing the practice of obtaining information in ways similar to that of scientists. It included a brief biography of Benjamin Franklin wherein he obtained new information in various ways throughout the passage, including reading, talking to others, and conducting his own experiments (McGraw-Hill, 2014). Thus, in contrast to a majority of the possible instances found in *Wonders*, this representation of the scientific practice of Obtaining Information was more true to the discipline of science.

Student engagement in this scientific practice mostly involved obtaining information from a single written text and then communicating it: verbally, 85 times (59.86%) and in writing, 57 times (about 40.14%). This form of obtaining and communicating information is essentially the same as the reading comprehension strategy of summarizing. Of the 40 student texts that were analyzed, 16 (40%) were expository texts. Expository texts are perhaps most similar to true science texts because of how they are structured: they contain domain-specific vocabulary, and they include multimodal forms of text, such as diagrams, maps, graphs, and timelines. Such texts were mainly found in Unit 1, Week 3; Unit 2, Week 4; Unit 4, Week 4; and Unit 5, Week 4. The genre focus for each of those weeks was Expository, so each week contained three expository texts and one comparison text of a different genre. Engaging students in summarizing expository texts focused on science topics suggests partial alignment with the practice of Obtaining, Evaluating, and Communicating Information, because doing so requires students to demonstrate the fundamental sense of science literacy, meaning the ability to read and write when the content is science (Norris & Phillips, 2003).

The portion of *Wonders* that perhaps aligned best with this scientific practice was the lesson plan included at the end of each week. As Table 5 shows, although students were never given the opportunity to observe a teacher or scientist evaluating information, every week did provide the opportunity for students to engage in evaluating information. This was mainly present in the form of a research project. For example, at the end of the fourth week of Unit 1, students were instructed to work in groups to research motion, force, friction, acceleration, or gravity. They were to use a variety of reliable print and online sources, and to "verify all facts in multiple sources" (McGraw-Hill, 2014, p. T220). Seeking out reliable sources and verifying facts in multiple sources is part of evaluating information. It should, however, be noted that the lesson plans did not include teaching students how to identify reliable sources. The final project involved students in communicating what they found both verbally and in writing, after collaborating in small groups to determine the best way to present their information to the class. Although this example engages students in obtaining information from existing print text, evaluating that text for accuracy, and communicating that information in some way, it might well be argued that this instance does not accurately represent how information is gathered, evaluated, and communicated in science. This is because the students are encouraged to obtain all information from other print sources, rather than from their own or others' scientific investigations.

CHAPTER 5

Discussion

The research questions for this study asked in what ways the science texts and their accompanying suggested instruction in the McGraw-Hill reading program, *Wonders* (2014), align with the scientific practices of Asking Questions, Constructing Explanations, Engaging in Argument from Evidence, and Obtaining, Evaluating, and Communicating Information, as described in the *Framework for K-12 Science Education* and *Next Generation Science Standards.* Examining possible alignment in order to answer these questions was worthwhile because it offered some insight into whether or not general literacy instruction has the potential to support the development of science literacy. Science literacy is vital in personal, social, and global contexts, which makes it a necessity for all students (AAAS, 1990; Bybee, 1995; NSES, 1996; OECD, 2016). It requires both the understanding of science concepts and principles and the understanding of scientific processes or practices (AAAS, 1990; Bybee, 1995; NSES, 1996; Norris & Phillips, 2003), which together comprise what Norris and Phillips termed the derived sense of science literacy. It also involves the development of fundamental literacy within the discipline of science, which means fluency in the language of science or the communicative practices of the discipline (Mendenhall, Smith, & Hall-Kenyon, 2019), including being able to read, write, analyze, and interpret scientific texts (Norris & Phillips, 2003; Osborne, 2007).

Of the eight scientific practices included in NGSS (NGSS Lead States, 2013), the four chosen for this study were selected because they represent the ability to read, write, and reason when the content is science. They were also chosen because of their strong connections to the *Common Core Standards for English/Language Arts* (CCSS for ELA; NGA Center & CCSSO, 2010), which suggest that students should begin learning to read and write science texts as early as grade two. Possible alignment between these practices and *Wonders* was worth investigating because, on average, elementary teachers devote nearly four times as much instructional time to general reading/language arts instruction each day as they do to science instruction (Banilower et al., 2013). If that reading/language arts instruction included enough science content, in terms of both science concepts and scientific practices, to allow for meaningful curriculum integration, as it has been defined in this study, then perhaps the vastly different amounts of time devoted to the two subjects could be justified.

To briefly summarize the findings of this study, *Wonders* aligns minimally with each of the four practices. Questions were present on every page of the analyzed text, but only about 12 percent of them (123 of 1,009) were scientific questions. Additionally, of those 123 scientific questions, only about four percent were instances in which students were encouraged to ask questions. Opportunities for students to observe and engage in the practice of Constructing Explanations were also partially present in *Wonders*. However, the scientific explanations students had an opportunity to observe were based on evidence only about 12 percent of the time (8 of 68). Students were instructed to base their own explanations on evidence about 31 percent of the time (8 of 26), but the evidence they were asked to include was text evidence, not evidence they had observed or gathered themselves. The scientific practice of Engaging in Argument from Evidence was somewhat present in *Wonders* in the form of claims being made and supported with evidence. However, alignment between *Wonders* and this practice was minimal, due to a lack of connection to disciplinary core ideas (DCIs) and to a lack of opportunities for students to evaluate one another's claims and reconcile any differences. Finally, *Wonders* also demonstrates partial alignment with the scientific practice of Obtaining, Evaluating, and Communicating Information. Out of 292 recording units coded, 109 (37.33%) were opportunities for students to observe or engage in obtaining information, 15 (5.14%) were opportunities for students to engage in evaluating information, and 168 (57.53%) were opportunities for students to observe or engage in communicating information. This alignment was mostly present in opportunities for students to read and summarize traditional print texts. The science texts included in *Wonders* contain very few multimodal texts, such as charts, diagrams, or graphs. Additionally, lesson plans included at the end of each week that involved students in conducting small research projects and then presenting and discussing their findings provided one way for students to engage in the practice in a way more authentic to the discipline of science.

As was described in Chapter 4, alignment between the explicitly labeled science texts and their accompanying suggested instruction in fourth-grade *Wonders* and each of the four focal scientific practices is minimal, but stronger in some weeks than it is in others. The following sections describe implications of this study's findings for student learning, particularly students' exposure to and ability to communicate within the language of science, and for teacher practice. They also offer recommendations for future research.

