How the nature of science is presented to elementary students in science read-alouds

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HOW THE NATURE OF SCIENCE IS PRESENTED
TO ELEMENTARY STUDENTS IN SCIENCE READ-ALOUDS

by

Seema Rivera

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Abstract

Students as early as elementary school age are capable of learning the aspects of the nature of science (NOS), and the National Benchmarks incorporate the NOS as part of the learning objectives for K-2 students. Learning more about elementary science instruction can aid in understanding how the NOS can be taught or potentially integrated into current teaching methods. Although many teaching methods exist, this study will focus on read-alouds because they are recommended for and are very common in elementary schools. The read-aloud practice is particularly helpful to young students because most of these students have a higher listening comprehension than reading comprehension. One of the main components of the read-aloud practice is the discourse that takes place about the trade book. Both explicit and implicit messages are communicated to students by teachers’ language and discussion that takes place in the classroom. Therefore, six multisite naturalistic case studies were conducted to understand elementary teachers’ understanding of the NOS, students’ understandings of the NOS, trade book representations of the NOS, and read-aloud practices and understandings in upstate New York. The findings of the study revealed that teachers and students held mostly naïve and mixed understandings of the NOS. The trade books that had explicit connections to the NOS helped teachers discuss NOS related issues, even when the teachers did not hold strong NOS views. Teachers who held more informed NOS views were able to ask students NOS related questions. All teachers showed they need guidance on how to translate their NOS
views into discussion and see the significance of the NOS in their classroom. Explicit NOS instruction can improve student understanding of the NOS, however the focus should be not only on teachers and their NOS understanding but also on the books used. These results show that quality trade books with explicit connections to the NOS are a useful instructional tool in elementary science classrooms. The results of the study encourage more science education research in the science read-aloud practice.

*Keywords:* NOS, read-aloud, elementary
Dedication

This work is dedicated to my family. First to my dearest husband Tony for his unconditional love and support and for believing in me. You were there for our growing family and me in so many countless ways in this journey, and I am eternally grateful. I also want to thank my mom and cousin Neil for their unconditional support and help while I struggled to balance being a full-time student and first-time mom. Finally, to my daughter, Lily, my life is more blessed because of you. Thank you for making me smile, I love you more than I could have ever imagined.
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CHAPTER 1
INTRODUCTION

One major goal of science education reform is to produce scientifically literate citizens or members of society with enough science knowledge and understanding to make informed decisions (American Association for the Advancement of the Sciences [AAAS], 2009; National Research Council [NRC], 1996). One of the vital components of this goal is the understanding of the NOS (AAAS, 2009; Driver, Leach, Millar, & Scott, 1996; Rutherford & Ahlgren, 1990). The NOS can be defined as “the epistemology and sociology of science, science as a way of knowing, or the values and beliefs inherent to scientific knowledge and its development” (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002, p. 498). Although the exact definition of the NOS is debated, particularly in regards to both the philosophy and history of science (Lederman et al., 2002; Osborne, Collins, Ratcliffe, Millar, & Duschl, 2003; Smith, Lederman, Bell, McComas, & Clough, 1997), there is a general consensus within academe concerning what should be taught about the NOS in K-12 science curricula (Lederman et al., 2002; Osborne et al., 2003; Smith et al., 1997). The idea is to teach students not only science content but also how to think about scientific knowledge at a deeper level and see science as a larger enterprise.

To help reach this goal of producing scientifically literate citizens who can make informed decisions, students should learn about the NOS by the time they graduate high school. Nevertheless, by the time students reach high school, many of them have misconceptions about the NOS (Moss, Abrams, & Robb, 2001; Ryan & Aikenhead, 1992). However, elementary students who receive teaching on the NOS
concepts over time show a more developed understanding of experimentation in science, the types of questions scientists ask, and the goals of science (Smith, Maclin, Houghton, & Hennessey, 2000). Therefore, introducing the NOS concepts in the early years of science education can help to avoid later misconceptions. Students as young as elementary school ages are capable of learning the NOS (Akerson & Hanuscin, 2007; Akerson & Volrich, 2006) and the National Benchmarks (AAAS, 2009) incorporate the NOS as part of the learning objectives for K-2 students.

Although strong consensus indicates that the NOS is important for students to learn, how they can learn it is not particularly clear (DeBoer, 1991; Forawi, 2007). Not knowing what methods work is a major hindrance in trying to teach the NOS to students. Some studies have shown that preservice and in-service teachers are able to develop teaching strategies to improve their students’ understanding of the NOS (Akerson, Abd-El-Khalick, & Lederman, 2000; Akerson, Flick, & Lederman, 2000; Akerson & Hanuscin, 2007; Akerson & Volrich, 2006). However, little research has addressed the methods of how students can attain a developed view of the NOS. A current popular science-teaching method, classroom inquiry, has been shown not to develop a sufficient understanding of the NOS for students (Akerson & Abd-El-Khalick, 2003). Although how students become well versed in the NOS is unclear, research has revealed that students’ views of the NOS can develop and change, depending on the type of classroom instruction implemented (Akerson, Abd-El-Khalick, & Lederman, 2000; Akerson, Flick, & Lederman, 2000). Therefore, learning more about elementary science instruction can aid in understanding how the NOS can be taught or potentially integrated into current teaching methods. While
many teaching methods are in use, this study will focus on the read-aloud because using this method is recommended for and very common in elementary schools (Allen, 2000; Anderson, Hiebert, Scott & Wilkinson, 1985; Beck, McKeown, & Omanson, 1987; Richardson, 2000).

Read-Alouds

Many students have their first exposure to the process of science in elementary school through read-alouds (Barlow, 1991). Students at the elementary level are novice readers who have not yet developed the comprehension skills needed to read and understand complex vocabulary. Therefore, having them read texts filled with science jargon might alienate them and prevent them from becoming engaged with the material (Baram-Tsabari & Yarden, 2005). Read-alouds are typically conducted in elementary K-6 settings, using trade books, and can be used to help students learn about science through reading. The read-aloud practice is particularly helpful to young students because most of these students have a higher listening comprehension than reading comprehension (Trelease, 2006). Additionally, the read-aloud practice helps students develop higher fluency (the ability to read quickly), which may help in understanding more complex scientific concepts (Brassell, 2006). Elementary school teachers are strongly encouraged to incorporate science read-alouds into their regular practices because of their potential to enhance science instruction. For example, read-alouds have been used as a way of exposing young students to informational—factual—texts (Duke & Kays, 1998; Smolkin & Donovan, 2001).
Substantial literature has shown the benefits of reading aloud to young children, such as teachers scaffolding students’ understanding of the content during the read-aloud; teachers providing rich context through voice, gestures, and accurate pronunciation (McCormick & McTigue, 2011); students seeing a more advanced reader interacting and making sense of the text (Delo, 2008), and stimulating students’ interest in learning (Albright, 2002). In addition, the discussions children participate in during read-alouds contribute to deeper understanding of content and better communication skills (Gambrell, 1996). Likewise, the National Research Council’s 5-E instructional model (2000)—engage, explore, explain, extend, and evaluate—was created to help students think more deeply about a concept, and read-alouds are a perfect way to engage students in a science topic.

When discussing read-alouds, the topic of trade books cannot be ignored because they are part of the read-aloud practice. Research on read-aloud practices has noted the importance of selecting the appropriate trade book for the read-aloud (Fisher, Flood, Lapp, & Frey, 2004; McCormick & McTigue, 2011). Trade books, as defined by Ford (2006), are books published for the general public and used in the science classroom. Blough (1973) demonstrated that, although trade books were first seen as a supplement to science instruction in school, their presence and role has increased. These trade books have been received as good alternatives to using only textbooks in a classroom because of their content, illustrations, graphics, and writing styles, making them generally more engaging to students than regular textbooks are. Moreover, in the typical read-aloud in an elementary classroom, the teacher selects a trade book to read aloud, not a textbook. Reading trade books to elementary students
can help increase their motivation and achievement in science (Kletzien & Dreher, 2004), foster a deeper understanding of content (Albright, 2002), improve vocabulary (Elley, 1992), increase student interest in the topic at hand (McClure & Zitlow, 1991), and acquire a love for science (Lake, 1993). Using trade books may increase students’ ability to read critically, emphasize the scientific process, and ultimately improve their NOS views. The literature has indicated that, together, trade books and read-alouds can help in teaching science to students.

Although the reviewed literature supported using read-alouds and trade books in elementary science classrooms, further research in this area is needed. Many articles encourage the use of science trade books and note the presence of read-alouds in elementary science (Abell, 2008; Braun, 2010; Heisey & Kucan, 2010; Mayer, 1995; McCormick & McTigue, 2011; Rice, 2002). However, very little research has addressed the science read-aloud practice. Even though the science read-aloud is recommended in elementary schools, much of the read-aloud research is focused on general literacy or reading. Further, few trade book studies (Abd-El-Khalick, 2002; Ford, 2006) examined the NOS in science trade books, and they do not go beyond investigating how teachers use the books. According to Ford, “Trade books can play an important role in learning about the nature of science, if chosen and used carefully, but they cannot by themselves adequately represent the complexities of science” (p. 231). These gaps in the literature support the need for research in understanding how teachers present trade books in science. Analyzing the NOS portrayal in these trade books and concurrently investigating how these books are used in the classroom will help to give a more complete picture of how the NOS is taught in elementary school.
Purpose of the Study

This study will contribute to the area of elementary science education by investigating the science read-aloud and how teachers and students with known NOS views make meaning of the NOS in trade books. This brief review of the literature supports the need to research the issues of the NOS in trade books and the NOS views of teachers and students in the context of the read-aloud. The research questions that guide this study are the following:

1. How do elementary teachers who practice science read-alouds view the NOS?
2. How do elementary students who participate in science read-alouds view the NOS?
3. How is the nature of science portrayed in the science read-aloud trade book?
4. How is the NOS negotiated through the discourse in the read-aloud practice?
5. How do teachers and students with known NOS views make sense of the NOS portrayed in trade books during science read-alouds?

Definition of Terms

The following terms are used in this study as defined below:

Case. A case is bounded system that is the object of study (Merriam, 1998).

Meaning making. Meaning making refers to creating an understanding through discourse between students and teacher.
Member check. A member check is participant review of data and analysis as a way to crosscheck research (Patton, 2002).

Naturalistic inquiry. Naturalistic inquiry is research conducted in natural or real-life settings. The natural setting in this study is the elementary classroom.

Nature of science. Lederman et al. (2002) indicated that scientific knowledge can varyingly be discussed in terms of (a) being tentative; (b) being empirical; (c) being theory-driven; (d) being partly the product of human inference, imagination, and creativity; (e) being socially and culturally embedded; (f) being based on observation versus inference; (g) being based on the myth of the scientific method; and (h) having theories and laws.

Read-aloud. A read-aloud is a process in which a teacher reads a book aloud to her students. It includes the process of selecting a book and any other preparation for reading the book; communication that occurs during the read-aloud, including physical and verbal; and any discussions that occur during or immediately following the read-aloud.

CHAPTER 2
LITERATURE REVIEW

Overview

The purpose of this study is to understand how elementary teachers’ and students’ views of the NOS together with its portrayal in texts help teachers and students to make sense of the NOS meaning during read-aloud practices. This chapter is a review of the scholarly literature related to the study. The review is organized into the following sections: (a) an introduction to the NOS, (b) the NOS and elementary students, (c) elementary teachers and their NOS beliefs, (d) read-aloud practices in elementary science classrooms and the integration of science and literacy, (e) the representation of NOS in science trade books, and (f) discourse about the NOS. This chapter concludes with the theoretical framework that will be used to investigate the research questions in this study.

To find literature for this review, I first searched science education journals—*The Journal of Research in Science Teaching, Science Education,* and *The International Journal of Science Education*—for references to the NOS and elementary science education. After finding many studies related to this topic, I limited the review of literature to the research that examined the accessibility of the NOS to elementary students and elementary teachers’ NOS views related to their practices. Studies centered on science read-aloud practices were searched for, and after very little related literature on this topic was found, the search was expanded to science read-aloud practices in reading, literacy, and elementary education journals. Many of the articles found were from practitioner journals, and very few were found
in peer-reviewed research journals. Considering the large volume of research on elementary read-alouds within these disciplines, I selected overarching concepts to limit my review to read-aloud practices related to the NOS and science content. I also searched for studies that examined the portrayal of the NOS in trade books; however, because there were so few studies, I broadened this search to include the portrayal of science content as well. These themes guide the following review of literature and provide implications for this research study.

**The Nature of Science**

Since the 1980s, many science education reform efforts have been focused on producing scientifically literate citizens (Driver et al., 1996; NRC, 1996, Rutherford & Ahlgren, 1990). According to the *National Science Education Standards* (the Standards; NRC, 1996), *scientific literacy* is defined as follows:

Scientific Literacy means that a person can ask, find or determine answers to questions derived from curiosity about everyday experiences. It means that a person has the ability to describe, explain and predict natural phenomena. Scientific literacy entails being able to read with understanding articles about science in the popular press and to engage in social conversation about the validity of the conclusions. Scientific literacy implies that a person can identify scientific issues underlying national and local decisions and express positions that are scientifically and technologically informed. A literate citizen should be able to evaluate the quality of scientific information on the basis of its source and the methods used to generate it. Scientific literacy also implies the capacity to pose and evaluate arguments based on evidence and to apply conclusions from such arguments appropriately. (p. 22)

One of the ways NRC (2000) described scientific literacy is having knowledge about the way science works or the nature of science. Within the science education community, there is disagreement over the social construction of the NOS (Lederman et al., 2002; Smith et al., 1997). Despite a disagreement among science educators concerning one single definition of the NOS in the research community,
“There is, we believe, a level of generality regarding NOS that is accessible and relevant to K-12 students and at which virtually no disagreement exists among experts” (Abd-El-Khalick, Bell, & Lederman, 1998, p. 787). Considering the research on science standards as well as initial research conducted by science educators, scientists, historians, philosophers, and science teachers concerning the possible components of the NOS, Alshamrani and McComas (2009) compiled a list of 12 key ideas about the NOS:

1. Scientific knowledge is not completely objective;
2. Science is creative;
3. Science is tentative;
4. Science is socially and culturally embedded;
5. Scientific laws are distinctive from scientific theories;
6. Science is empirical;
7. The scientific method is not step-wise;
8. Observations and inferences have differences;
9. Science cannot answer all questions;
10. Cooperation and collaboration are often present in developing scientific knowledge;
11. Science and technology are interdependent;
12. Experiments have a role in science.

One of the many disagreements that exist in the academic world concerning the NOS is that these components are too abstract for K-12 students to understand. However, this concern can be diminished depending on how the degree to which one includes these components. Abd-El-Khalick, Bell, and Lederman (1998) stated, “There is, however, an acceptable level of generality regarding the NOS that is accessible to K-12 students and also relevant to their daily lives” (p. 418). Therefore, it is acceptable to examine the NOS among elementary (K-6) students in this study.

In the next section, I provide evidence that elementary students are capable of understanding NOS concepts and describe how teachers can facilitate that
understanding. I also discuss how teachers’ NOS views play a crucial part in developing the NOS views of students.