Implications

In the first chapter of this report, curriculum integration was presented as a possible solution for elementary teachers seeking to overcome a perceived lack of instructional time available for teaching science. In this study curriculum integration has been defined as an idea similar to what Lederman and Niess (1997) called *interdisciplinary* instruction. It is a type of instruction that makes connections across disciplines in meaningful ways, with the two disciplines remaining identifiably separate. Keeping in mind the potential for integrating literacy and science instruction, this study focused on the possibilities of making connections between four scientific practices and the science texts and their accompanying suggested instruction included in *Wonders*. Because connections between *Wonders* and the scientific practices, while weak overall, were stronger with some practices than others, implications for student learning and teacher practice are separated by scientific practice in the following subsections.

Asking questions. This study found that of the 123 times scientific questions were asked in the analyzed portions of *Wonders*, they were only asked by students five times (4.07%). Considering that questions are "the engine that drives science and engineering" and that the ability to "ask well-defined questions is an important component of science literacy" for all students (NRC, 2012, p. 54), this finding has troubling implications for student learning. It diminishes the role students play in the classroom learning environment. Reiser et al. (2017) suggested that encouraging students to ask questions and then honoring those questions by helping students refine them and allowing them to guide investigations increases student motivation and allows students to process things more deeply.

The main implication, then, for those teachers who plan to use *Wonders* to help teach students the scientific practice of Asking Questions, and particularly for those who are required to use the *Wonders* program in its entirety, is that students will need to be encouraged to ask questions much more often than the text suggests. Additionally, those teachers will need to instruct students in the types of questions they should ask. A mini-lesson on asking and answering questions was included in the analyzed portion of *Wonders*. It emphasized teaching students to ask questions for reading comprehension purposes, to help them focus on important information and details and to help them better understand what they were reading, but it did not include any instruction related to the types of questions students should ask (McGraw-Hill, 2014). If students are to understand the nature and importance of asking questions in science, they will need to be taught to ask explanatory questions that get at how or why phenomena occur, as well as questions that have the potential to lead to investigations. This would require those teachers hoping to make connections between what they are already teaching in *Wonders* and the scientific practice of Asking Questions to devote some planning time to writing well-defined scientific questions related to the texts they are reading, thereby providing students with models to consider as they attempt to ask their own scientific questions. Along with this, teachers should plan lesson extensions that would allow time for students to discuss as a class or in small groups what related scientific investigations might look like, and then allow them to engage in scientific investigations. This would help students understand that in science questions are a driving force (NRC, 2012). They lead to action.

For those teachers who have more flexibility regarding to what extent they use *Wonders* in their classrooms, the findings of this study suggest that some weeks of instruction are better suited for integrating literacy instruction with the scientific practice of Asking Questions than others. Unit 4, Week 3 did not include any scientific questions; and Unit 3, Week 5 and Unit 5, Week 3 included very few scientific questions. This suggests that a teacher who has the opportunity to select which weeks of *Wonders* to use might not want to use those weeks. On the other hand, Unit 1, Week 4 and Unit 4, Week 4 might be worth utilizing, because they were the two weeks identified through data analysis as being best aligned with the scientific practice of asking questions.

Constructing explanations. The findings of this study suggest that the scientific practice of Constructing Explanations is only minimally present in *Wonders*. Unit 4, Week 3 does not include scientific explanation at all, and the other weeks, while they might include some explanations that answer questions about scientific phenomena, rarely include evidence to support those explanations, particularly when one considers that scientific evidence should be something that can be observed, modeled, and/or grounded in data. From a science perspective, these findings contain alarming implications for student learning. Developing theories and constructing explanations is at the core of the discipline of science. It is what scientists do to construct knowledge and make sense of the world (McNeill et al., 2017). The explanations of science concepts included in *Wonders*, which are mainly presented as unsupported facts, might cause students to believe that content knowledge in science is a collection of static, unchanging, proven facts. It would leave them with little to no understanding of how knowledge construction actually occurs in science. Therefore, a major implication for teachers suggested by these findings is that it would be best to not use *Wonders* at all in helping their students understand the scientific practice of Constructing Explanations.

For those teachers who have no choice but to use *Wonders* in its entirety and, despite the challenges, want to help their students make connections to the practice of Constructing Explanations while they do so, there are options. Explanations of scientific phenomena are present, though often unsupported by evidence. One way to use *Wonders* and help students connect to this practice might involve asking students questions that encourage them to think about the evidence behind the explanations. Examples of such questions might include: How do you think scientists figured that out? What observations, measurements, or models might be used to support that explanation? Could we conduct our own experiments or demonstrations to prove that the explanation is accurate? By asking questions such as these and providing opportunities for discussion and further investigation (e.g., developing or using models, or designing and conducting investigations/experiments), teachers could build upon the scientific concepts and explanations included in *Wonders* to help students better understand how scientists construct knowledge. The texts in Week 4 of Unit 1 showed the most alignment with Constructing

Explanations, and, therefore, might be the best option for a teacher hoping to integrate literacy instruction with science instruction. Unfortunately, the science content included in those texts is related to concepts of force and motion that are not included in fourth-grade NGSS standards. Examples like this one suggest that science topics and DCI connections are another idea a teacher should consider when deciding whether or not it is worth the extra planning time to try to integrate science instruction with *Wonders* literacy instruction.

Engaging in argument from evidence. The findings of this study show that students had opportunities to observe claims being made and supported or to engage in making and supporting their own claims a combined total of 121 times. Those claims were linked to DCIs only 17 times (14.04%). Additionally, the scientific practice of Engaging in Argument from Evidence was only fully present, meaning that claims were made and supported, those claims were evaluated, and then differing claims were reconciled, only one time in all the analyzed texts. It occurred during the fifth week of Unit 3, when students were asked to engage in a debate regarding whether or not growing genetically modified corn was a good idea. Moreover, similar to the example described in the previous section that most closely aligned with the practice of Constructing Explanations, this example does not include any connection to the DCIs included in the fourth-grade standards of NGSS. Therefore, the main implication of these findings relates to teacher practice: elementary teachers would be wise not to use *Wonders* to help teach students the nature of scientific argumentation.

Still, the presence of 121 supported claims in *Wonders* suggests that a teacher who is willing to put forth a little extra effort could help students make connections to the practice of Engaging in Argument from Evidence. CCSS for ELA maintains that constructing an argument, whether in science or ELA, involves providing evidence to support a claim, (Lee, 2017). This suggests that connections could be made between skills used in argumentative writing and skills used in scientific argumentation. However, this idea also has important and negative implications for student learning. Successful integration would require making clear to students the difference between expressing an opinion and supporting it with examples or reasons and making a scientific claim and supporting it with observable, measurable, concrete evidence. As teachers and students come across supported claims in *Wonders* that are related to specific DCIs from NGSS or to other scientific content, teachers would need to guide students in conducting further research to gather more concrete evidence for supporting the claims. For example, after reading "Energy Island," the narrative nonfiction text included in the third week of Unit 6, students could spend time researching renewable energy sources. They could also determine what renewable resources might be the best options for use in their own communities.

Obtaining, evaluating, and communicating information. When considering implications of this study's findings related to the scientific practice of Obtaining, Evaluating, and Communicating Information, one should take into account the number and nature of the texts included in the analysis. Data analysis focused on the 40 texts that can be found within the weeks labeled "science" in the fourth-grade *Wonders* reading/writing workshop textbook. Of those 40 texts, 16 (40%) were expository, making them the most like science texts. While these did include some text structures similar to those found in science texts (e.g., cause and effect, problem and solution), unfortunately, few of them included charts, tables, graphs, or diagrams, and none of them included the reporting of data that had been gathered in scientific experiments or investigations. The main implication related to these findings is that teachers hoping to use literacy instruction to help students understand how scientists obtain, evaluate, and communicate information must supplement the science texts found in *Wonders* with additional science texts, preferably texts more true to the discipline of science.

The findings of this study showed that the most authentic opportunities for students to engage in Obtaining, Evaluating, and Communicating Information were included at the end of each week, when suggested instruction in the teacher's edition involved guiding students in conducting their own research projects. Students would choose a science-related topic, gather information from multiple print or online sources, check to make sure their sources seemed reliable, and then create a presentation to share with the class. Teachers desiring to make the most of this project's natural connections to the scientific practice of Obtaining, Evaluating, and Communicating Information would need to plan carefully to allow students adequate time for the project. They should also provide time and instruction to help students design and conduct their own investigations, rather than encouraging them to only focus on the findings of others. Additionally, because data analysis revealed no opportunities for students to observe Evaluating Information and comparatively few opportunities for students to engage in this part of the scientific practice, teachers would need to plan additional time for teaching students how to evaluate information.

Finally, the findings of this study yielded a positive implication for student learning related to the scientific practice of Obtaining, Evaluating, and Communicating Information. While findings related to Asking Questions and Constructing Explanations showed opportunities for students to observe the practice far outnumbering opportunities for students to engage in the practice, findings related to Obtaining, Evaluating, and Communicating Information showed significantly more opportunities for students to engage in the practice (243) than to observe it (49). Because science literacy involves not only what students should know about science, but also what they should be able to do in science, providing more opportunities for students to engage in scientific practices allows them to deepen their understanding of those practices. For this reason, utilizing *Wonders* to help students understand the scientific practice of Obtaining, Evaluating, and Communicating Information, though not an ideal practice due to a lack of multimodal texts and fourth grade science content, is more likely to be successful than utilizing *Wonders* to help students understand the other three scientific practices.

Recommendations for Future Research

The findings of this research study, along with its limitations, could be used to recommend several options for related future research. First, educational researchers should consider conducting similar investigations on a larger scale. A content analysis of all grade level editions of *Wonders* would help determine if the findings of this study are typical of the program as a whole, or if some grade level editions might align more closely with scientific practices than others. It would also allow researchers to determine if the progressions through the practices are appropriate to grade level/grade bands as recommended by the *Framework* and NGSS (NRC, 2012; NGSS Lead States, 2013). Other options for larger, related studies might include looking for alignment with all eight of the scientific practices included in the *Framework* and NGSS, or, additionally, looking closely at the ways in which *Wonders* aligns with the other two dimensions of science education included in the *Framework* and NGSS: cross-cutting concepts and disciplinary core ideas. Finally, a larger, more comprehensive study would compare the ways in which *Wonders* aligns with the scientific practices to the ways in which other widely-used commercial literacy programs align with the scientific practices. These options could all be quite similar in design to this study, but would yield much more information and would, therefore, be more generalizable.

Another recommendation for future research would involve using the findings of this study and their implications for teacher practice to plan integrated instruction and then assess its effectiveness. This would mean using *Wonders* as instructed for English/Language Arts instruction, but also supplementing it in ways that place more emphasis on any partial or complete alignment with scientific practices. Effectiveness of such integration could in part be measured by looking at student scores on state end-of-level testing. One might, however, face some significant challenges in conducting such a study. For example, it would likely be difficult to find a commercial literacy program that aligns with a state's literacy standards and also includes science topics aligned with that state's core curriculum standards for science, because common standards do not exist across the United States. Forty-one states have adopted CCSS for ELA (Council of Chief State School Officers and National Governors Association, 2017), and 30 states have adopted NGSS or written their own standards based on the *Framework* and NGSS (National Science Teachers Association, 2014).

A final recommendation for future research would involve conducting more studies similar to those conducted by Romance and Vitale (1992) and Fang and Wei (2010). In these studies, rather than focusing on teaching literacy and trying to connect it to science, teachers focused more on teaching science and trying to connect it to literacy, and, as a result, their students showed greater success in both subjects. If more research could be completed that would show successful integration models such as these that do not involve the use of commercial literacy programs, perhaps fewer teachers would be required by their administrators to devote vast amounts of instructional time to general literacy instruction and the use of commercial literacy programs, and could therefore devote more instructional time to high quality science instruction.

Conclusion

The overarching goal of this study was to begin an investigation into whether or not general literacy instruction has the potential to support the development of scientific literacy among students. The findings of this study suggest that if that general literacy instruction is based on the science texts and their accompanying lesson plans in fourth-grade *Wonders*, then it does not. Evidence of the scientific practices of Asking Questions, Constructing Explanations, Engaging in Argument from Evidence, and Obtaining, Evaluating, and Communicating Information is, in most cases, minimally present in *Wonders*. Fourth grade teachers hoping to use *Wonders* as a tool for curriculum integration and/or to increase their students' science literacy would need to supplement what is included in *Wonders* by providing students with more opportunities to ask questions that lead to investigations, to construct explanations based on evidence derived from their own observations and investigations, to engage in scientific argument, and to obtain, evaluate, and communicate information in ways true to the discipline of science. This would require additional planning time and additional instructional time, which would not solve any problems for elementary teachers who already perceive a lack of instructional time available to them for teaching science.