**Elementary Students and the NOS**

Several studies have explored elementary teachers’ and students’ views of the NOS. Akerson and her colleagues have completed a significant amount of research on understanding elementary student’s views of the NOS. In one particular study, Akerson and Donnelly (2010) studied K-2 students who were given explicit NOS instruction in Saturday morning science sessions designed to improve students’ views of the NOS. The study addressed the kinds of NOS understandings that K-2 students can develop when experienced teachers teach them. The researchers sought explicit activities that attracted the students’ interests, focused more on science and the real world instead of vocabulary, and stressed the importance of the NOS concepts considered accessible to young students. These concepts include tentativeness, subjectivity, creativity, the difference between observation and inference, and the empirical aspect of the NOS. A View of Nature of Science Survey (VNOS, form D) was used to gather information on students’ understanding of the NOS before instruction; then interviews were conducted at the end of the program.

The study found that students held naïve views of the NOS prior to the intervention. However, students showed improvements in their understanding after completing the program. Following explicit NOS instruction, most students increased their conceptual knowledge concerning creativity and tentativeness in science and the differences between observations and inferences. The empirical nature and subjectivity of the NOS were a bit more difficult for students to understand. The
authors noted that, although many students were able to improve their understanding of NOS concepts, none reached the level of informed understanding. The authors argued that elementary students could improve their understanding of the NOS with effective teaching strategies. They stated, contrary to what others may have believed, young children are capable of understanding NOS concepts with appropriate instruction:

Teachers and researchers of young children should not feel constrained by the idea that students are not developmentally ready to attain improved understandings of NOS, but instead strive for effective teaching strategies that enable young children to obtain the best understandings of NOS that they can. (p. 120)

This study by Akerson and Donnelly (2010) showed the potential for NOS learning in elementary school with the proper teaching methods and indicated that, when students are given explicit NOS instruction along with science instruction, NOS views can be improved.

Akerson and Abd-El-Khalick (2005) examined fourth-grade students and their understandings of the NOS, particularly the inferential, creative, and tentative aspects. In this study, according to VNOS results, the teachers had more developed NOS views and taught students science for one hour a day. However, only a small number (9%) of students could express understandings of creativity and inferences in terms of the NOS. These results were quite different from the other studies in which teachers gave students explicit NOS instruction, regardless of their own views of the NOS.

Akerson and Volrich (2006) also examined explicit NOS instruction by studying first-grade students’ views of the creative, tentative, and inferential aspects of the NOS. Researchers found that the first-grade in-service teacher who held appropriate views of the NOS, according to VNOS results, was also motivated to
teach the NOS and had experience finding and showing NOS aspects in physics content to peer college students. Akerson and Volrich found the teacher was better able to emphasize the NOS during specific teaching methods. For example, she not only introduced the NOS at the beginning of a lesson but also embedded the lesson with more explicit NOS discussion and even finished her lesson with a discussion of NOS aspects, such as “How was what we did like what scientists do?” (p. 391). In addition to observing and interviewing the teacher, the researchers interviewed the first-grade students before and after instruction to measure the effects of explicit NOS instruction. At the start of the study, students held many misconceptions about the NOS, such as its tentative nature and how creativity is a part of developing scientific claims. For example, at the beginning of the study, students did not believe scientists would change their views on a science topic, but at the end of the study, a student said, “Things will change in the future, so scientists will change their ideas too” (p. 385). This study is evidence that elementary students are capable of developing an understanding of the NOS.

A study by Khishfe and Abd-El-Khalick (2002) also found that, if teachers want to teach NOS concepts to their students, they need to refer explicitly to those concepts when teaching. Within the two groups of sixth-grade students who participated in this study, 85% held naïve NOS views at the onset of the study. One group engaged in inquiry activities followed by a reflective discussion of the targeted NOS topics (tentative, empirical, inferential, and creative) while the other group of students participated in the same inquiry activities but not in discussion of or reflection on NOS concepts. By the end of the treatment, all students were
interviewed and asked to complete an open-ended questionnaire on the NOS. The group that received the reflection discussion on the NOS performed better and improved their NOS understandings while the group that did not receive the discussion or reflection “did not substantially improve their NOS understanding” (p. 573). This study contributed to the argument that explicit NOS instruction is necessary for students to develop more developed NOS views.

These studies presented evidence that, contrary to prior research, elementary students are capable of understanding the NOS; thus, they create the need for research on how this understanding happens. The current study will contribute to the current body of knowledge by exploring what elementary students’ views are of the NOS and whether they understand the NOS presented to them during the read-aloud practices. Subsequently, the study can help show how read-alouds may be crafted to create meaningful NOS instruction.

**Teacher Beliefs and NOS Instruction**

A study by Akerson and Abd-El-Khalick (2003) found that teachers being motivated to teach the NOS are insufficient in changing students’ conceptual knowledge of the ideas. The researchers aided the teacher in the study to translate her NOS views into meaningful NOS instruction. The authors found the teacher needed support in translating her NOS views into explicit NOS instruction, yet they could not help the teacher develop and better understand her own NOS views; they were not able to help the teacher prioritize the need to teach about the NOS. The teacher was able to discuss her NOS views with the lead researcher to try to figure out how to implement the ideas in her teaching and change her discourse about science.
Qualitative findings showed that the teachers would have to break the stereotypes she once held about science if she was to be more successful. The researchers believed that the teacher needed “socially mediated contextual professional support” (p. 1045). The teacher needed a model to follow in how to incorporate NOS explicitly into her instruction because her prior teaching experience did not include any NOS instruction. However, ways of translating teacher NOS knowledge into practice are still uncertain and are in need of further research. This need is evidenced in a study by Abd-El-Khalick et al. (1998) that found that, even when teachers hold informed views of the NOS, they might not incorporate them into their teaching. They found that pre-service teachers did not believe the NOS was as important as content and felt unsure of how to implement NOS activities and uncertain of their own ability to teach it properly.

A similar study reviewed pre-service science teachers’ perspectives of the NOS and its relationship to classroom practice (Brickhouse, 1990). Over a 4-month period, Brickhouse observed and interviewed three teachers about their positions on the NOS, and supplementary materials were collected, such as teacher documents, laboratory activity sheets, tests, and quizzes. Some of the teachers’ beliefs seemed to contradict their actions in class; for example, one teacher, “McGee,” taught students the scientific method as a step-wise process and asked students to design a study following this scientific method. However, he simultaneously shared stories in class about scientists conducting research with no structured order. Furthermore, the teacher in the study with the most sophisticated NOS views reflected her beliefs in her teaching activities most frequently. The researcher also found that the two
teachers with more teaching experience were very consistent in inserting their beliefs into their teaching, whereas the beginning teacher was unpredictable. The beginning teacher had varied data, and only after asking more concrete questions about his rationale following his teaching instruction were the researchers able to differentiate between his beliefs and practices. In addition, the beginning teacher had more conflicting beliefs and felt less free in his teaching methods because of his administration. Although this current study does not focus on teacher experience, experience should be taken into account in the study because it can affect the data.

Furthermore, studies by Tobin and McRobbie (1997) and Waters-Adams (2006) showed that teachers’ NOS views were not reflected in their NOS teaching in their classrooms. One possible reason for this lack is that the instruments used to gather the teachers’ NOS views may not have been accurate (Lakin & Wellington, 1994). In addition, teachers may have beliefs that differ from their practices, that is, perhaps that knowledge, beliefs, and classroom practice are three separate components (Waters-Adams, 2006). If this idea is true, it would explain that the pre-service teachers in the above study allowed their knowledge to outweigh their beliefs when teaching students.

Given the importance of students learning the NOS, it is imperative that elementary teachers are appropriately supported in their endeavors of teaching NOS concepts regardless of their beliefs. Research has encouraged understanding teachers’ NOS views to provide a more detailed picture of the reasoning behind their teaching practices. This current study explores how teachers prepare for and enact
read-alouds in their classroom, and understanding their NOS views will provide a richer description of the read-aloud practice.

**Read-Alouds**

Future research should explore the kinds of teaching strategies that improve young children’s NOS understandings, as well as ways to help early childhood teachers deliver effective instruction. (Akerson & Donnelly, 2010, p. 121)

Elementary teachers are required to teach all content areas but tend to focus on reading, writing, and math skills because of high-stakes testing in these areas (Jorgensen & Vanosdall, 2002). This pressure combined with many elementary teachers feeling uneasy about teaching science because of lack of content knowledge (Mulholland & Wallace, 2001) leaves elementary science education at risk of falling behind.

One of the ways to counteract this scenario is by combining science and literacy. In recent years, research has supported the effectiveness of combining both science and literacy in instruction (Guthrie & Ozgungor, 2002; Palincsar & Magnusson, 2001). Elementary teachers are strongly encouraged by literacy researchers, such as Kletzien and Dreher (2004), to incorporate science read-alouds into their regular practices as a way of helping elementary students stay motivated in science and cultivate a deeper understanding of content. In addition, Lake (1993) found that read-alouds are valuable because they can help students to develop a love for science. Stiffler (1992) wrote that science trade books help students see that science is part of everyday life and that, by using these trade books, students first become engaged and then can explore science, beyond the limited class time set aside for “science.” Therefore, it is essential that science educators learn more about science read-alouds, how they are practiced and how teachers use them to teach
Science. Science educators can then use this knowledge to better support elementary teacher’s practices of teaching science content to their students.

Heisey and Kucan (2010) used read-alouds to introduce students to the Standards (NRC, 1996) related to science as a human endeavor and to science as inquiry. Three trade books were selected and questions developed to be asked after small segments were read and after the entire book had been read. The participants consisted of first and second graders from two elementary classrooms in a university lab school. The researchers were interested in finding whether any differences existed in comprehension of text for each read-aloud session between the group that was asked questions during the reading and after the reading. They also were interested in how student talk differed between groups during the reading and after the reading.

The books selected for the study showed scientists at work and had other factors that were considered for clarity of ideas, age appropriateness, and coherence. Texts were edited to match each other in time length for comparisons but revised so that the revision did not disrupt the presentation or omit any significant ideas related to scientific inquiry. The authors described the three books selected to have both “breadth and depth of scientific inquiry” (p. 668). The read-aloud exercise procedures were based on the questioning the author (Beck, McKeown, Hamilton, & Kucan, 1997) and text talk (Beck & McKeown, 2001) approaches that have teachers break the reading into chunks of appropriate length. Questions used in the study were created to focus on the scientists at work, science content, connections to previous texts read, and science vocabulary. The questions posed to students in the after-
reading group were the same questions as those asked the group questioned during the readings. Pretests and posttests were completed to capture students’ understanding of the science content in the books.

The results from this study (Heisey and Kucan, 2010) showed that students who were asked questions only after the story performed poorly on the tests in comparison to those asked questions during the read-aloud. The authors suggested looking at the results as two kinds of understandings: (a) understanding an individual book and (b) understanding multiple books over time. The researchers concluded that having several experiences with one concept across books gives students “more time to build a mental representation of important ideas” (p. 675). The study supported that using more than one text is a useful instructional technique when trying to help students improve their science understanding. The authors also suggested that, the group asked questions during the reading performed better because they were able to interact with the text and, therefore, were able to consider things like content and vocabulary, remaining attentive in general and to the particular chunk of text. The authors found the results of their study supported using read-alouds; therefore, they indicated a future for more research on read-aloud practices.

A 2004 study in The Reading Teacher established the effectiveness of a read-aloud by investigating the components of an effective read-aloud (Fisher et al., 2004). The researchers worked daily with classroom teachers who conducted read-alouds decided to study the teachers who had “a reputation of being exceptional models of read-aloud instruction and whose students consistently performed at or above the school norms on reading achievement” (p. 9). In Phase I of the study, 25 teachers
who were identified as experts in the read-aloud practice were selected at random to participate in the study. The teachers were observed twice by two researchers simultaneously, and steps were identified for using read-alouds. Researchers used these steps to create a Likert scale to measure the quality of read-aloud components for Phase II of the study.

In Phase II of the Fisher et al. (2004) study, 120 teachers were selected randomly and were observed implementing read-alouds in their classrooms. Eighteen of the teachers from each of the grades were interviewed to improve understanding of their teaching practices. During the interviews, teachers were shown components of the read-aloud model by the experts and were asked to compare their techniques in their own read-aloud performances.

In the Fisher et al. (2004) study, rubrics were created by the expert teachers and used to rate the teachers participating in Phase II of the study. Interview data were also used to help give context to their findings. Based on the study, the researchers recognized seven components of a quality read-aloud based on their study: (a) appropriate book selection, (b) teacher practice/preview of book, (c) a clear purpose for the read-aloud, (d) fluent oral reading of the book by teachers, (e) teachers using animation and expression while reading, (f) teachers pausing to ask students thoughtful questions focused on specifics of the text, and (g) intertextual connections being made. In reference to the sixth component, some expert teachers asked students to talk to a partner about what they saw in the book, what their predictions or reactions were about the reading, and whether they were confused about any parts of the book. The teachers asked students more specific questions
clarify ambiguous parts. Concerning the seventh component, expert teachers connected the read-aloud experience to writing or independent reading done in class. The read-aloud practice was always connected to a larger part of classroom instruction and not done as an isolated occurrence.

The findings of Fisher et al. (2004) indicated teachers were highly consistent in the types of books they selected to teach with in their classes and tended to have the same types of discussions. They were given a fair rating for consistently establishing a purpose of the read-aloud, but they were not consistent in previewing/practicing with the books, reading fluently, and connecting the read-aloud to other literacy activities. Several of the teachers mispronounced words, stumbled while speaking, or emphasized parts of a sentence that changed the meaning. The researchers also found that sometimes a read-aloud seemed disconnected to the rest of the classroom activities in that there was an abrupt end to it and then a new, unrelated activity was started. The authors in this study concluded the expert teachers were essential in implementing effective read-aloud and encouraged more research in the area of read-aloud practices.

A study by Varelas and Pappas (2006) examined the intertextual connections made by children and teachers during seven science read-aloud sessions in primary grades. The researchers defined *intertextuality* as “the juxtaposing of two texts” (p. 211) and combined it with hybridity or “mixing of discourses” (p. 212) to see how dialogic read-alouds can allow teachers and students to co-construct meaning from the books. After collecting data through videotapes and field notes, the researchers discovered that, when children struggled with concepts, teachers rephrased the idea,
and together, they explored science concepts and ways of conveying them. For example, several students talked about “iced cubes” that were really icicles. This study showed that

creating spaces for children to use both narrative and scientific language to make sense and talk science as the teacher, and the texts available to them, and model scientific language may be necessary for children to construct and own scientific knowledge. (p. 252).

In other words, these intertextual connections being made allowed for the negotiation of scientific understanding. Although students also experienced some hands-on science experiences related to the science topics during this study, it was evident that using the read-aloud practice helped students in understanding science.

One study (Fisher et al., 2004) reviewed in this section examined read-aloud practices in general, and the others (Heisey and Kucan, 2010; Varelas and Pappas, 2006) citations) in this section examined read-aloud practices of science content. In the review, I did not find any articles that specifically addressed the NOS in read-aloud practices, so this present study will help fill this gap in the science-literacy connection. The next section includes discussion of trade books.