References

Altheide, D. L. (1987). Ethnographic content analysis. *Qualitative Sociology, 10*(1), 65-77.

American Association for the Advancement of Science (AAAS). (1990). *Science for all Americans: Project 2061.* New York, NY: Oxford University Press.

American Association for the Advancement of Science (AAAS). (1993). *Benchmarks for science literacy.* New York, NY: Oxford University Press.

Anthony, A. B. (2009). *The generic structure potential of science nonfiction selections in four basal readings series, grades one and two* (Doctoral Dissertation). University of Virginia, Charlottesville, VA. Retrieved from https://search-proquestcom.erl.lib.byu.edu/pqdtglobal/docview /305011312/9716A2C00EFD4F34PQ/1?accountid=4488

Appleton, K. (2003). How do beginning primary school teachers cope with science? Toward an understanding of science teaching practice. *Research in Science Education, 33*(1), 1–25.

Banilower, E. R., Smith, P. S., Weiss, I. R., Malzahn, K. A., Campbell, K. M., & Weis, A. M. (2013). *Report of the 2012 national survey of science and mathematics education*. Chapel Hill, NC: Horizon Research.

Beane, J. (1996). On the shoulders of giants! The case for curriculum integration. *Middle School Journal, 28*(1), 6-11.

Berland, L. K., McNeill, K. L., Pelletier, P., & Krajcik, J. (2017). Engaging in argument from evidence. In C. V. Schwarz, C. Passmore, & B. J. Reiser (Eds.), *Helping students make sense of the world using next generation science and engineering practices* (pp. 229-257). Arlington, VA: National Science Teachers Association Press.

Blank, R. K. (2013). Science instructional time is declining in elementary schools: What are the implications for student achievement and closing the gap? *Science Education, 97*(6), 830-847.

Brenner, D., & Hiebert, E. H. (2010). If I follow the teachers' editions, isn't that enough? Analyzing reading volume in six core reading programs. *Elementary School Journal, 110*(3), 347-363.

Bricker, L. A., Bell, P., Van Horne, K., & Clark, T. L. (2017). Obtaining, evaluating, and communicating information. In C. V. Schwarz, C. Passmore, & B. J. Reiser (Eds.), *Helping students make sense of the world using next generation science and engineering practices* (pp. 259-281). Arlington, VA: National Science Teachers Association Press.

Busch, C., De Maret, P. S., Flynn, T., Kellum, R., Le, S., Meyers, B., . . . Palmquist, M. (2017). *Writing@CSU writing guide: Content analysis*. Retrieved from https://writing.colostate.edu/guides/guide.cfm?guideid=61

Bybee, R. W. (1995). Achieving scientific literacy. *The Science Teacher, 62*(7), 28-33.

Committee on Science, Engineering, and Public Policy. (2007). *Rising above the gathering storm: Energizing and employing America for a brighter economic future*. Washington, D.C.: The National Academies Press.

Council of Chief State School Officers & National Governors Association. (2017). *About the standards*. Retrieved from www.corestandards.org/about-the-standards/

Czerniak, C. M., & Johnson, C. C. (2014). Interdisciplinary science teaching. In S. K. Abell & N. G. Lederman (Eds.), *Handbook of research on science education* (Vol. 2; pp. 395-411). New York, NY: Routledge.

DeBoer, G. E. (1991). *A history of ideas in science education: Implications for practice.* New York, NY: Teachers College Press.

Draper, R. J., & Siebert, D. (2010). Rethinking texts, literacies, and literacy across the curriculum. In R. J. Draper (Ed.), *(Re)Imagining content area literacy instruction* (pp. 20-39). Berkeley, CA: National Writing Project and Teachers College Press.

Draper, R. J., Smith, L. K., Hall, K. M., & Siebert, D. (2005). What's more important--literacy or content? Confronting the literacy-content dualism. *Action in Teacher Education, 27*(2), 12-21.

Everett, S., & Moyer, R. (2009). Literacy in the learning cycle: Incorporating trade books helps plan inquiry-learning experiences. *Science and Children, 47*(2), 48-52.

Fang, Z., & Wei, Y. (2010). Improving middle school students' science literacy through reading infusion. *The Journal of Educational Research, 103*(4), 262-273.

Gee, J. P. (2001). Reading as a situated language: A sociocognitive perspective. *Journal of Adolescent & Adult Literacy, 44*(8), 714-725.

Graneheim, U. H., & Lundman, B. (2004). Qualitative content analysis in nursing research: Concepts, procedures, and measures to achieve trustworthiness. *Nurse Education Today 24*(2)*,* 105-112.

Griffith, G., & Scharmann, L. (2008). Initial impacts of No Child Left Behind on elementary science education. *Journal of Elementary Science Education, 20*(3), 35-48.

Hall-Kenyon, K. M., & Smith, L. K. (2013). Negotiating a shared definition of curriculum integration: A self-study of two teacher educators from different disciplines. *Teacher Education Quarterly, 40*(2), 89-108.

Houseal, A., Gillis, V., Helmsing, M., & Hutchison, L. (2016). Disciplinary literacy through the lens of the Next Generation Science Standards. *Journal of Adolescent & Adult Literacy, 59*(4), 377-384.

Hsieh, H., & Shannon, S. E. (2005). Three approaches to qualitative content analysis. *Qualitative Health Research, 15*(9), 1277-1288. doi: 10.1177/104932305276687

Jennings, J., & Rentner, D. S. (2006). *Ten big effects of the No Child Left Behind Act on public schools*. Washington, DC: Center on Education Policy.

Krippendorff, K. (2004). *Content analysis: An introduction to its methodology*. Thousand Oaks, CA: Sage Publications.

Lederman, N. G., & Niess, M. L. (1997). Integrated, interdisciplinary, or thematic instruction? Is this a question or is it questionable semantics? *School Science and Mathematics, 97*(2), 57-58.