**Trade Books**

Ford (2006) examined 44 juvenile science trade books selected from a public library for their explicit and implicit representations of science. Ford indicated the books were randomly selected by selecting every 20th children’s science trade book in a local public library on a single day as a good representative sample of what teachers might read to their classes. However, it is not clear that any of the books examined were typically used or had ever been used in a read-aloud. To examine how science is represented in these books, Ford used the Helms and Carlone (1999, as
cited in Ford, 2006) heuristic framework that has a neutral perspective on the NOS and includes many NOS components established in the literature.

The results of Ford (2006) showed the books largely covered life science content with the physical sciences being the least covered. She argued that this finding illustrated a missed opportunity to connect the public with physical science just because life sciences tend to be more easily relatable to ordinary people. In the books selected, 75% explicit mentioned the scientific practice or scientific practitioners; however, all the trade books showed people and methods used to produce scientific data as being separate from scientific knowledge. None of the books selected showed how data collection was connected to theories or a community of science, and scientists that were shown tended to be displayed as “heroes.” Ford stated, “Although science facts are mentioned either on their own, or with a reference to a person or method that produced them, rarely is information provided describing knowledge development itself” (p. 224). Ford correctly addressed the concern with this finding because, according to science education literature and National Science Standards, it is essential that elementary and middle school students understand scientific reasoning and the process by which knowledge is developed (Chinn & Malhotra, 2002; NRC, 1996).

Ford (2006) found that, although the scientific method was represented in the books and observation prominently mentioned, the interpretation of data was implied and never clearly addressed. Twenty-four percent of the books described experimentation and presented the scientific method as a step-wise procedure. Ford (2006) gave an example of a book that stated that students should follow the steps in
order, do not substitute materials and if the results are not what they are expected to be, start over. These types of messages reinforce the misconception that science is done in a neat linear order. The books also used vague terms such as *test* and *look for* when describing things like collecting data, without giving the reader a clearer picture of how data were actually collected. In only one book from the entire sample were readers exposed to the complex nature of scientific research. However, this lone book was presented “for the more sophisticated reader,” implying that only more advanced students will be able to understand developed NOS views.

In addition, Ford (2006) indicated scientists were mentioned in the books in a vague manner, with only 5% of them showing the human side of scientists. The images in the books were stereotypical, showing all illustrations of scientists as either white males or white females. Only 3% of these books described the interactions that take place among scientists, an omission that does not support the NRC’s (1996) goal of helping children see scientists as part of a larger community of practitioners.

Ultimately, Ford (2006) found very little content that could lead students to deeper understanding of science. Scientific theories, scientific reasoning, and the scientific community were never clearly connected to the science in these trade books. Ford concluded that using a single trade book is very unlikely to give direct NOS instruction to students. Ford asserted, “Trade books can play an important role in learning about the nature of science, if chosen and used carefully, but they cannot by themselves adequately represent the complexities of science” (p. 231). Ford’s study showed there is potential for trade books to be helpful in developing students’ understanding of science if presentation of the books is appropriately prepared. The
read-aloud practice should be well thought out, book meanings considered, potential activities planned, and certain questions for asking students developed in consideration of the appropriate responses. Ford summarized that the trade books in her sample presented science as a separate entity from the people or practice behind it. Ford’s study showed that trade books do send a message to the reader about science. Ford (2006) is one of the few research articles in science education addressing how the NOS and the practice of science are presented in trade books.

Abd-El-Khalick (2002) examined the NOS portrayal in middle-school science trade books. Only four books were selected for this study, but they were randomly selected from the National Science Teachers Association (NSTA) list of award-winning science trade books for 2000 and 2001. A content analysis examining the themes of the NOS in the books, as well as any implicit and explicit messages of NOS, was completed. Abd-El-Khalick stated,

All four books were devoid of any explicit references to ideas about NOS. There were no discussions whatsoever of the processes involved in, or notions underlying, the development of the scientific ideas and claims presented in the books. As such, the analysis boiled down to inferring an image of NOS that was implicitly conveyed in the narratives. (p. 123)

According to Abd-El-Khalick (2002), the science in the books was presented strictly as a list of facts, even when there were opportunities to make a link to the NOS, such as fertile soil or animal defenses in the contexts of ecological systems and adaptive behaviors, respectively. Besides a single example, there were no mentions of individuals or groups of individuals who were doing or had done science. The science collected in one instance was very vague, indicating only that scientists “watched” something to collect data. There was no further explanation of the thinking associated with the processes of science. Abd-El-Khalick notably argued
that, even though these books were not expected to give all details of every topic, the “process involved in collecting such evidence, and thinking associated with developing knowledge consistent with evidence could still be vividly represented in the narrative” (p. 124). In addition, the facts were written with little or no human involvement mentioned, giving them a sense of certainty, which is the opposite of the NOS aspect of tentativeness. Abd-El-Khalick stated that, because it was such a small sample, the results could not be generalized to all trade books; however, because they were listed as award-winning books, they are considered representative of this genre. The researcher concluded that these young students’ somewhat-extreme images of science were a result of the portrayals of the NOS in the trade books. He argued teachers need to know how NOS is portrayed in instructional materials before using them.

Furthermore, Buxton and Austin (2003) searched for trade books that met two criteria: They had to “show science as an active process of inquiry rather than a passive collection of facts,” and the scientists in the book needed to reflect what real scientists look like. After searching through hundreds of science trade books, they found 32 that presented science as a process. The books were then given to an elementary science methods course for pre-service teachers to evaluate by selecting one book and writing a paper on how science and scientists were represented in the book. From these data, the researchers identified five major themes shown in Table 2.1.

Table 2.1

<table>
<thead>
<tr>
<th>Major Themes</th>
<th>Example from the data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major themes</td>
<td>Example from the data</td>
</tr>
<tr>
<td>Connecting science to students’ lives</td>
<td>“Scientists can be women, married and have children. It shows students that all discoveries are not found in a laboratory but that they can be found anywhere, even in your own back yard.”</td>
</tr>
<tr>
<td>Presenting science through engaging stories</td>
<td>“Scientists can be women, married and have children. It shows students that all discoveries are not found in a laboratory but that they can be found anywhere, even in your own back yard.”</td>
</tr>
<tr>
<td>Showing specific inquiry skills of experts</td>
<td>“[It] is essentially saying there’s not only one method, such as the scientific method, but many other ways to answer questions and make discoveries.”</td>
</tr>
<tr>
<td>Giving science a human side</td>
<td>“He showed us that science is so much more than the data that is collected. Science is about real people and unlocking keys to the past.”</td>
</tr>
<tr>
<td>Showing how science is always evolving</td>
<td>“Science is not a stagnant body of knowledge, but a process of discovery and investigation, and Voyager makes this clear.”</td>
</tr>
</tbody>
</table>

Buxton and Austin (2003) concluded that there are not many science trade books that can help teachers implement goals set by the National Science Education Standards, but those that do exist not only help the reader learn science content but also portray more accurate ideas about the NOS. They also argued that books like these can engage readers who are already interested in science and attract those who were never interested in science, possibly changing their views.

Because research examining NOS content of trade books is minimal, I extend this examination of trade book NOS research to include research on science content of trade books. Although science content and the NOS are not identical, they are not mutually exclusive; for example, the theory of evolution is both content and theoretical in nature. The NOS concepts are contextualized in science content;
therefore, science content can be used as a springboard to teach or discuss NOS concepts. Furthermore, Abd-El-Khalick et al. (1998) stated,

Consequently, an individual’s understanding that observations are constrained by our perceptual apparatus and are inherently theory-laden is part of that individual’s understanding of the NOS. Although there is overlap and interaction between science processes and NOS, it is nevertheless important to distinguish the two. (p. 418)

Therefore, I also examined several studies on science portrayal in elementary school trade books. These studies are also used as evidence of a dearth in knowledge on NOS portrayal in elementary trade books. Therefore, this study also includes content analyses of the trade books used in the research. These topics are discussed in detail in the next chapter.

A study by Smolkin, McTigue, Donovan, and Coleman (2009) examined science trade books praised by science educators for their frequency of explanatory passages. Smolkin et al. (2009) described the need for explanation in science education and the lack of research conducted in this area, indicating that the definition of explanation is not agreed upon among science educators. Their study explained that, with the prevalent use of text in elementary science and lack of explanation in elementary science teacher discourse, it is necessary to explore the books children see and read for any potential learning.

Smolkin et al. (2009) selected trade books over a 5-year period from the NSTA/CBC Outstanding Trade Book list because of its accessibility to elementary classroom teachers. The researchers, however, were unable to find the same amount of physical science trade books for younger and older students, a problem Ford (2006) also dealt with because of the lack of physical science trade books for elementary-age students. The main categories used for analysis were overall
explanation (including causal and predictive explanations), fact (exposition) and description, engagement, and irrelevance. All four researchers indicated strong agreement in rating the books, with the inter-rater agreement being greater than 94%. The study results showed the books to contain largely factual and descriptive text (71% for life science books and 62% for physical science books) as opposed to explanatory text.

The books also had more facts and description than explanations for older grades than for the early primary grades. This finding is interesting because Smolkin et al. (2009) stated, “For trade books written to be read aloud to children, there is an understanding that adults will clarify the meanings for children as they read together” (p. 605). This finding indicates it is essential to look at how teachers actually present the science trade books to students. The authors also argued that, when science trade books had explicit explanations, the elementary school teachers end up spending more time helping students understand the reasoning behind the explanations compared to trade books that had fewer explicit statements. They stated that a possible explanation is that “teachers have less trouble explicating the textual explanations found in well-written, carefully explained trade book text than they do providing such explanations during other science instruction” (p. 604). This same argument may also hold true for teachers making explicit explanations about the NOS in science trade books, but little supporting research exists in this area. Additionally, the trade books may implicitly convey messages about the NOS to students, but because the books are being used in the context of a read-aloud, understanding how teachers present science to students through the trade book is imperative.
Although the previously discussed studies examined only trade books, they still emphasized the need for examining how teachers clarify the meanings of content in the books to students when using them in the classroom. The trade books contain explanations of science content and processes and, therefore, are predicted to contain some inherent NOS concepts as well. Smolkin et al. (2009) concluded that, although it is critical to examine what is in science trade books to determine their helpfulness in teaching science to elementary students, it is also imperative to investigate how teachers actually use them.

Rice (2002) examined 50 elementary science trade books by completing a content analysis. Rice investigated how accurate the science content in children’s trade books was, and the research found “numerous examples of misinformation” (p. 556) in the 50-book sample examined. Some examples from the trade books with misinformation showed seeds flying high enough to be burned up by the sun; mushrooms being referred to as plants; chameleons changing to bright red, blue, or yellow; and crocodiles being able to walk on two legs. Rice concluded that the elementary trade books contained “questionable content” (p. 6). The questionable content could be either text or pictures that are scientifically untrue or science content that may be interpreted incorrectly by the students. This questionable content may also affect students’ NOS views as well because they are both closely related.

The second part of the study (Rice, 2002) examined trade books to determine whether the science content in them influenced what students learned. By using a pretest and posttest, findings showed the majority of the questions, children did not change their answers from pretest to posttest. When they did change answers, however, the posttest
answers very closely mirrored the information in the book that had been read to them, whether the information in the book was correct or incorrect. (p. 557)

Although no statistics were provided to argue the significance, the fact that any students changed their answers because of the content in the book shows the influence of trade book content. Therefore, it can be argued that students may not be able to distinguish between accurate or inaccurate information in trade books. This finding helps to assert that what is in trade books may influence student views about science and arguably, therefore, the NOS.

A similar study by Mayer (1995) showed comparable effects. Mayer examined how effective fiction books are in helping students learn science concepts. Mayer read a trade book about whales to individual students and asked them to retell the story in their own words and answer 10 science-content-related questions. Mayer found that the students not only learned very little from the story, but the misrepresentations in the book actually interfered and confused the students. When asked whether they learned anything new about whales, more than half of the students answered “nothing new” (p.17) and five of the 16 students learned “facts” from the book, that were actually misconceptions represented in the book. Mayer argued that, if science trade books are not appropriately selected, they may foster misconceptions among students. Considering the results of her study, Mayer proposed a general checklist for selecting trade books, such as checking for accuracy and keeping a positive attitude toward science that will help inform decisions about trade book choices. She concluded it is ultimately the responsibility of the teacher to select the proper book for his or his classroom and teachers should consider such factors as these.
A study by Schussler (2008) also investigated trade books about plants to
determine how plant reproduction is portrayed and to identify any possible
misconceptions fostered by the books. Schussler searched for “children and plant”
and “children and garden” on two popular book websites (Amazon and Barnes and
Noble) to create a list of books that elementary teachers may select to teach about
plants. She excluded books that contained photographs and kept those with
illustrations because she indicated the illustrations “visually represent” plants and
may have more room for error. She created a list of 108 books that were read by
researchers who paid special attention to both text and illustrations. A content
analysis was done on the text and illustrations in all the books, creating such
categories as potential misconceptions and presentation of reproduction.

Furthermore, a large-scale study by Marriott (2002) examined 1,074 randomly
selected picture books for their portrayals of science and the natural world. Marriot
stated that, during analysis, it was obvious that putting the books into categories
would be too difficult because the boundaries between books were blurry. Instead,
themes such as domestication of animals and images of the natural world emerged
from the books. Marriott found that fewer than 10 of the 500 books having animals
or their habitat theme could be used to help students understand the environment. He
concluded that, while a few books were helpful, most were not worthy of
recommendations to teachers. However, Marriot explained that his study did not
include children, so he was only speculating concerning how students would perceive
the books.
The findings of Schussler (2008) supported those of Rice (2002) and Mayer (1995) concerning trade books conveying misconceptions. Schussler noted erroneous content, such as inaccurate use of terms and overgeneralization and oversimplification of science concepts. Schussler found instances in which potential pollinators of plants were not mentioned in the text, but they were seen in illustrations, assuming that students would figure out pollination on their own. Other examples included flowers never being described as the site of fruit development and inaccuracies between the words *fertilization* and *pollination*. Schussler’s study showed that teachers should be careful in selecting trade books to use for science, being especially aware of the inaccuracies and content gaps present. The books could be effective if teachers correctly align them to the content in their classrooms, analyze them on their own, and whenever possible, have content experts make recommendations for books.

The studies in this section showed that the content in trade books needs to be carefully considered when using them to teach students in the science classroom. Having access to a large selection of high-quality trade books can help teachers in this endeavor by giving them more options (Chittenden, 1976). From the studies that examined the presentation of the NOS in trade books, it is evident there is potential for student learning and student engagement in science that can be supported through the careful selection and use of trade books. Many of the uses of trade books suggested by these authors included the practice of reading aloud to students.

The literature reviewed in this chapter investigated NOS concepts and science portrayal in trade books, NOS knowledge of elementary students, NOS beliefs of
elementary teachers, and read-aloud practices. It was shown that, although some research has examined both trade books and science content, such research is minimal. Therefore, this present study examines the topics mentioned above in a qualitative research analysis.

**Discourse Surrounding the Nature of Science**

One of the main components of the read-aloud practice is the discourse that takes place surrounding the trade book. Teachers interact with students to varying degrees during read-alouds. Authoritative interaction with students, such as the initiate-response-evaluate (IRE) discourse pattern, is typical of read-alouds in which teachers tend to dominate the discussion and ask questions of the students (Cazden, 2001; Edwards & Mercer, 1987; Young, 1992). In contrast, dialogically oriented read-alouds encourage students to share their views and ideas and ask questions (Nystrand, 1997; Wells, 1999) about the trade book. Although these types of interactions differ, both these types of read-alouds may reinforce or contrast with the NOS views of the trade book. In traditional classroom teaching, much of the communication that occurs in school science misrepresents the NOS (Sutton, 1996) by conveying science as absolute. Such a view may be conveyed strictly through the book or through the manner in which the teacher presents the book to students.

Teachers may use a book to describe explicitly the scientific process to students. At the same time, implicit messages are communicated to students by teachers’ language. Zeidler and Lederman (1989) showed that, through language, science teachers expressed implicit concepts of the NOS and consequently influenced students’ understandings of the NOS. More recently, Oliveira, Akerson, Colak,
Pongsanon, and Genel (2012) examined two elementary teachers’ ability to teach the NOS through inquiry discussions. The analysis included examining any hidden NOS messages communicated to students by teachers’ hedges (words expressing tentativeness) and boosters (words conveying certainty). It was found that both teachers and students used hedges and boosters commonly during science inquiry lessons to express both naïve and developed views of the NOS. Oliveira et al. argued that classroom communication is significant in conveying messages of science to students. From the teachers’ indexical meanings of the NOS, students consequently incorporated the same meanings into their subsequent statements. In other words, when teachers made hedged statements, it prompted students to do the same. Similarly, when teachers conveyed boosters about the absolute nature of science, students followed. The findings of this study indicated that students form similar beliefs about science to those their teachers express during science inquiry lessons.

Although no research has been completed concerning the NOS in the read-aloud context specifically, the communication between teacher and students during an inquiry lesson about the NOS is similar to the interaction in a read-aloud session. Both inquiry lessons and read-alouds encourage students to think and engage with the teacher about the science at hand.

Varelas and Pappas (2006) examined two primary-grade classrooms for intertextual connections made by both students and teachers during seven information book read-aloud sessions. Intertextual connections with hybridity were examined during the read-alouds to see whether they could help students develop thoughts and use the scientific vocabulary more regularly. The authors found that, when spaces (a
time or place to connect language from home and school) were created for students to use narrative and scientific language, in addition to teachers modeling scientific language for students and texts being made available to students, students were able to shift from narrative language to more scientific language. In addition to such occurrences, students made fewer intertextual connections to events and more intertextual connections to “hands on explorations that embodied many of the ideas involved in the unit” (p. 252). Therefore, it can be argued that using intertextual connections can help negotiate scientific meaning and understanding with students.

Moreover, Varelas and Pappas (2006) found that, during dialogic inquiry in read-alouds, intertextuality led to a hybrid discourse or a mix of both narrative and scientific language. Eventually, this discourse led to classroom discussion that contained many characteristics of scientific language. The use of intertextual connections, therefore, led to more scientific discourse among students. The authors concluded that, although there is no one formula to increase all students’ scientific discourse, offering students many opportunities for intertextuality, such as practicing read-alouds in class, can help to increase hybrid and, subsequently, scientific discourse. In addition, other initial findings highlight teachers’ ability to help students understand science by interrupting read-alouds to provide textual (meaning of words), contextual, and re-contextual (parallels between original and local contexts) information (Oliveira, Colak, & Akerson, 2009).

These studies in this section showed that teacher discourse in the science classroom is a powerful tool that can be used to shape students’ views and communication skills. The focus on discourse in this present study will contribute to
this growing field of literature. The review of literature concludes with discussion of the theoretical framework. Two broad learning theories will be discussed, as well as a formulated theoretical framework based on the literature reviewed.

**Theoretical Framework**

The theoretical foundation for this study can be found in the components of two learning theories, as well as a framework proposed by this researcher. One learning theory, social constructivism, describes how humans understand and make sense of the world around them, how they experience their surrounding phenomena and construct meaning from it (Patton, 2002). According to this theory, all the views and perspectives of understanding phenomena are unique and equally important. Closely related to social constructivism is the theory of social constructionism. Social constructionism examines how participants in a setting work together to negotiate meaning relative to their environment. Social constructionism and social constructivism are closely related, and the terms are often used interchangeably (Patton, 2002). Crotty (2010) clarified the difference between the two:

> Whatever the terminology, the distinction itself is an important one. Constructivism taken in this sense points up the unique experience of each of us. It suggests that each one’s way of making sense of the world is as valid and worthy of respect as any other, thereby tending to scotch any hint of critical spirit. On the other hand, social constructionism emphasises the hold our culture has on us: it shapes the way in which we see things (even the way in which we feel things!) and gives us a quite definitive view of the world. (p. 58)

This distinction helps to delineate the knowledge that is constructed during the socially engaging read-aloud practice in elementary classrooms and the individually constructed student and teacher knowledge that forms concurrently. This view of
how learning happens has helped to guide this present study and is reflected in the methods used to collect data, discussed in a later chapter.

Considering the literature reviewed in this chapter and my prior experience researching elementary school read-alouds, I propose a framework for this study (Figure 2.1). There are three components in the read-aloud practice: the teacher, the students, and the trade book. In Figure 2.1, the double arrow between the teacher and trade books represents the interaction between teacher and trade book: the teachers’ selection of the book, how the teacher chooses to present the book to the students, the teachers’ understanding of the book (including content, pictures, and the NOS), and any other activity or program initiated by the book. In Bandre (2005), teacher trade book selection was affected by such factors as personal favorites, books matching or supporting the curriculum, and favorite books of previous student. Therefore, the interaction between teacher and trade book is not necessarily as straightforward as a teacher reading a given book, but several factors may affect this relationship.

In Figure 2.1, a connection is also depicted between the trade books and students. When the teacher is reading the book to the students, the students are hearing the words and seeing the pictures in the book and creating their own interpretations and understandings of the material. Trade books can introduce students to concepts, engage them, and help them to begin the science inquiry process (Fredericks, 2003; Rice, Dudley, & Williams, 2001). Researchers have found that pictures, such as photographs, diagrams, and drawings, in science textbooks and trade books help to promote student understanding of science content (Bean, Searles, Singer, & Cowen, 1990), improve student recall and comprehension of concepts.
(Vosniadou & Brewer, 1987; Watkins, Miller, & Brubaker, 2004), and engage elementary students in science (Ford, 2006). Therefore, during read-alouds, it is likely the books have some effect on students through content or pictures. However, large or small this effect may be leads to the third segment in this triad: the teacher–student interaction.

**Figure 2.1.** Theoretical framework.

The teacher is not just reading the book aloud but reading it to her audience. During read-alouds, teachers make intertextual links with students by referencing other texts, such as movies or music, to aid in student understanding (Pappas, Varelas, Barry, & Rife, 2004) and interrupt their read-aloud to give students
explanation and contextualization to assist their comprehension (Oliveira et al., 2009). In addition, teachers are known to motivate struggling readers in their classes by reading informational books aloud (Kletzien and Dreher, 2004). During these read-aloud discussions, students and teachers may negotiate meaning and understanding of science content and the NOS.

Finally, Akerson and Abd-El-Khalick (2005) and Akerson, Abd-El-Khalick, and Lederman (2000) showed that explicitly teaching the NOS concepts are currently the best way to help students understand the NOS. An example of this approach might be a teacher-student discussion reflecting on the NOS in a recent activity. In addition, read-aloud exercises, such as questioning the author (Beck et al., 1997) and text talk (Beck & McKeown, 2001), have teachers break books into chunks for reading, discussing, and questioning the content. Fisher et al. (2004) found several characteristics of teachers that make a quality read-aloud: (a) making intertextual connections, (b) pausing to ask students thoughtful questions, (c) using animation and expression while reading, and (d) having fluency in oral reading. Braun (2010) also recommended strategies to teachers when conducting read-alouds, such as a “pair-share,” in which, after students hear part of a text, they turn to a partner and discuss the book’s connection to science, or an activity called “And the answer is,” in which the teacher gives information or an answer from the text and the students must develop the question. Other read-aloud activities, such as questioning the author (Beck et al., 1997) and the two-word strategy (Hoyt, 2010), are among several that are recommended by reading and writing specialists. Consequently, it is evident that discourse between teacher and student during read-alouds is not only promoted but
has the ability to shape the course of the read-aloud. These interactions that take
place among the components in the model contain not only explicit but implicit
messages. An example is a trade book that contains pictures of only White males
doing science, giving the implicit message that science is only for White males.
Another example occurs during classroom discourse with a teacher leaving a student
to understand that science must be done in a step-wise fashion. Therefore, the
diagram represents both implicit and explicit communication that takes place among
the components.

Finally, at the top of Figure 2.1 is the prior knowledge of both students and
teachers. As mentioned previously, Bandre (2005) showed that teachers might select
books they have had good prior experience with or that they know previous students
had enjoyed. Teachers do not come to the read-aloud as blank slates but with some
opinions, knowledge, and biases. Even for their first read-aloud, they bring
knowledge of working with students and learning content and pedagogy from their
teacher education. Students in elementary school also come to the read-aloud with
some prior background in being read to in the past, such as in preschool or by a parent
or caregiver (Heisey & Kucan, 2010), and they have been exposed to some science
either in the previous school year or through first-hand experience. Thus, prior
knowledge is shown in the diagram to represent students’ and teachers’ knowledge
and experience they bring to a read-aloud. This prior knowledge and experience may
influence the questions asked, comments made, and effects on the course of the read-
aloud.
The literature reviewed in this chapter investigated portrayals of the NOS and science in trade books, elementary students’ understanding of the NOS, the NOS beliefs of elementary teachers, and elementary read-aloud practices. Research has addressed read-alouds and the NOS separately, but very little research has addressed how the NOS is presented during the classroom read-aloud. Therefore, this present study examines these topics in a qualitative research analysis, using the theoretical framework discussed.
CHAPTER 3

METHODOLOGY

People only see what they are prepared to see.

—Ralph Waldo Emerson (1803-1895)

Overview

The literature reviewed in Chapter 2 draws attention to the current research on the NOS in elementary science education, the NOS in trade books, and read-aloud performance in elementary schools. The NOS has been established as an essential learning goal in elementary grades, yet little is known about how attaining this goal can be accomplished. At the same time, read-alouds are regularly practiced in the elementary classrooms with trade books that portray the NOS. This study is focused on analyzing the science read-aloud practice in elementary classrooms to determine how the NOS is understood. The research question guiding this study is as follows: “How do teachers and students with known NOS views make sense of the NOS portrayed in trade books during the science read-aloud?” This chapter will discuss the methods of inquiry, data collection, and data analysis for this qualitative research study. To conclude the chapter, both validity and data quality are addressed.

Methodology

A qualitative research approach is selected to investigate the research questions for providing a rich description of the answers. A qualitative research method can provide details about the beliefs of teachers, the beliefs of students, and the read-aloud experience and analyze the content of a book. A qualitative study is most suited to this type of research because it helps give individual meaning and in-

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depth detail to the research question. Patton (2002) described how researching a small random sample of participants using in-depth interviews, direct observations, and analysis of written documents helps increase the credibility of the results. This study is focused on answering how teachers, together with students, make meaning of the NOS in trade books during the science read-aloud, with an in-depth look at teachers’ and students’ understandings and trade book content. Therefore, using a qualitative research approach over a quantitative one makes the most sense. Creswell (2007) noted the qualitative researcher is the primary instrument in qualitative research; therefore, I included a description of the researcher’s background in the study.

**Research Design**

The research question guiding the study led to the choice of the research design. A multisite naturalistic case-study method was used in this study to conduct an investigation of the NOS views of teachers and students, the trade book NOS portrayal, and the read-aloud experience. According to Yin (2009), “A case study is an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-life context, especially when the boundaries between phenomenon and context are not clearly confident” (p. 18). This study is focused on investigating the aforementioned phenomena in depth and within the context of the elementary school setting. The case-study design was used because of its ability to give “intensive descriptions and analyses of a single unit or bounded system such as an individual, program or groups” (Merriam, 1998, p. 19). Although case studies can be singular and still exemplary, this study includes multiple case studies in hopes of
understanding the relationships among elementary school teachers’ NOS views, elementary students’ NOS views, trade books’ NOS portrayals, and read-alouds. Each case in this study was limited to the classroom level; that is, each case included the teacher’s views of the NOS, the students’ views of the NOS, the discourse that took place during the read-alouds concerning the NOS (both explicitly and implicitly), the trade book used in the read-aloud, and both the teacher’s and the students’ views of the read-aloud practice.

In addition, the embedded case-study design was used. According to Yin (2009), this design is desirable when research involves more than one piece of analysis. The researcher conducted six case studies of third- or fourth-grade classrooms with data from a variety of sources: observations, including some videotaped recordings; surveys; student writings; and interviews. Merriam (1998) defined case studies as being “particularistic,” meaning that the case study focuses on a “particular situation” or “phenomenon.” This research was particularistic because it focused on elementary teachers conducting science read-alouds in upstate New York, a phenomenon in a particular situation. Case studies are considered descriptive because they try to achieve “a rich and thick description of the phenomenon under study” (p. 29). Because of the descriptive nature of a case study, participants’ backgrounds are included in the findings section of this study. The researcher also described the categories and subcategories that emerged from the interviews and class interaction for each participating teacher during the analysis section of the study. These in-depth descriptions were used to give the readers rich detail of the data and analysis.
Through the case-study method, an in-depth understanding of the phenomenon and meaning for those involved is presented. The case study method was selected because of its ability to give a holistic description and its ability to give a sufficient and comprehensive picture, without losing its central focus (Patton, 2002). Data were analyzed using descriptive analysis, both within case and cross-case; coding; and constant comparison, which are described further later in this chapter. Having several data sources helped to triangulate the data and substantiate findings (Patton, 2002). Finally, the researcher knew the field from having conducted other related research in elementary classrooms herself, experience that helped in asking probing questions and good follow-up questions. Yin (2009) considered asking probing questions a skill needed to collect sufficient evidence. The researcher’s background also helped in creating the survey to elicit participants.

Participants

Teachers were invited to participate in the study through a call (See Appendix A) the researcher placed through the Capital Area School Development Association (CASDA) office at the University at Albany, a posting on a listserv for science teachers in New York State, and a posting on the researcher’s Facebook page. The call asked for elementary (third and fourth grade) teachers who use science read-alouds to complete a survey (Appendix B) that collected some basic demographic information about the class and asked about frequency of read-alouds conducted. Grades 3 and 4 were selected because the likelihood of read-alouds occurring in primary grades is higher than it is for intermediate or upper grade levels (Hoffman, Roser, & Battle, 1993) and because younger students are less likely to be able to
articulate their views. In addition, prior studies conducted on read-alouds examined children in third and fourth grades (Fisher et al., 2004; Gambrell, Palmer, & Codling, 1993), indicating read-alouds are typically done in these grade levels.