Lee, O. (2017). Common core state standards for ELA/Literacy and Next Generation Science Standards: Convergences and discrepancies using argument as an example. *Educational Researcher, 46*(2), 90-102.

McGraw-Hill. (2014). *McGraw-Hill reading wonders* (4th grade ed.). New York, NY: McGraw-Hill Companies.

McGraw-Hill Communications Team. (2013). *Authors of McGraw-Hill reading wonders, key contributors to development of common core standards, speak on literacy issues at International Reading Association's 2013 annual convention* [Press Release]. Retrieved from https://www.mheducation.com/news-media/press-releases/authors-mcgraw-hill-reading-wonders-key-contributors-development-common-core-state.html

McMurrer, J. (2008). *Instructional time in elementary schools: A closer look at changes for specific subjects*. Washington, D.C.: Center on Education Policy.

McNeill, K. L., Berland, L. K., & Pelletier, P. (2017). Constructing explanations. In C. V. Schwarz, C. Passmore, & B. J. Reiser (Eds.), *Helping students make sense of the world using next generation science and engineering practices* (pp. 205-227). Arlington, VA: National Science Teachers Association Press.

Mendenhall, M. P., Smith, L. K., & Hall-Kenyon, K. M. (January, 2019). *What does communication look like in science?: Grades 6-8 teachers' conceptions of science text.* Paper presented at the Association for Science Teacher Education Annual International Conference, Savannah, GA.

Moje, E. B. (2008). Foregrounding the disciplines in secondary literacy teaching and learning: A call for change. *Journal of Adolescent & Adult Literacy, 52*(2), 96-107.

National Center on Time and Learning. (2011). *Learning time in America: Trends to reform the American school calendar*. Retrieved from https://www.timeandlearning.org/sites/default/files/resources/learningtimeinamerica.pdf

National Commission on Excellence in Education. (1983). *A nation at risk: The imperative for educational reform.* Washington, DC: Government Printing Office.

National Governors Association Center for Best Practices & Council of Chief State School Officers (NGA Center & CCSSO). (2010). *Common core state standards*. Washington, DC: Authors.

National Research Council (NRC). (1996). *National science education standards*. Washington, DC: The National Academies Press.

National Research Council (NRC). (2006). *America's lab report: Investigations in high school science*. Washington, DC: National Academies Press.

National Research Council (NRC). (2007). *Taking science to school: Learning and teaching science in grades K-8*. Washington, DC: National Academies Press.

National Research Council (NRC). (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas*. Washington, DC: National Academies Press.

National Research Council (NRC). (2014). *Literacy in science*. Washington, DC: National Academies Press.

National Science Teachers Association. (2014). *About the next generation science standards*. Retrieved from http://ngss.nsta.org/About.aspx

NGSS Lead States. (2013). *Next generation science standards: For states, by states*. Washington, DC: National Academies Press.

Norris, S.P., & Phillips, L.M. (2003). How literacy in its fundamental sense is central to scientific literacy. *Science Education, 87*(2), 224-240.

Norris, S.P., Phillips, L.M., Smith, M.L., Guilbert, S.M., Stange, D.M., Baker, J.J., & Weber, A.C. (2008). Learning to read scientific text: Do elementary school commercial reading programs help? *Science Education, 92*(5), 765-798.

Obama, B. (2011, January). *State of the union address*. Presented at Washington, D.C. Retrieved from https://www.whitehouse.gov/the-press-office/2011/01/25/remarks-president-state-union-address

Obama, B. (2012, January). *State of the union address*. Presented at Washington, D.C. Retrieved from https://www.whitehouse.gov/the-press-office/2012/01/24/remarks-president-state-union-address

Obama, B. (2013, January). *State of the union address*. Presented at Washington, D.C. Retrieved from https://www.whitehouse.gov/the-press-office/2013/02/12/remarks-president-state-union-address

Obama, B. (2014, January). *State of the union address*. Presented at Washington, D.C. Retrieved from https://www.whitehouse.gov/the-press-office/2014/01/28/president-barack-obamas-state-union-address

Obama, B. (2015, January). *State of the union address*. Presented at Washington, D.C. Retrieved from https://www.whitehouse.gov/the-press-office/2015/01/20/remarks-president-state-union-address-january-20-2015

Obama, B. (2016, January). *State of the union address*. Presented at Washington, D.C. Retrieved from https://www.whitehouse.gov/the-press-office/2016/01/12/remarks-president-barack-obama-–-prepared-delivery-state-union-address

OECD (2016). *PISA 2015 Assessment and analytical framework: Science, reading, mathematics, and financial literacy*. Paris, France: PISA, OECD Publishing.

Osborne, J. (2007). Science education for the twenty first century. *Eurasia Journal of Mathematics, Science, & Technology Education, 3*(3), 173-184.

Reiser, B. J., Brody, L., Novak, M., Tipton, K., & Adams, L. S. (2017). Asking questions. In C. V. Schwarz, C. Passmore, & B. J. Reiser (Eds.), *Helping students make sense of the world using next generation science and engineering practices* (pp. 87-108). Arlington, VA: National Science Teachers Association Press.

Roberts, D. A., & Bybee, R. W. (2014). Scientific literacy, science literacy, and science education. In N. G. Lederman & S. K. Abell (Eds.) *Handbook of research in science education* (Vol. 2; pp. 545-558). New York, NY: Routledge.

Romance, N. R., & Vitale, M. R. (1992). A curriculum strategy that expands time for in-depth elementary science instruction by using science-based reading strategies: Effects of a year-long study in grade four. *Journal of Research in Science Teaching, 29*(6), 545-554.

Sandelowski, M. (2000). Whatever happened to qualitative description?. *Research in Nursing and Health, 23*(4)*,* 334-340.

Shanahan, C., & Shanahan, T. (2014). Does disciplinary literacy have a place in elementary school? *The Reading Teacher, 67*(8), 636-639.

Shenton, A. K. (2004). Strategies for ensuring trustworthiness in qualitative research projects. *Education for Information, 22*(2), 63-75.

Stemler, S. (2001). An introduction to content analysis. *ERIC Digest*. College Park, MD: ERIC Clearinghouse on Assessment and Evaluation.

Victor, E., Kellough, R. D., & Tai, R. H. (2008). *Science K-8: An integrated approach* (11th ed.). Upper Saddle River, NJ: Pearson Education.