The survey (Appendix B) was comprised of a series of questions that asked for some basic demographic information, such as classroom settings, frequency of read-alouds, frequency of science read-alouds, teacher experience, and teacher preparation. It described not only the purpose of the study but the methods that would be used if they participated in the study. This survey also asks teachers whether they perform read-alouds, whether they incorporated any activities or discussions during or immediately following a read-aloud, and whether they discussed the science in the books during a read-aloud. From the respondents, teachers who performed science read-alouds regularly and more frequently than other respondents were recruited for interviewing to allow for the most naturalistic setting for collecting data. The six teachers considered “telling” cases by the researcher were selected; that is, they could be the cases “in which the particular circumstances surrounding [each] case serve to make previously obscure theoretical relationships suddenly apparent” (Mitchell, 1984, p. 239). The six teachers’ survey responses contained relevant details for the study were selected. In addition, surveys that gave rich details were targeted because of the descriptive nature of the study.

After selecting the six teachers who practice read-alouds most frequently at the third- or fourth-grade levels, the researcher gave them the Views of Nature of Science (VNOS) survey to complete (Appendix C). This VNOS survey was used to determine the teachers’ views of the NOS. The VNOS includes a researcher section
that explains a way of “scoring” the responses. Naïve views of the NOS are evidenced by respondents indicating the scientific method is an objective process; knowledge is discovered through the scientific process; after accumulating evidence, scientific theories “become” laws; and science is “value free” or cultures and beliefs do not affect science. Sophisticated views of the NOS are evidenced by responses indicating science is subjective and has creative aspects to it, scientific models are not copies of reality, science is tentative, and science is socially and culturally embedded.

Statements such as the following may exemplify naïve views:

- If you get the same result over and over and over, then you become sure that your theory is a proven law, a fact.
- A scientist only uses imagination in collecting data. . . . But there is no creativity after data collection because the scientist has to be objective.
- Science deals with using an exact method. . . . That way we know we have the right answer. (Lederman et al., 2002, pp. 514–515)

Statements such as the following may exemplify sophisticated views:

- Everything in science is subject to change with new evidence and interpretation of that evidence.
- Logic plays a large role in the scientific process, but imagination and creativity are essential for the formulation of novel ideas . . . to explain why the results were observed.
- When you are in sixth grade you learn that here is the scientific method and the first thing you do this, and the second thing you do that and so on . . . That’s how we may say we do science, but [it is different from] . . . the way that we actually do science. (Lederman et al., 2002, pp. 514–515)

The case-study method involved each teacher participant and his or her students; therefore, six teachers was a reasonable number for one researcher to investigate within the projected time. Teachers selected received a stipend of $100 for their participation. All students in the classroom received parental consent forms (See Appendix D) for the video-recorded read-aloud and assent forms for the students themselves to sign. All students with signed consent and assent forms participated in
the study by completing the VNOS-D or VNOS-E survey (further described in the
next section) and answering two questions at the end of the read-aloud (Appendix E).
These questions are referred to in this study as *ticket-out-the-door* questions. The
ticket-out-the-door activity for this study involved students’ writing their answers to
one or two questions related to the read-aloud and served the purpose of conveying
the students’ perspectives of the read-aloud. These questions also gave the researcher
the ability to track individual students’ views of the NOS, their participation in the
read-alouds, and their views of the read-alouds. Each teacher was interviewed
(Appendices F and G) for her or his views on the read-aloud practice both before and
after the read-aloud.

The researcher used e-mail to schedule meetings and interview times with the
participants. The researcher gave the teacher participants the teacher consent forms
when conducting the interviews (Appendix H), along with the student parental
consent forms so they could take them home and obtain their parent or guardian
signatures for participation.

**Data Collection**

The timeline of this research study is as follows:

<table>
<thead>
<tr>
<th>Month</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>December 2011</td>
<td>IRB approval</td>
</tr>
<tr>
<td>January 2012</td>
<td>Call for participants</td>
</tr>
<tr>
<td></td>
<td>Survey and select participants</td>
</tr>
<tr>
<td>February 2012</td>
<td>Teacher interview</td>
</tr>
<tr>
<td></td>
<td>Teacher VNOS</td>
</tr>
<tr>
<td></td>
<td>Student VNOS</td>
</tr>
<tr>
<td>March–April 2012</td>
<td>Classroom observation</td>
</tr>
<tr>
<td></td>
<td>Trade book analysis</td>
</tr>
<tr>
<td></td>
<td>Ticket-out-the-door questions</td>
</tr>
</tbody>
</table>
Data collection included the following:

- Survey of teacher participants
- Teacher VNOS
- Student VNOS
- Teacher interview (audio-recorded)
- Classroom observation (video-recorded)
- Student ticket out the door
- Trade book analysis

Collecting data from all of these resources helped give a holistic view of the participants’ decision-making processes, how their read-aloud book selections and performances were conceptualized and prepared, how students understood the NOS, whether the teachers felt their read-alouds were successful, and their reflection on how the trade books portrayed the NOS. Following each read-aloud, I briefly interviewed the teachers (Appendix G) concerning what they thought the students learned from the read-aloud.

The VNOS survey assessed teachers’ and students’ views of the NOS. The VNOS was created by Lederman et al. (2002) and is used with interviews to help assess the NOS views of a learner. The VNOS-C is an open-ended questionnaire used to elicit the NOS views of teachers and was administered at the start of this present study when recruiting participants. Eliciting understanding of the NOS may be difficult at the elementary-school level because students are still developing as readers and writers. Several forms of the VNOS exist to help facilitate student
understanding, either verbal or written, by answering several open-ended questions. The VNOS-D (Elementary and Middle School Version; Appendix I) was developed for kindergarten through fourth-grade students, and the VNOS-E (Appendix J) was developed for kindergarten through third-grade students (Lederman, 2007). The VNOS-D uses a written sample to evaluate elementary and middle school students’ understandings of several NOS concepts: creativity, tentativeness, subjectivity, empirical nature, inferential nature, and the use of a variety of methods. The VNOS-E is also focused on the creative, inferential, empirical, tentative, and subjective nature of science, as well as science as a way of knowing. The VNOS-E was developed for students (K-3) who are too young to read and write easily, so questions can be read aloud and answers recorded. It can be used with an individual student or a group of students, as well as administered individually with paper and pencil. In this study, when some students were not able to write yet or write easily, the researcher and the teacher helped the student record answers. The VNOS for students was given by the teacher before the read-alouds occurred as a way of understanding students’ views during the read-aloud and help to understand student questions, comments, or answers during the read-aloud. Lederman et al. (2002) examined the validity of the VNOS by comparing teachers’ VNOS results with interview transcripts used to capture the same teachers’ NOS understandings and found they were in agreement with each other. All the VNOS versions produced consistent results in the areas in which they overlap (Lederman et al., 2002).

The interviews and observations took place on agreed-upon dates and times between the participants and the researcher. The interview protocols are in
Appendices F and G. Because the state of New York had state exams at the end of
the school year, gathering data in the winter or early spring was ideal because of
reduced conflicts with scheduled exams in the schools.

**Interviews**

In addition to taking the VNOS, teachers were interviewed on their ideas and
beliefs about the read-aloud. Interviewing techniques used were from Kvale and
Brinkmann (2009), which addressed the seven stages of an interview inquiry. The
first stage, thematizing, was be slightly adapted. Instead of trying to formulate any
hypotheses or create a specific theme, the theme remained broad and allowed the
teacher participant to focus on the area of read-alouds. The interview was
semistructured in that interview protocols were used to prepare discussion with the
participants and helped the researcher keep the interview focused specifically on the
current study. The researcher allowed participants to discuss their views of science
books and their selection processes. The interviews included basic biographical
information on the teachers and questions pertaining to their read-aloud preparations
and performances. The final contact with the teachers was for teachers to check the
accuracy of the data collected through member-checking the data (Patton, 2002).
This step included member-checking of the teacher VNOS surveys (because there
was not enough time allowed at the school to member-check with each student
participant). Imperative parts of the interview were audio-recorded and then
transcribed, allowing the researcher to go back and listen carefully to and examine
each participant’s answers more carefully.
Classroom Observations

One of the data sources for this study was the video-recorded classroom observation. The researcher was able to gain a better understanding of how the participants—both teachers and students—behave regularly in a typical classroom read-aloud by reviewing video. The discourse that took place during the read-aloud was the focus of the data analysis. Teachers were asked not to make any changes in their teaching or read-aloud performance because of the researcher’s presence. Each participating teacher was observed for two read-aloud performances. Viewing two read-alouds for each teacher instead of only one allowed the researcher to have a more accurate view of how the teachers typically performed a read-aloud. Viewing more than two read-alouds per teacher may have been difficult to schedule because of the other content areas teachers taught and may have taken away time from the other ways the teachers instructed science (such as hands-on activities, individual projects, etc.) and the limited time teachers had to devote only to read-alouds. In addition, observing each participating teacher for two read-alouds gave the researcher 12 read-alouds to analyze, a manageable number for one researcher. The researcher also video-recorded the read-alouds to review the teachers’ performance for clarity. Doing so allowed the researcher to take notes and have multiple opportunities to review the read-aloud performance.

Trade Book

In keeping with the naturalistic nature of the study, the teachers selected the books for the read-aloud observations. During the scheduling of the first read-aloud, the researcher instructed the teacher to make his or her own trade book selections for
both read-alouds. Giving the teachers the choice of trade books to present allowed the researcher to stay within the naturalistic scope of the study and allowed for questions on the book selection process. Thus, the researcher was able to ask the teachers why they selected the books for the read-alouds and whether they made any preparations to present them to their classes. The researcher purchased all the trade books presented for analysis purposes.

Data Analysis

Pertinent information from interviews and audio and video recordings was transcribed, and their contents were used as the major portion of the data analyzed in this study. The VNOS results were analyzed by carefully reading the content of each answer and were used as evidence to support conclusions about both teacher and student views of the NOS. The observations of the read-alouds were described in full detail, highlighting the discourse (discussion, questions, or comments) having to do with the science process or science content. The read-alouds were described in the context of the trade book being read and indicated how the students participated.

The contents of the trade books were investigated based on data analysis techniques developed by Ford (2006); Titscher, Meyer, Wodak, and Vetter (2000); and Bricker (2005). As with those studies, the books in this study were read in their entirety for both implicit and explicit messages of the NOS. To aid in this analysis, the content of the trade books were analyzed using an analysis form created and based on Bricker (2005) to examine trade books and their NOS portrayals. The NOS was targeted using the “Trade Book Analysis Form” (Appendix K) that allowed the researcher to tally the NOS components in each book and share an example and any
explanations necessary to express the NOS portrayal in the book. Each component of the NOS is included on the analysis form, helping to guide the researcher to find examples in the books of the NOS portrayal. Both explicit and implicit messages in the books were considered, and the researcher included examples and evidence from the books to help justify the analyses. A few examples of trade book analysis are shown in Table 3.1.

Early on during the trade book analyses, it became apparent that the message of the NOS was not explicitly or obviously presented; instead, the books had to be closely evaluated to determine what they were saying about the NOS in implicit messages. Therefore, the form to evaluate books (Appendix K) was used initially to consider what was in the books in terms of the NOS, but each book had to be examined carefully to identify the real NOS message being communicated.

Table 3.1

*Examples of Trade Book Analysis*

<table>
<thead>
<tr>
<th>Example text</th>
<th>NOS message</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geologists, the scientists who study the earth, wondered why this region was so rocky. They discovered that huge sheets of ice, called glaciers, had covered these northern areas just a few thousand years ago.</td>
<td>Scientific understanding is created by people. There is no further explanation into the scientific process.</td>
</tr>
<tr>
<td>People listened and imagined a sparkling river, full of fish. They imagined pebbles shining up through the clear waters. They signed petitions and sent letters. They protested to politicians and showed them jars of dirty water. They convinced the paper mills to build a plant to process the waste. They persuaded the factories to stop dumping. Finally, new laws were passed and the factories stopped polluting.</td>
<td>Science can be influenced by society, such as political, social, and cultural groups.</td>
</tr>
</tbody>
</table>
The VNOS results for both teachers and students included answers categorized as naïve, mixed, or informed according to the following criteria:

Naïve: Student’s or teacher’s response is not consistent with any part of NOS aspect.

Mixed: Student’s or teacher’s response is consistent with some, but not all, parts of NOS aspect.

Informed: Student’s or teacher’s response is consistent and addresses all parts of NOS aspects.

The Table 3.2 shows examples of VNOS responses scored as naïve, mixed, and informed. The table indicates the NOS aspect being tested and the corresponding response (the exact quote) by the teacher or student. Detailed analysis of all results appears in Chapter 4.

Table 3.2

<table>
<thead>
<tr>
<th>NOS aspect</th>
<th>Naïve view</th>
<th>Mixed view</th>
<th>Informed view</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scientific work uses imagination</td>
<td>I don’t think scientist should use their imaginations because they could not be right or make people think what’s wrong (student).</td>
<td>Yes Because Albert Einstein used it to discover the speed of light (student).</td>
<td>Yes [scientists use their imagination] when they don’t have enough information (student).</td>
</tr>
<tr>
<td>Difference between scientific theory and law</td>
<td>A scientific theory is an idea that has not been proven or disproven due to insignificant evidence (teacher).</td>
<td></td>
<td>A law is a unifying and universal concept that provides insight into a topic. A theory seeks to</td>
</tr>
</tbody>
</table>
During the analysis, the researcher provided examples of the trade book analysis form to disclose how the NOS was represented and describe how the book presented the different NOS aspects. This process has been used in another dissertation (Bricker, 2005) that studied the NOS in children’s books. Expansive records of the read-aloud data were examined to identify the main types of discourse interactions that occurred between the teacher and students to negotiate meaning concerning the NOS. These interactions included questions, comments, suggestions, and any other verbal exchange between teachers and students. This approach to data analysis focused on salient features of the read-aloud, including discourse structures such as dialogically oriented read-alouds or questioning strategies that teachers used, such as questioning the author, text talk, and any other discourse specifically related to the NOS. The teachers’ use of hedges and boosters when communicating were also examined for their relatedness to the tentative nature of science, either explicitly or implicitly. The scope of the study was centered on the NOS; therefore, any key interactions in the read-alouds that highlighted the NOS were carefully examined.

This study used a grounded theory approach to create theory from the collected data. According to Charmaz (2006), grounded theory can complement other research methods, such as case studies. In grounded theory, there is much flexibility when collecting and analyzing data. Charmaz stated, “Grounded theorists
evaluate the fit between their initial research interests and their emerging data” (p. 17). Furthermore, Strauss and Corbin (1998) described theory as themes interconnected through statements that show their relationships to help explain some types of phenomena. The main purpose of this present study was to determine how elementary teachers and students with known NOS views make meaning of NOS messages in trade books. Grounded theory involves three types of coding in the processing of data. According to Strauss and Corbin, the three coding schemes are open coding, axial coding, and selective coding. Open coding is the process by which concepts are “identified and their properties and dimensions are discovered in data” (p. 101), axial coding is “the process of relating categories to their subcategories” (p. 123), and selective coding is assimilating and refining the theory (p. 143). The analysis for this research started with this type of coding to create a theory on how teachers and students view the NOS and make meaning of it in trade books.