Worth, K., Moriarty, R., & Winokur, J. (2004). Capitalizing on literacy connections. *Science and Children, 41*(5), 35-39.

Zhang, Y., & Wildemuth, B. M. (2009). Qualitative analysis of content. In B. Wildemuth (Ed.), *Applications of social research methods to questions in information and library science* (pp. 308-319). Westport, CT: Libraries Unlimited.

APPENDIX A

Explanation of Coding Categories and Rules for Coding

Qualitative content analysis should be systematic (Altheide, 1987) and reproducible (Busch et al., 2017; Stemler, 2001) to help ensure trustworthiness. The following sections, designed to help achieve system and reproducibility, describe each a priori coding category, explain why it is important, and suggest what it might look like within a text.

SP1: Asking Questions

The *Framework* describes questions as “the engine that drives science and engineering” and states that the ability to “ask well-defined questions is an important component of science literacy” for all students, not only those who will go on to become scientists or engineers (NRC, 2012, p. 54). In science, the questions students and teachers ask should guide inquiry, seek to refine models or explanations, and/or challenge the premises of arguments (NRC, 2012). This makes asking questions a critical starting point because it leads students into other scientific practices, including investigating and explaining phenomena. In turn, the practices of planning and carrying out investigations and constructing explanations leads to asking even more questions, thus making asking questions an ongoing process (Reiser, Brody, Novak, Tipton, & Adams, 2017).

Reiser et al. (2017) suggest that there are three key features to the scientific practice of asking questions. First, the nature of the questions needs to be explanatory, meaning that they get at how and why a phenomenon occurs. Second, in a classroom setting, the role of asking questions is critical for both teachers and students. Students ask initial questions based on observation of the phenomenon and prior experiences and then continue to ask questions throughout the investigative process. Teachers may also ask initial questions based on observation of the phenomena, as well as probing questions throughout the investigation in order to help students refine their thinking. Third, the questions should guide student inquiry by helping identify what needs to be investigated about a phenomenon. These three features will be coded separately. All of the codes used in this study will begin with SP and a number to indicate which scientific practice is represented. For example, SP1 refers to the first scientific practice listed in the *Framework*: asking questions. Each code will then include a letter at the end to indicate which key feature of the practice is present. The code SP1E will be used to indicate each time an explanatory question is present within a *Wonders* text; SP1B will be used to indicate instances in *Wonders* when both teachers and students are engaged in the practice of asking questions; and SP1I will be used when asking questions leads directly to investigations. Because asking questions is commonly taught as a strategy for clarifying understanding and increasing comprehension during language arts instruction, focusing on the three key features of the scientific practice of asking questions (Reiser et al., 2017) will be important during text analysis. Instances in the text where students are able to observe others asking questions or are asked to themselves engage in the practice of asking questions will only be included if the questions are explanatory in nature and might possibly lead to scientific investigation.

SP6: Constructing Explanations

According to the *Framework*, “Scientific theories are developed to provide explanations aimed at illuminating the nature of particular phenomena, predicting future events, or making inferences about past events” (NRC, 2012, p. 67). As a practice, developing theories and constructing explanations is at the core of the discipline. It is what scientists do to make sense of the world (McNeill, Berland, & Pelletier, 2017). Scientific explanations should “focus on a specific question about a phenomenon and construct a how or why account for that phenomenon" (p. 207). They must also be based on evidence, something that can be observed, modeled, measured, or demonstrated. Engaging in this practice will provide students with a stronger understanding of the natural world, help them understand how knowledge is produced in science, deepen their understanding of science concepts, allow them to see that scientific understandings are revisable and continually changing, and, finally, increase their science literacy and 21st-century skills (McNeill et al., 2017).

McNeill et al., (2017) suggest three key elements for a scientific explanation: (a) it answers a question about a phenomenon, (b) it explains why or how that phenomenon occurs, and (c) it is evidence-based. Coding for this practice would include indicating when any of those three elements are present. Each element will have its own code: SP6Q for a question, SP6HW for an explanation of how or why a phenomenon occurs, and SP6E for an explanation that is evidence-based. Evidence of this practice might occur in *Wonders* in a few different ways. First, within the literature anthology or reading/writing workshop textbook, students might read scientific explanations, particularly in expository texts, that include the three elements. Second, they might read narrative nonfiction texts in which others engage in constructing explanations. Finally, within the lesson plans included in the teacher's edition, suggested instruction might involve asking students to construct scientific explanations, which should include the key elements described above. The final phase of data analysis will involve determining the number of times all three of the key elements were present in each text labeled "science", as well as how often only one or two elements were present. These numbers can then be compared to the numbers from the other *Wonders* science texts to help determine in what ways, if any, reading these texts and engaging in these lessons might help promote science literacy amongst fourth graders.

SP7: Engaging in Argument from Evidence

The practice of engaging in argument from evidence “entails making and supporting claims, evaluating one another’s ideas, and working toward reconciling their differences” (Berland, McNeill, Pelletier, & Krajcik, 2017, p. 231). This practice is about constructing scientific knowledge, rather than simply accepting science as a collection of static facts. It helps students see how tentative and revisable scientific knowledge really is. Being able to engage in argument from evidence is an important part of science literacy that makes students critical consumers of science. According to the *Framework*, “The knowledge and ability to detect bad science are requirements both for the scientist and the citizen” (NRC, 2012, p. 71). Engaging in argument from evidence can occur around any and all of the other seven practices (Berland et al., 2017).

Identifying this practice within a text involves looking for its three main components: (a) supported claims, (b) evaluation and critique, and (c) reconciliation. Similar to practice six, these components will be coded separately: SP7S for a supported claim, SP7E for evaluation of a claim, and SP7R for reconciliation of differing claims. Defending, evaluating, critiquing, and revising are some key words that might help identify these components. One might also look for synonyms of these key words or phrases or sentences that express similar ideas.

Scientific argumentation must also be related to a disciplinary core idea or involve constructing knowledge about scientific content (Berland et al., 2017). According to the *Framework* (NRC, 2012), a disciplinary core idea represents central or fundamental knowledge in physical science; life science; earth and space science; or engineering, technology, and applications of science. Instances that include this connection to scientific content will be coded as SP7C. Evidence of argumentation within a text that does not include that connection can still help students learn discourse moves associated with the practice. This should be considered during interpretation. Scientific argumentation is not present if a claim is presented and supported, but there is little discussion or feedback. Narrative nonfiction texts in *Wonders* might show scientists or students engaging in argumentation. These will be marked with an ‘O’ on the coding form because they provide an opportunity for students to observe some part of the practice. Other instances that might connect to this practice are any that suggest that scientific knowledge can be constructed and is revisable. Within lesson plans, this practice might be found if teachers are supposed to ask students to make claims and support them with evidence from the text. These will be marked with an ‘E’. However, without evaluating one another’s claims and engaging in discussion or debate, this would not be true scientific argumentation. The final step in data analysis will require the researcher to determine how often true scientific argumentation is represented, based on how many times all three key elements are present and connected to a disciplinary core idea. As with coding for the other practices, the number of times scientific argumentation is represented will be compared across all *Wonders* texts analyzed in this study.

SP8: Obtaining, Evaluating, and Communicating Information

According to Bricker, Bell, Van Horne, and Clark (2017), the practice of obtaining, evaluating, and communicating information “involves students in gathering, critically examining, and using resources to further their collective investigations and sense-making about the natural and designed world” (p. 261). They suggest that half of scientists’ time is devoted to this practice. It involves “disciplinary literacy-related skill sets” (p. 262), which are important for anyone and everyone when it comes to personal and societal decision-making. This practice shows the most overlap with the Common Core Standards for English and Language Arts and suggests the need for all students to learn to read, interpret, and create science texts.

The practice of obtaining, evaluating, and communicating information will be coded according to its three separate processes. SP8O will be used for obtaining information; SP8E, for evaluating; and SP8C, for communicating. This practice seems like it might be most prevalent within the *Wonders* lesson plans, particularly in any part of them that focuses on teaching students how to understand complex texts and, specifically, how to comprehend scientific texts, which contain domain-specific vocabulary and possibly charts, diagrams, and equations, and which also vary in organization and structure from narrative texts. It could also be present in narrative nonfiction, if characters are engaging in the practice. Every week in *Wonders* requires students to do some form of writing. If that writing component requires students to obtain information from multiple sources, evaluate it for accuracy/reliability, and create their own science texts to communicate their findings to others, then it is explicitly asking teachers to engage students in this scientific practice. Obtaining information from a variety of texts is important. This is not just traditional report writing; it is active knowledge construction. It needs to be "integrated with ongoing sense-making in the classroom" (Bricker et al., 2017, p. 269). Evidence of this practice will also exist anywhere students are receiving instruction/guidance in reading and understanding multimodal science texts, such as charts, diagrams, equations, or models.

APPENDIX B

Coding Form

Text	Location within Text	Asking Questions				Constructing Explanations		Engaging in Argument from Evidence				Obtaining, Evaluating, and Communicating Information			
		SP1E	SP1I	SP1T	SP1O	SP6Q	SP6E	SP7S	SP7E	SP7R	SP7C	SP8O	SP8E	SP8CV	SP8CW

- Instances marked ‘T’ indicate teacher questions; instances marked ‘S’ indicate student questions; and instances marked ‘I’ indicate questions asked within a student text.
- Instances marked ‘O’ indicate evidence of opportunities for students to observe others engaged in the practice.
- Instances marked ‘E’ indicate evidence of the text suggesting the teacher ask students to engage in the practice.

APPENDIX C

Explanation of Changes to Coding Categories

The coding process revealed that in order to keep categories mutually exclusive and exhaustive, a few changes needed to be made to the a priori categories. These changes are described in the following sections.

SP1: Asking Questions

Reiser et al. (2017) suggest that there are three key features to the scientific practice of asking questions. First, the nature of the questions needs to be explanatory, meaning that they get at how and why a phenomenon occurs. Second, in a classroom setting, the role of asking questions is critical for both teachers and students. Third, the questions should guide student inquiry by helping identify what needs to be investigated about a phenomenon. These three features were to be coded separately. SP1E was to indicate when explanatory questions were asked; SP1B was to indicate instances where both teachers and students were engaged in asking questions; and SP1 would indicate when questions were being asked that might lead directly to investigations.

Data collection and analysis suggested that use of the code SP1B failed to accurately describe the data. It was eliminated, and instead questions asked by teachers were marked with a ‘T’ on the coding form; questions asked by students were marked with an ‘S’; and questions appearing within student texts were marked with an ‘I’. The other change involved adding categories that might include the high number of questions in *Wonders* that were neither explanatory nor investigative in nature. These were mainly questions focused on reading comprehension. Those that were explicitly answered within the text were coded SP1T. An example of this type of question from Unit 2, Week 4 is: What is this paragraph mostly about?

(McGraw-Hill, 2014, p. T208). Comprehension questions that went beyond the text and were perhaps more open-ended were coded SP1O. An example of this type of question, also from Unit 2, Week 4, is: Why does the author contrast spiders and insects? (p. T217B). Differentiating between these two types of questions was important, because the second type, though still more focused on reading comprehension than science, often begin with the words why or how and are more explanatory in nature, making them more similar to scientific questions.

SP6: Constructing Explanations

Scientific explanations should "focus on a specific question about a phenomenon and construct a how or why account for that phenomenon" (McNeill, Berland, & Pelletier, 2017, p. 207). They must also be based on evidence, something that can be observed, modeled, measured, or demonstrated. These ideas were initially used to establish three coding categories related to Constructing Explanations: (a) explanations that answered questions about a phenomenon, (b) explanations that explained how or why a phenomenon occurred, and (c) explanations that were based on evidence. Data analysis revealed that explanations that described how or why a phenomenon occurred were also answering at least one question about that phenomenon, so the two categories were combined. Any explanation that answered a question about a phenomenon, including explaining how or why that phenomenon occurred, was coded SP6Q.

SP8: Obtaining, Evaluating, and Communicating Information

According to Bricker et al. (2017), the practice of obtaining, evaluating, and communicating information "involves students in gathering, critically examining, and using resources to further their collective investigations and sense-making about the natural and designed world" (p. 261). This practice was initially to be coded according to its three separate processes. SP8O was to be used for obtaining information; SP8E, for evaluating; and SP8C, for communicating. Data collection and analysis revealed that it might be more descriptive to divide the category for communicating information into two separate categories, in order to indicate if the communication was verbal or written. Therefore, verbal communication was coded SP8CV, and written communication was coded SP8CW.