Memo writing was also used as part of the data collection, helping to identify connections between different categories (Charmaz, 2006). Codes were created from the data during the collection process and adapted as collection proceeded. The constant-comparative analysis was used because the procedures of analysis and interpretation were entwined (Lincoln & Guba, 1985; Patton, 2002). The names of codes used for categories were created from any concepts the researcher observed in the data. Although several concepts arose in the data, the codes created were broad and all encompassing. Chapter 4 includes in-depth description of the codes that emerged from the data. The codes were used to create broad themes and, along with
the evidence, used to help organize data. Any discrepant data was also considered.

The following major codes were created during the data analysis:

- Hedging
- Closed questioning
- NOS connection
- NOS avoidance
- NOS ideas and misconceptions

Although it was hypothesized that the NOS aspects would be the major codes during data analysis, staying true to grounded theory, I allowed the data to guide me in creating codes (Figure 3.1). First, the read-aloud videos were watched to highlight key moments or segments that took place during the read-aloud. These segments were then transcribed and preliminarily coded. After all individual coding was completed, all codes were combined to make a master list of codes. A chart was created to show the occurrences of all codes across all teacher read-alouds. Codes that had similar conceptual meanings or led to similar discussions were merged. These codes were then examined and compared to the codes divergent from them.

The coding levels of analysis were as follows

Analysis Level 1: Highlight and/or create data segments
Analysis Level 2: Preliminary coding of segments
Analysis Level 3: Create a master list of codes
Analysis Level 4: Examination and enumeration of repeated codes
Analysis Level 5: Merge codes with similar conceptual meanings
Analysis Level 6: Examine convergent and divergent codes across all data

Emerson, Fretz, and Shaw (1995) explained it is helpful to have a set of questions to answer as a guide through the preliminary coding process. Thus, the researcher created codes by cognitively answering the questions and attaching a term or code that identified that segment of data. For this study, the following questions helped to guide the read-aloud video coding:
1. Are any of the NOS aspects present, implicitly or explicitly, during the read-aloud?
2. Does the teacher ever show certainty or uncertainty in her or his discussion of the book?
3. What does the teacher do in addition to simply reading the book?
4. What does the teacher say in addition to simply reading the book?
5. What does the teacher do to keep students engaged in the book?

These questions helped in understanding how the read-alouds were facilitated and the types of discussions that arose from the read-alouds.

Grounded theory interviewing involves asking participants questions about a narrow field of topics so researchers can obtain explicit data to help construct their framework. The data analysis for this study was based on grounded theory techniques and examined at length. More details concerning how analysis was conducted and the categories and theories created are discussed in Chapter 4. Table 3.3 shows how the research questions were answered in this dissertation.

![Figure 3.1. Procedures for data collection and analysis.](image)

Table 3.3

<table>
<thead>
<tr>
<th>Research question</th>
<th>Data collection method</th>
<th>Data analysis method</th>
</tr>
</thead>
</table>

Figure 3.1. Procedures for data collection and analysis.
<table>
<thead>
<tr>
<th>Research question</th>
<th>Data collection method</th>
<th>Data analysis method</th>
</tr>
</thead>
<tbody>
<tr>
<td>How do elementary teachers who practice science read-alouds view the NOS?</td>
<td>-VNOS for teachers</td>
<td>Grounded Theory:</td>
</tr>
<tr>
<td></td>
<td>-Teacher interviews</td>
<td>-Analysis of VNOS using established item description criteria</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Interview transcription</td>
</tr>
<tr>
<td>How do elementary students who participate in science read-alouds view the NOS?</td>
<td>-VNOS-C or VNOS-D</td>
<td>Grounded Theory:</td>
</tr>
<tr>
<td></td>
<td>-Read-aloud observations</td>
<td>-Analysis of VNOS using established item description criteria</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Interview transcription</td>
</tr>
<tr>
<td>How is the nature of science portrayed in the science read-aloud trade book?</td>
<td>-NOS trade book analysis form</td>
<td>Content analysis of the trade book</td>
</tr>
<tr>
<td></td>
<td>-Memoing</td>
<td></td>
</tr>
<tr>
<td>How is the NOS negotiated through the discourse in the read-aloud practice?</td>
<td>-Read-aloud observations (videotape and field notes)</td>
<td>Grounded Theory:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Transcription of video recordings</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Selection and analysis of relevant themes</td>
</tr>
<tr>
<td>How do teachers and students with known NOS views make sense of the NOS portrayed in trade books during the science read-aloud?</td>
<td>-Read-aloud observations (videotape and field notes)</td>
<td>-Ticket out the door</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Teacher interview</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Videotape of read-aloud</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Content analysis of trade book form</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Creating codes/descriptive analysis</td>
</tr>
</tbody>
</table>

The surveys were scored individually and then broken down by question for each class, for both teachers and their students. Although no specific rules were available to guide the discourse analysis, the analysis must help lead to answering the research questions. The reason for using discourse in this current study was to understand how discourse surrounding science read-alouds can help or hinder students’ understanding or learning of the NOS. The study also examined the read-
aloud discourse to investigate how teachers and students make sense of the science they are reading about.

**Validity Issues**

According to Yin (2009), generally, four tests are used to start a case study with a certain substantial quality: construct validity, internal validity, external validity, and reliability. The researcher in this study interviewed and observed as part of data collection to help validate the data. The researcher also discussed the initial draft of the data presentation with the participants as a way of verifying or member-checking the data. Construct validity can sometimes be difficult to establish because of subjective statements made in the data, but using multiples sources of data and member-checking can help to counteract this problem.

Although determining a definitive causal relationship in this study was not possible, Yin (2009) mentioned several tactics to help establish internal validity, such as building explanations and pattern matching. One way to develop an explanation for multiple cases is to “build a general explanation that fits each individual case, even though the cases will vary in their details” (p. 142). The researcher built an explanation for all cases studied and identified possible patterns in the data for the multiple cases. In addition, the researcher compared findings across cases to look for possible patterns or themes.

Although some researchers have argued that case-study data is not generalizable and, therefore, is poor in external validity, case-study analysis tries to “generalize a particular set of results to some broader theory” (p. 43). This study used a grounded theory approach in which each case was considered individually and
the researcher created a theory for the existing data, then applied it to the other cases, modifying it as need be. The last test of case study quality is reliability, the ability to replicate the data. As suggested by Yin (2009), the researcher conducted the research process with detailed documentation, such as collecting detailed field notes while interviewing, audio-recording the interviews, using an interview protocol, and analyzing the trade books and detailed field notes of observations, thereby simplifying replication of the research. Each case includes a description of how and why the teacher was selected and the background of the teacher to help give context to the collected data. All these measures helped to provide an audit trail of evidence (Yin, 2009).

The nature of interviews leaves room for interpretation; therefore, the researcher had participants member-check the data analysis for verification. The researcher also triangulated data with interview transcriptions, observations and material collected, and weekly memos. In addition to these methods, the researcher discussed the study with colleagues in “peer debriefing” (Lincoln & Guba, 1985, p. 243). This type of validity check allowed the researcher to develop interview questions and create and adjust categories when necessary.
CHAPTER 4

RESULTS

Overview

This chapter includes the results of a grounded theory study completed to understand the NOS discourse that takes place in an elementary school science read-aloud. In this chapter, the data from the study were interpreted and then reconstructed as the researcher read through each case. Analysis of the read-aloud videos showed varying degrees of discussion surrounding the NOS. These dialogic and collaborative read-alouds were given more focus in this study because they directly addressed the research questions.

These results consist of a written case for each of the six participants and a conclusion that encompasses the six cases. Within discussion of each case, sections address the background of the classroom, the teachers’ NOS views, the students’ NOS views, books used in the read-alouds, and the reads-aloud observed. Combined, these sections answer the all-encompassing research question for the study: “How do teachers and students with known NOS views make sense of the NOS portrayed in trade books during the science read-alouds?” The last section of this chapter discusses all the cases together to provide an account of the trends seen among the classrooms.

Classroom 1

Matthew’s Case

Classroom 1 was a fourth-grade class in a rural elementary school in upstate New York. The classroom teacher, Matthew, was the only male participant in the
Matthew received his undergraduate degree in elementary education and geography and his master’s degree in teacher excellence. He had been teaching elementary school for 7 years and was motivated to become a teacher after having some influential teachers in his high school years. Matthew seemed to be a very energetic and outgoing teacher, made apparent by his lively classroom that included an aquarium with a snake, another aquarium with some frogs, and a large freshwater aquarium with trout for students to observe all year (Interview, 3/5/12). Matthew regularly read trade books to his students either to introduce a science topic or to reinforce an idea or vocabulary. He stated some read-alouds were strictly to “enhance the lesson and knowledge base” in science and some were for both English language arts (ELA) and science (Survey, 3/5/12).

**Matthew and Science**

Matthew’s NOS understandings are shown in Table 4.1. Matthew’s answers on the VNOS indicated his varying understanding of the NOS. He had a naïve understanding of the investigative properties of science; the relationship between theories and laws; and the effects of human inference, society, and culture on science. Question 2 on the VNOS helps in clarifying respondents’ understanding of what an experiment is, and Question 3 evokes the notion that there are multiple methods of investigating science. Both questions are used together to help assess respondents’ ideas of what an experiment is and the processes involved. Matthew replied, “[An experiment is] an activity that requires a prediction (hypothesis), implementation [sic], observing and reflection.” Matthew’s understanding of an experiment was representative of a naïve view of the NOS, seeing science requiring certain steps to
proceed instead of seeing the role that evidence plays in science as a way to know something about the natural world. He was not able to articulate that scientists use models and/or programs to understand phenomena but did state that scientists were “very certain” of the atomic structure (as opposed to being 100%).

Matthew’s answer to Question 8 illustrated an informed view of creativity in science: “Creativity and imagination are important to all stages of scientific discovery,” but in response to Question 10, which asked about producing similar results, Matthew stated, “[T]he core of scientific studies always produce similar results regardless of who performs the experiment” (Matthew VNOS, 2/3/12).

Matthew acknowledged that creativity exists in all stages of science but simultaneously expressed belief that the “facts” come out to be true or proven at the end. The understanding that scientists are individuals with independent thinking and creative thoughts and that facts or the same results will always surface in scientific experimentation or analysis is a trend seen in the rest of the data.

The naïve NOS views expressed by Matthew are those that are commonly misunderstood. Examples include Matthew writing that experiments require certain parts or steps, one being a hypothesis, and describing theories and laws in a hierarchal order. He held the naïve view that, when changes need to be made to a law, it is downgraded to just a theory. He was more certain and informed about the tentative nature of science. He answered “Absolutely” (Matthew VNOS, 2/3/12) to Question 6 about theories possibly changing and was very positive that scientists must be creative and imaginative in all parts of scientific investigations. Overall, Matthew had moderate or mixed views of the NOS concepts assessed in the VNOS. He was
able to express the creativity that exists in science but was not exactly certain where and how much creativity fits into science as a whole. He tended to hold more naïve views about the processes of science and how the results of scientific investigations are expressed.

Table 4.1

*NOS Views and Portrayals in Matthew’s Class*

<table>
<thead>
<tr>
<th>NOS theme</th>
<th>Teacher views</th>
<th>Student views</th>
<th>Book 1&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Book 2&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Present in discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Empirical</td>
<td>Mixed</td>
<td>Naïve/mixed</td>
<td>Very little</td>
<td>Little</td>
<td>None/slight</td>
</tr>
<tr>
<td>Observation</td>
<td>Naïve</td>
<td>Naïve</td>
<td>Very little</td>
<td>Moderate</td>
<td>None/slight</td>
</tr>
<tr>
<td>Myth of scientific method</td>
<td>Informed</td>
<td>N/N/N = Naïve</td>
<td>None</td>
<td>Very little</td>
<td>None/slight</td>
</tr>
<tr>
<td>Methods of investigation</td>
<td>Mixed</td>
<td>Naïve</td>
<td>Very little</td>
<td>Moderate</td>
<td>Book 2: Ben Franklin; student discussion</td>
</tr>
<tr>
<td>Human imagination/creativity</td>
<td>Informed</td>
<td>Naïve</td>
<td>Moderate</td>
<td>Highly present</td>
<td>None/slight</td>
</tr>
<tr>
<td>Theory driven and theory/law</td>
<td>Naïve</td>
<td>N/A</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tentativeness</td>
<td>Mixed</td>
<td>Naïve</td>
<td>None</td>
<td>Little</td>
<td>Books 1 &amp; 2</td>
</tr>
<tr>
<td>Sociocultural embeddedness</td>
<td>Naïve/mixed</td>
<td>N/A</td>
<td>None</td>
<td>None</td>
<td>Book 1: Present</td>
</tr>
</tbody>
</table>

*Note.* Views from VNOS answers.

<sup>a</sup> *Electricity* by Darlene Stille (2006).

<sup>b</sup> *Simply Science Electricity* by Darlene Stille (2001).

**Students’ Understanding of the NOS**

Matthew’s students held largely naïve NOS views. Table 4.1 shows his students rarely held informed views. The first questions on the VNOS asked students
to define *science* and describe how science is different from other subjects they were learning. Many students reported science to be different from other subjects because it had labs, experiments, and involved a lot of math. Several students made comments about science being fun or more fun than the other subjects, and a few students described how electricity (the topic they were currently studying) was different from other subjects by stating things that run on electricity and the batteries they were using when studying electricity. Some of these answers included the following:

- You learn different things like about electricity (T3, Matthew’s Class).
- Science where you try to learn new things and have a hypothesis (E, Matthew’s Class).
- I think science is the study of some math cemstry and how stuff works (B, Matthew’s Class).

Another question on the VNOS asked students how scientists know dinosaurs once lived on the earth and the level of certainty scientists have about the way the dinosaurs looked. Three fourths of the students in Matthew’s class were either very unsure of how the scientists know about dinosaurs or believed the scientists were positive about how dinosaurs looked because of fossils. One student (MS2) answered that scientists know how dinosaurs looked because of fossils and were certain of this because they are scientists. It was apparent from these answers that these students were assuming that, because “scientists” know these facts, they were absolute truths and not up for negotiation.

Question 5 asked why, if all scientists have the same facts about the extinction of dinosaurs, there is disagreement as to how the dinosaurs died. The question aimed to show that science is a human endeavor, therefore partly influenced by human
views. A little over two thirds of Matthew’s students held naïve views about this idea while just one student made the connection that scientists are people who have different ideas:

They have different opinions because they are all different people and everybody can have different ideas (C, Matthew’s class).

This question also had the fewest replies; many students left a question mark in the space for an answer or just left it blank. Some students seemed to be confused by this question, possibly because it did not fit into what they understood scientists to be: that is, there should be one answer to a problem, and all scientists agree on it.

Students were also asked about TV weather people and the certainty of their predictions. This question, similar to Question 5, was probing for ideas about observations, inferences, and tentativeness. No students held informed views about this topic, and most students (n = 9 students, 13 students answered this total), again, held naïve views about how certain science is. Many students believed the weather people were “very sure” or “pretty sure” about their weather forecasts because of the radar and satellites available today:

Their really sure because of the technology we have today (G, Matthew’s class).