APPENDIX D

Tables

Table 1

Final Coding Categories

Component of Scientific Practice	Category	Code	Example
Scientists and/or learners ask explanatory questions.	Asking Questions	SP1E	What keeps you in your seat during the loop-the-loops of a roller coaster?
Scientists and/or learners ask questions that lead directly to investigations.	Asking Questions	SP1I	Why is the way a city is built important if an earthquake happens?
Scientists and/or learners construct explanations that answer a question about a phenomenon.	Constructing Explanations	SP6Q	A character's explanation of gravity answers the question, "Why do we fall down instead of up or sideways?"
Scientists and/or learners construct explanations that are evidence-based.	Constructing Explanations	SP6E	A character explains how mass, acceleration, and force are related and then demonstrates with skaters on a ramp.
Scientists and/or learners make and support claims.	Engaging in Argument from Evidence	SP7S	A character in a narrative nonfiction text suggests windmills as the best renewable energy source for his community and explains why.
Scientists and/or learners evaluate the claims of others.	Engaging in Argument from Evidence	SP7E	Characters in a narrative nonfiction text consider several options for renewable energy sources.

Scientists and/or learners reconcile differing claims.	Engaging in Argument from Evidence	SP7R	Characters in a narrative nonfiction text agree on the best renewable energy source for their community.
Argumentation is related to scientific content, such as a disciplinary core idea.	Engaging in Argument from Evidence	SP7C	The claims that are made and supported relate to NGSS 4.ESS.3.
Scientists and/or learners obtain information.	Obtaining, Evaluating, and Communicating Information	SP8O	Students are instructed to work in small groups to research how to prepare for a type of natural disaster.
Scientists and/or learners evaluate information.	Obtaining, Evaluating, and Communicating Information	SP8E	Students are told to use reliable print and online sources.
Scientists and/or learners communicate information verbally.	Obtaining, Evaluating, and Communicating Information	SP8CV	Students present their findings to the class.
Scientists and/or learners communicate information in writing.	Obtaining, Evaluating, and Communicating Information	SP8CW	Students create posters to display their findings.

Note. Examples were modeled after instances present in *Wonders* (McGraw-Hill, 2014).

Table 2

Scientific Questions Asked in Wonders

	Explanatory (*n*=97)			Leads to Inquiry (*n*=26)		
	Student	Teacher	In-Text	Student	Teacher	In-Text
Unit,Week	#/%	#/%	#/%	#/%	#/%	#/%
1,3	0/0	5/5.15	6/6.19	1/3.85	1/3.85	0
1,4	1/1.03	26/26.80	12/12.37	0/0	2/7.69	3/11.54
2,3	0/0	4/4.12	3/3.09	0/0	0/0	3/11.54
2,4	0/0	7/7.22	6/6.19	0/0	0/0	0
3,5	0/0	0/0	0/0	0/0	0/0	4/15.38
4,3	0/0	0/0	0/0	0/0	0/0	0
4,4	3/3.09	10/10.31	7/7.22	0/0	1/3.85	0
5,3	0/0	0/0	2/2.06	0/0	0/0	2/7.69
5,4	0/0	2/2.06	3/3.09	0/0	2/7.69	0
6,3	0/0	0	0	0/0	2/7.69	5/19.23
Total	4/4.12	54/55.67	39/40.21	1/3.85	8/30.77	17/65.38

Table 3

Frequencies of Scientific Explanations

Unit,Week	Primary Genre	Students Observe		Students Engage	
		Explanations (#)	Based on Evidence (#/%)	Explanations (#)	Based on Evidence (#/%)
1,3	Expository	11	0/0.00	3	1/33.33
1,4	Narrative Nonfiction	18	8/44.44	11	2/18.18
2,3	Narrative Nonfiction	6	0/0.00	2	2/100.00
2,4	Expository	6	0/0.00	3	1/33.33
3,5	Persuasive Article	1	0/0.00	0	na
4,3	Historical Fiction	0	na	0	na
4,4	Expository	11	0/0.00	2	1/50.00
5,3	Biography	1	0/0.00	0	na
5,4	Expository	9	0/0.00	5	1/20.00
6,3	Narrative Nonfiction	5	0/0.00	0	na
Total		68	8/11.76	26	8/30.77

Note. The abbreviation ‘na’ used in the percent column indicates that a percent is not applicable, due to the absence of scientific explanations.

Table 4

Frequencies of Partial Scientific Arguments

		Students Observe		Students Engage	
Unit,Week	Primary Genre	Claims Made and Supported (#)	Linked to DCI (#/%)	Claims Made and Supported (#)	Linked to DCI (#/%)
1,3	Expository	8	2/25.00	4	0/0.00
1,4	Narrative Nonfiction	2	0/0.00	11	3/27.27
2,3	Narrative Nonfiction	2	1/50.00	5	1/20.00
2,4	Expository	2	0/0.00	5	1/20.00
3,5	Persuasive Article	7	0/0.00	9	0/0.00
4,3	Historical Fiction	8	0/0.00	12	0/0.00
4,4	Expository	0	na	4	0/0.00
5,3	Biography	5	1/20.00	7	0/0.00
5,4	Expository	2	0/0.00	6	1/16.67
6,3	Narrative Nonfiction	9	7/77.78	13	0/0.00
Total		45	11/24.44	76	6/7.89

Note. The abbreviation ‘na’ used in the percent column indicates that a percent is not applicable, due to the absence of supported claims.

Table 5

Frequencies of Obtaining, Evaluating, and Communicating Information

Unit,Week		Obtain Information		Evaluate Information		Verbal Communication		Written Communication	
		Students Observe	Students Engage	Students Observe	Students Engage	Students Observe	Students Engage	Students Observe	Students Engage
1,3	Expository	3	9	0	2	0	7	3	4
1,4	Narrative Nonfiction	1	10	0	2	4	17	1	8
2,3	Narrative Nonfiction	0	9	0	1	0	15	0	8
2,4	Expository	0	8	0	1	1	13	1	5
3,5	Persuasive Article	0	7	0	2	0	4	0	5
4,3	Historical Fiction	0	4	0	1	0	6	0	3
4,4	Expository	2	9	0	1	1	8	1	2
5,3	Biography	10	11	0	2	2	5	3	8
5,4	Expository	5	12	0	1	3	5	3	9
6,3	Narrative Nonfiction	2	7	0	2	1	5	2	5
Total		23	86	0	15	12	85	14	57