I think they are very sure about the weather for the next day because they have a radar like thing in space that helps them do the weather (C, Matthew’s class).

Students were asked whether they thought scientists use their imaginations when they do their work. Students in Matthew’s class all scored either naïve or mixed on this question. A few students remarked that scientists do use their imaginations before doing their work, and two students responded in the affirmative concerning scientists using their imaginations because there is always more than one
answer. However, many students (n = 9 students, 19 students answered this total) associated imagining to not be realistic, considering it fake and having no place in science, where only “facts” should exist, as shown in one example, “Because they need to focus on realistic stuff in their work” (G, Matthew’s class).

Books Chosen by Matthew

Matthew’s two books for the read-alouds were Electricity by Darlene Stille (2006) and Simply Science Electricity by Darlene Stille (2001). The first book Matthew read about electricity, Electricity (Stille, 2006), was a book generally filled with science “facts” about electricity. Although the book was very factual in nature, it contained vibrant drawings of children using electricity. Seven of the nine pages in the book were filled with people actively using or observing electricity, such as plugging in appliances and watching lightning (see Figure 4.1). The personal pronoun you was used occasionally; for example “Have you ever dragged your feet on a carpet and then touched a doorknob? The shock you felt in your fingers came from a kind of electricity called static electricity” (p. 5). The book featured children using electricity and used personal pronouns to illustrate the social aspect of science. Using the pictures and personal pronouns, students were able to see that science is not just facts or work done in a laboratory. Using the personal pronoun you kept the reader involved in the narrative. The book also made a connection to society through technology by describing the types of energy (nuclear, fossil fuel, solar, and water) people need and use.

This book did not use many hedges and presented the data as facts about electricity, such as electric current traveling in a circuit. One of the few times the
book hedged was in describing energy sources needed to create electricity. For example, “*Most* power plants get energy from burning coal, oil, or gas” (p. 18). “Nuclear power plants get *huge amounts* of energy from a substance called uranium” (p. 18). “*Some* power plants get energy from falling water” (p. 19). These few hedges were used in the book concerning the more tentative part of energy—the part of energy that is currently changing in the world as countries look for other types of energy sources beyond fossil fuels. Therefore, it was appropriate hedges were used to help convey this tentativeness.
The book showed very little of the empirical nature of science, with no experiments or descriptions of how scientific data are collected. However, it gave readers instructions on how to observe scientific evidence around them. For example, the book stated, “Look at the cord on a hair dryer. It looks like it is made of rubber, but the rubber is only on the outside. There are metal wires inside the cord” (p. 10). These directions helped somewhat to express that science uses observations and is
based on evidence, but they did not go beyond that concept. The people in the book illustrated how science is used in society and how it is harnessed. However, the book did not show that these sources of electricity are a result of human imagination. Therefore, the book showed science as being embedded in society but did not go further.

The second book Matthew read, *Simply Science Electricity* (Stille, 2001), was also very factual in nature but included some history on electricity as well. One section indicated

Benjamin Franklin was a famous American. He lived in the 1700’s. People did not know much about electricity then. Benjamin Franklin watched lightning in the sky. He thought it looked like a giant spark. He wondered if lightning was electricity. (p. 9)

This quote illustrated the inquisitive and curious nature of science. The book did not use the word *creative* to describe the scientist, but it did show how a scientist used curiosity to investigate scientific concepts. In addition to the text in the book, the pictures also communicated messages of the NOS. *Simply Science* (Stille, 2001) contained pictures that were conceptual (science content only) and pictures that had humans using electricity (e.g., boy creating static electricity with balloon and Benjamin Franklin flying a kite in a lightning storm). *Simply Science* (Stille, 2001) also explained that scientists in the 1700s and 1800s learned how to make a battery using chemicals and, over time, scientists learned how to build machines that make large amounts of energy that can be readily available in people’s homes. This information described the fluid nature or tentativeness of science because it changes over time. The description of Ben Franklin’s experiment discovering electricity helped to show that the scientific method is not a neat step-by-step process. It may be
messy, unpredictable, and dangerous, and investigation can be merely a result of human curiosity. Beyond this concept, the book used very little hedging, such as “Some electrons jumped from your shirt to the balloon” (p. 13) and presented facts about electricity as absolute. The book also showed how science (electricity) is routed to people’s homes, becoming a part of their culture. At the same time, it showed the steadfast nature of science when it showed Edison’s invention of the light bulb years ago and still used today.

**How the Views of the NOS Shaped the Read-Aloud Experience**

While reading the first book about electricity, Matthew stopped to discuss the content or the pictures, asked students questions, and fielded questions from students. The book focused primarily on facts about electricity, but the discussion in the classroom centered on explanations of how electricity works and where students encounter electricity in their lives. Matthew also asked several closed questions to students, that is, looking for one specific answer:

Matthew: [reading] Electric current can go through only certain kind of materials called conductors. [stops] Does anyone know what the opposite of a conductor is?

Student: Resistor?

Matthew: Resistor? Kind of. What else do we call it? Starts with an I, sometimes we use it to keep us warm . . . kind of a stretch of a definition. It’s called an insulator! We’ll be talking about those.

Matthew: What kind of electricity do you get when dragging across the floor? [looking for the answer static electricity]

Matthew: What two things allow electricity to flow through it?

These types of questions imply that teachers are looking for one right answer and not necessarily what students’ thoughts are. They also give the impression that,
in science, there is one “right” answer and show science to be very firm or inflexible as opposed to indefinite. These examples show Matthew looked for specific terms, and although the vocabulary may not change, students may have been given the impression that science is only about looking for that one “right” answer.

The students held largely naïve views about tentativeness while Matthew held mixed views about tentativeness. However, Matthew did implicitly express tentativeness in science when he talked to his students, as evidenced by his hedges. While reading the book, he made the following statements (hedges are italicized):

- *Not all* lightning comes down; *some of it* goes back and forth
- *Sometimes* there are ice particles out there . . .
- *So it kind of goes* in one prong and then out the other.
- *It’s kind of like* what we talked about a second ago, about water flowing. . . . *It’s kind of like you taking a piece of wood and blocking it*

The second book on electricity also showed very little tentativeness in science, and Matthew made similar hedges. In response to a student’s question about microwaves and sparks from metal objects, Matthew replied, “You shouldn’t put anything metal in the microwave. But certain soup bowls have that metal ring and they can go in, I’m not sure about how those work.” Concerning creating a spark with a fleece blanket, Matthew replied, “Sometimes I’ll get a spark; sometimes you’ll get a spark. . . . Do you have a fleece blanket at home?” Matthew’s hedging during discussion, intentional or not, may have compensated for the lack of tentativeness expressed in both books.

The second book on electricity that Matthew read displayed methods of investigation in science. Students scored naïve on the VNOS for this aspect, and
Matthew scored mixed views, but the topic was raised in the discussion during the read-aloud, both by students and Matthew. During the read-aloud, when Matthew read about Benjamin Franklin, students asked how Franklin knew to try this experiment.

Student: Why would he [Benjamin Franklin] want to know why if lightning was electricity?

Matthew: Because he was a thinker, he was someone who always questioned the world around him?

Student: Why would he do that?

Matthew: How else would he find out lightning was electricity? How would you find out lightning was electricity, if you had to find the experiment. If I said to you, how do you know, how can you prove lightning is electricity?

Student: Well I would watch the lightning if it hit metal and it did [inaudible]

Matthew: So instead of sitting and watching it hit the metal on the roofs he made it, he hit his key by taking that kite and sticking it out there

Another student: I’d take a metal rod and put it in the ground and take a string thingy and put it through there. So if the metal got hit it would travel through the thingy and something read it.

Matthew: You’re thinking that would be a great experiment, so you’re saying setting up a tower right? And a metal pole with a graph or chart and tells you when something happens.

The book and students’ interests led to this discussion of the empirical nature of science, that science is based on evidence. This discussion showed students that human creativity and imagination are intertwined with scientific thinking. Matthew’s informed score on both creativity and the myth of the scientific method apparently allowed students to have this discussion on how science is done. This example indicates that, even when students have naïve views on certain topics, the teacher may spark more informed discussions because of his or her own knowledge, especially when the read-aloud book highlights those topics.
This discussion carried over into students’ tickets out the door. Students were asked what they liked about the read-aloud and several students answered:

When we talked about the topic on Ben Franklin (Ta).

I didn’t know that Ben Franklin flied a kite just to make electricity (T1).

Yes, I liked when they talked about when Benjerman Flaklen did his science project (Tr).

One of the few areas that Matthew scored informed on was the creativity and imagination used in science. Students held largely naïve thoughts on this area, and even though the books showed some creativity, it was never directly brought up in discussion. This lack may have to do with what is considered creative in science. The creativity in the books was not marked but implied. For example, the first book on electricity showed the different ways to harness energy. The book did not go into how these processes were created or thought up, only that they did exist. The creative thinking of how to harness energy was not shown, but it was implied or taken for granted. Matthew did not talk about how these alternate energy sources came about or why they are relevant in detail but showed students that they do exist and how they are used. Matthew mentioned that solar cells are used on top of the school gymnasium, and a student asked about why they needed to cycle their special power bikes in gym class to produce electricity, and Matthew stated that it provided energy to turbines needed to produce electricity. He did briefly talk about the possibility of harnessing energy from electricity, but no students responded or asked questions, so Matthew continued reading the book. This creativity implication was also present during the discussion on Ben Franklin; the various methods of how to investigate
were raised, but creativity was never explicitly addressed. Matthew’s informed views helped further discussion on creativity even though students held naïve views on it.

Matthew’s discussion during the read-alouds included many personal pronouns:

How many of you have gone in a plane to fly . . . ?

Did you notice outside of the window . . . ?

Our classroom uses a ton of electricity.

You guys know when you grab a power cord, it’s not the . . . the rubber protects you from getting electrocuted.

It’s kinda like what we talked about a second ago, about water flowing. . . . It’s kind of like you taking a piece of wood and blocking . . . .

We’re going to a house that runs on solar panels and a windmill, and we can ask how things works in their house.

How does ours work; how does our battery work? Do you guys remember . . . ?

This approach allowed Matthew to include his students in the learning process. Many of these discussions Matthew started caused students to raise their hands and share their own experience with electricity, permitting them to feel included and have ownership of their learning. This approach may have also helped to give the idea that science is not authoritarian and oppressive but instead open to all citizens.

Ben Franklin’s experiment described in the book gave Matthew the opportunity to discuss how science is conducted, using imagination and not adhering to a specific plan. Matthew’s discussion focused on how students see and experience electricity in their lives and how different sources of energy (solar, wind, etc.) exist. The topic of these two books, electricity, enabled Matthew to make the connection from science to technology. The role of the read-aloud in this learning experience
allowed the teacher and students to exchange ideas and information on electricity. The book acted as a guide, leading the teacher through the science topic, and because of the nature of a book, the teacher was able to stop and ask students questions about the content and the scientific endeavor and even personal questions about how the content affects students individually.

**Classroom 2**

**Carey’s Case**

Classroom 2 was very similar to Classroom 1: Both were fourth-grade classrooms in the same school. This class was taught by Carey, a fourth-grade teacher with an undergraduate degree in physical education (P.E.) and a master’s degree in reading. She has 20 years of teaching experience. Carey enjoyed teaching math the most and the reading portion of the English language arts (ELA) curriculum. Carey’s background in science after high school included three college science courses, including anatomy, astronomy, and kinesiology. Although she liked science, Carey particularly enjoyed enacting hands-on activities to teach science. In her opinion, kids love the hands-on experience, but without having a designated lab space in the elementary school, Carey felt very restricted when teaching science. Her main goal for science was to have students pass the New York State Science Exam, but she also thought it was important to teach students about the environment (Carey Interview, 2/17/12).

Carey read science trade books to her students to “give and build background knowledge” (Survey, 2/6/2012). She selected books related to the curriculum and “kid friendly/enjoyable” (Survey, 2/6/2012). She incorporated read-alouds into
science teaching by reading the books prior to lessons and regularly focusing on vocabulary while reading. Additionally, she added activities to the read-alouds, such as journal writing responses or group assignments for students to become “experts” on one topic presented in the book. Carey stated, “In fourth grade our students are not graded. We discuss the concepts and engage in activities that support our learning” (Survey, 2/6/12). The following subsections describe Carey’s teaching context and explore the ways in which the NOS was negotiated during the two read-aloud sessions in Carey’s class.

**Carey’s Classroom and the Use of Trade Books**

Most of Carey’s students were White, with a few African Americans or Hispanics. She described her class as

Dynamite . . . but some kids who really need more than a general ed classroom offers, because I have umm . . . children who are autistic, I have children who are on medication and I have children who have [a] very difficult time controlling their behavior. Then I have kids who are just the crème de la crème, they are just wonderful students, they will learn so easily and pick up concepts so quickly. (Carey Interview, 2/17/12)

She regularly used trade books in class and stated she “loves” read-alouds (Carey Interview, 2/17/12). One of the many reasons for her love of read-alouds was that students focus more on the book than when they are asked to read articles or textbooks; students are more engaged when someone is telling them a story.

However, she struggled to find “good science books” for her class and said there was a need for better science trade books (Carey Interview, 2/17/12). She said she does not formally assess students after a read-aloud but considered a read-aloud to be successful if students were listening. Concerning preparing to read science trade books to her students, Carey said
Well, I think you have to . . . know your kids and what they are going to like. I think you have to have uh . . . you have to read it ahead of time, so that you can kind of anticipate questions . . . but also so that you can read it fluently, umm . . . you have to, I think it’s important to be a a a good fluent reader, and love pictures with the the books, that’s one of the reasons I like the story books, uh even though they are non fiction they are still telling the story about a topic and pictures are important. (Carey Interview, 2/17/12)

She also added that using dramatic voice helped when reading aloud to her students because it is like a performance in class. She believed that, for a read-aloud to be engaging, there needs to be something exciting or catchy, like a dramatic voice, to grab the students’ attention. The underlying message was that science books are not that interesting by themselves and they require dramatics for students to become interested.

**Carey and Science**

Unlike the other teachers in the study, Carey acknowledged the uncertainty or tentativeness that exists in science. Her understanding of science was that creativity, culture, philosophy, and society and political groups influence it. Overall, Carey had mixed views on the nature of science. Table 4.2 shows Carey’s understanding of each of the NOS aspects.

Carey was asked about the possibility of scientific theory changing, a question focused on the tentative nature of science. She answered this question by saying,

The flat Earth theory just didn’t stand up to the test of time, and humans discovered more ways to look at both the land and the sky in relationship to our presence. No sailor ever fell off the edge, and so the horizon was determined to be dynamic and not static. (Carey VNOS, 2/15/12)

Thus, Carey’s understanding of the tentative nature of science is informed. She stated in her view that scientific theories do change over time because of new discoveries. She did not, however, expand on that statement to show the most informed view of
the tentative nature of science, which would have included a statement about how re-examining old data can also change theories and that the changing nature of science is not only reliant on new discoveries.

Carey also held informed views on the aspects of sociocultural influences, creativity, and subjectivity in science. For example, one VNOS question asked about the different theories scientists have on how the dinosaurs became extinct, even though they have the same data set. The subsequent question asked whether science is infused with views from society, politics, and culture or whether it is more universal—that is, whether it transcends the boundaries of culture and society. Carey answered both questions together:

Different conclusions are possible about the same event even if the scientists in both groups are accessing the same set of data because human brains are multi-faceted and are open to interpretations from any given data set. As a personal example, I have 7 siblings and when we talk about our childhood, we are likely to tell 8 different stories about the same event. We’re swayed by our position as the event occurs, and by where we were before the event occurred. “Life is a cube,” we are all looking at things from different perspectives. When I think of quantum physics, I have to believe that social, political, philosophical, and intellectual norms are reflected in research. The depth of understanding is beyond most people/scientists at the present time. And yet it is being studied. As time goes on, I believe more and more people will come to easily understand the questions we have today about quantum physics, and another “big” question that is unheard of today, will be asked. (Carey VNOS, 2/15/12)

Carey was also asked about the aspects of human inference and subjectivity influencing the work of scientists, specifically what factors scientists use to determine a species and how certain are they about their characterization. Carey answered, “I don’t know how certain, scientists are about their characterization. I imagine scientists used the evidence of reproduction, habitat, life style and other patterns of living to decide about types of species” (Carey VNOS, 2/15/12). She
articulated her more developed view of the NOS by expressing the uncertainty scientists have in characterizing species. Carey also showed her sophisticated understanding of the NOS when asked whether scientists use creativity and imagination when conducting science experiments:

Scientists are bound by/to the existence of their thoughts. I imagine those thoughts do have an impact on their investigations. We all bring our background to bear on much of what we do. . . . Certainly a scientist has to use creativity/imagination to develop these parts of an investigation. I also think that scientists must have an idea of what they may find. Perhaps this idea colors their outcome. (Carey VNOS, 2/15/12)

While Carey did express the idea that scientists are people who have their own thoughts and ideas, she stated that the creativity takes place in the planning, design, and data collection phases, leaving out the analysis stage (the inclusion of which would have shown a more developed view of the NOS).

Carey did show some naïve views of the NOS, particularly concerning the empirical or investigative nature of science. She defined an experiment in Question 2 as “trying out guesses to see if they explain something” (Carey VNOS, 2/15/12) and articulated the difference between scientific theory and scientific law in Question 5 as follows:

Scientific theory seems to be a “best guess” about the why or now of something . . . anything. I don’t have any idea about scientific law, but I think it would be something that has worked and been proven in human history, such as the law of gravity. (Carey VNOS, 2/15/12)

These two responses show underdeveloped views of the nature of scientific processes. Question 2 clarified the respondent’s understanding of what it means to experiment, and Carey held the more naïve view of experiments; that is, she thought that experiments are largely “trial and error.” Question 5 clarified the respondent’s understanding of law as opposed to theory, and Carey also indicated naïve views in
this instance. The naïve view centers on a law being “proven” or a theory needing to be “proven” to be a law, neither of which is true. Therefore, overall, Carey showed mixed views about the NOS.

Table 4.2

<table>
<thead>
<tr>
<th>NOS theme</th>
<th>Teacher views</th>
<th>Student views</th>
<th>Book 1a</th>
<th>Book 2b</th>
<th>Present in discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Empirical</td>
<td>Naïve</td>
<td>Naïve/mixed</td>
<td>Little</td>
<td>Moderate</td>
<td>None</td>
</tr>
<tr>
<td>Observation</td>
<td>Mixed</td>
<td>Naïve</td>
<td>Little</td>
<td>Little</td>
<td>Book 1: slight; Book 2: none</td>
</tr>
<tr>
<td>Myth of scientific method</td>
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<td>Naïve</td>
<td>None</td>
<td>Little</td>
<td>None</td>
</tr>
<tr>
<td>Methods of investigation</td>
<td>Naïve/mixed</td>
<td>Naïve</td>
<td>Little</td>
<td>Moderate</td>
<td>None</td>
</tr>
<tr>
<td>Human imagination/creativity</td>
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<td>Naïve</td>
<td>Very little</td>
<td>Little</td>
<td>Book 1: Limited; Book 2: None</td>
</tr>
<tr>
<td>Theory driven and theory/law</td>
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<td>N/A</td>
<td>None</td>
<td>None</td>
<td>Book 1: Very limited</td>
</tr>
<tr>
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<td>Informed</td>
<td>Naïve</td>
<td>Very little</td>
<td>Little</td>
<td>Book 1: Limited</td>
</tr>
<tr>
<td>Sociocultural embeddedness</td>
<td>Informed</td>
<td>N/A</td>
<td>Very little</td>
<td>Highly present</td>
<td>Book 1: Limited discussion</td>
</tr>
</tbody>
</table>

Note. Views from VNOS answers.

aThe Big Rock (Hiscock, 1999).
bThe Shortest Day (Pfeffer & Reisch, 2003).

Students’ Understanding of the NOS

As a whole class, Carey’s students tended to have generally naïve with some mixed views on the NOS (Table 4.2). When students were asked to define science,
several students in Carey’s class described that learning science had to deal with learning about the past:

Science is when you learn about stuff that happened a long time ago (K, Carey’s class).

Science is studying stuff from long ago (P, Carey’s class).

Science is thing that is what happened a long time ago (T, Carey’s class).

A few students however had more specific answers to what is science

Science is where you study chemicals and light and you have to know math to know to learn/do science (M, Carey’s class).

Experiments, having fun (P, Carey’s class).

Science is what explain what technology and other this are (L, Carey’s class).

When students were asked whether what scientists know will change the future (focusing on the tentativeness of science), all students in Carey’s class focused on knowledge changing because of scientists conducting more experiments or finding new information. The more developed answer would also include re-evaluating old data in a different way; however, several students held the more stereotypical view that knowledge will change because of scientists discovering new things

I think it will change because they will might find more fossils, also they might find more chemicals (M, Carey’s class).

I think that scientists will change our future because they make new things and use their imagination (P, Carey’s class).

Yes because scientists are very smart (J, Carey’s class).

Several students relied on the idea that, because scientists are “smart,” what they predict will be true, and they have all the facts.

Students were also prompted to share their understanding of observation, subjectivity, and creativity in understanding science by being asked how scientists
know that dinosaurs once lived on earth and how sure the scientists are about the way
dinosaurs looked. Several students answered as follows:

[T]hey knew because the calected teeth that were baryied and people would
find spines and ribs. [The scientists are sure] because they have put together a
dinosaur bodies (K, Carey’s class).

Scientists know that dinosaurs once lived on earth because they found the
bones of them. Scientists aren’t very sure the way dinosaurs looked because
no people lived then (P, Carey’s class).

scientist know that dinosaurs lived on earth because they found dinosaur
bones. [Scientists are sure] because they looked at the bones and pictured in
they’re head what the dinosaurs looked like (D, Carey’s class).

The students had a better understanding of scientists using observations, in this case
finding dinosaur bones and putting them together. Only one student (P) expressed
understanding the tentativeness of scientists by stating scientists are not very sure.
However, almost all the other students in Carey’s class thought that scientists were
positive about how dinosaurs looked and were not tentative at all about their thoughts.

Students were also asked why scientists have different theories about the
extinction of dinosaurs even though they have the same data, and in Carey’s class,
this question elicited a few more informed views of students than the rest of the
questions:

They all have different ideas because they didn’t know what happend (P,
Carey’s class).

Because some of them don’t agree on the other scientists thoughts (D, Carey’s
class).

because they are different people (J, Carey’s class).

Everyone has different opions and some have the same opions (A, Carey’s
class).

Because they have different opinions (B, Carey’s class).

I think they do that becase they arent that sure (C, Carey’s class).
Because they have different ideas about how they died (P2, Carey’s class).

Because they are different scientics they have different opinions that’s way they disagree about this (T, Carey’s class).

In contrast to previous questions to which students showed naïve views about scientists using creativity or having subjectivity, these answers spotlighted the fact that many students still recognized scientists as individuals who all think differently. Two distinct themes emerged from these responses: Scientists have different opinions, and scientists do not always know the answers.

Students were also questioned about their understanding of inferences, observations, and tentativeness when asked about the certainty of the weather forecasts by meteorologists. The students held various views about how confident meteorologists are in their weather predictions. Several students stated that meteorologists are confident because they have tools such as satellites and pictures while other students stated that meteorologists were correct only some of the time (in their opinion) and they just guessed at the weather by looking around them. Both of these views indicate that students understood that scientists, in this case meteorologists, use technology and equipment to help them understand phenomena, but ultimately, a prediction is still an opinion.

The last question on the student VNOS asked students whether scientists use their imagination when working, eliciting remarks on creativity and imagination in science:

I don’t think scientinsts should use their imaginations because they could not be right or make people think what’s wrong (P, Carey’s class).

No because their imaination will not help (B, Carey’s class).

no because they need the real facts so they can tell people about it (T, Carey’s
class).

No! Because then the wouldn’t Be called scientists (M, Carey’s class).

[No] They don’t use there imaginations because then they wouldn’t have invented all of that stuff (K, Carey’s class).

Students in Carey’s class overwhelmingly thought scientists do not and should not use creativity or imagination when doing their work (no students scored ‘informed’ on this question). This view actually contradicted some of their previous statements that scientists think and have different opinions. This contradiction indicates that the students had muddled thinking about how scientists work and how science “facts” come into being. Students may have understood the concept but equated creativity and imagination with make-believe, thus, not seeing how they can coexist. Students may not have had the vocabulary to describe this understanding. This finding may also lead to clarify what kind of creativity is referred to in the NOS, creativity based on known aspects, such as some factual information or data or an open imagination-kind of creativity.

Books Chosen by Carey

Carey read two books to her students: The Big Rock by Bruce Hiscock (1999) and The Shortest Day: Celebrating the Winter Solstice by Wendy Pfeffer and Jesse Reisch (2003). The Big Rock (Hiscock, 1999) is a narrative about a large rock that sits in the Adirondacks of New York State. The book described how the rock was formed from the earth’s crust and eventually pushed and folded into a mountain range. It described the rock’s change over time because of erosion, weathering, and other environmental changes. The visuals in the book included drawings on almost
every page showing the earth’s crust, seas with simple plants and primitive animals, glaciers, and the Ice Age and the Triassic Period.

The book showed the empirical nature of science with illustrations of scientists working in the field. The text described the scientists working and was complemented by a drawing of geologists using tools to collect data from a rock (Figure 4.2). The book briefly noted the notion of science being evidenced-based in the same picture of the two geologists. The text stated,

There are many places, in the northern part of the world, where the land is stony and dotted with rounded boulders. Geologists, the scientists who study the earth, wondered why this region was so rocky. They discovered that huge sheets of ice, called glaciers, had covered these northern areas just a few thousand years ago. (p. 5)

The book did not include details concerning how geologists collected the data on glaciers, but the reader was at least given the idea that scientists collect and try to make sense of data. The only other mention of humans in the book accompanied a drawing of two people sitting near a rock. The text on the page stated, “The first people came to the valley about then, following the herds of game. They were stone age families and made spear points from pieces of rock” (p. 24).
The book also contained many hedges, particularly about the timeline of events. Using hedges is a way of showing tentativeness or uncertainty in science: “They discovered that huge sheets of ice, called glaciers, had discovered northern areas just a few thousand years ago” (p. 6). “The big rock is a chunk of granite that comes from a very old part of the earth’s crust. The granite was formed about a billion years ago . . .” (p. 9). “As the ages passed, the mountains above . . .” (p. 10). “The seas lasted millions of years, depositing layers . . .” (p. 11). “In a few million years there may be nothing left . . .” (p. 25). No personal pronouns or other clear connections to the NOS were in the book.

*The Shortest Day* (Pfeffer, 2003) discussed when the sun rises and sets and how that changes throughout the year, the tilt of the earth, how the winter solstice came to be known, and how different cultures all over the world celebrate the shortest
day (winter solstice). The book contained drawings of the sun setting at different points of the day and was largely filled with drawings of different people and societies during the changing seasons and celebrating the solstice. The end of the book had two pages of “solstice facts” and then six pages of activities for students to do to celebrate the winter solstice, such as measuring shadows on the shortest day and making a model of how the earth tilts (causing seasons).

As *The Big Rock* (Hiscock, 1999) did with geologists, *The Shortest Day* (Pfeffer, 2003) illustrated astronomers at work, looking at the sky and watching for the sun to set in different places on the horizon:

> These early astronomers planned to mark the shortest day. Then each year people would know when the days would be getting longer again. On the day when the sun reached its southernmost point on the horizon, the astronomers carried out their plan. Workers stacked stones to frame the setting sun. They made a special opening, like a keyhole or the eye of a needle. When the setting sun’s rays beamed through that opening, people knew the shortest day was over. (p. 14)

In addition, the book indicated, “In China, over 3,000 years ago, astronomers measured shadows to determine the shortest day” (p.18). The astronomers in the book are described as doing science by collecting data and investigating.

In the beginning of *The Shortest Day* (Pfeffer, 2003), early humans were described as not understanding why the sun shined less on a certain day than it had the day before, so they “held ceremonies that lasted for weeks to persuade their gods to bring the sun back” (p. 9). Later in the book, astronomers described the shortest day when stating, “People know that days get colder when their part of the earth tilts away from the sun. They know that days get shorter when the sun appears low in the sky” (p. 26). Therefore, the book indicated that, because astronomers investigate and collect evidence, new knowledge exists. By acknowledging that astronomers
investigate, the empirical aspect of the NOS is evident to readers. This book also showed that scientific ideas are open to change based on new or reinterpretation of evidence. Understanding of astronomy is shown to be a result of human inference, creativity, and investigation. The book showed astronomers trying to understand phenomena by conducting an investigation.

The authors of *The Shortest Day* (Pfeffer, 2003) emphasized people, which made up more than half of the images. As mentioned above, some of the drawings showed astronomers working, such as those in China measuring shadows (Figure 4.3). Roman, European, and Peruvian celebrations were shown, as well as current-day people celebrating the solstice by exchanging gifts. These examples helped to communicate the idea that science has global interpretations and is part of social traditions. The end of the book showing people celebrating and understanding the science behind the winter solstice conveyed the historical development of scientific knowledge. Overall, this book showed how science is embedded in society.
Figure 4.3 Scenes from *The Shortest Day*.

**How the Views of the NOS Shaped the Read-Aloud Experience**

While sitting at their desks for each read-aloud, students were asked to take out a sheet of paper, write down any notes they thought were important about the
book, and write down any words they thought were science vocabulary words. One point of interest in this case was that Carey’s views of the NOS limited or hindered discussion to help student understanding of the NOS. Carey held naïve views about the empirical nature of science while her students held naïve and mixed views, but both books selected demonstrated the empirical nature of science. Carey chose not to discuss this aspect of science, that is, collecting data and using them in scientific research. Students seemed confused in the subsequent ticket-out-the-door activities because several students did not understand how astronomers collecting data all over the world could be studying the same concept and why the day is shorter. A few ticket-out-the-door questions were as follows:

I liked how it said that 5,000 years ago the people built a sculpture and they let the sun go through a hole in it. I wanted to know how the other people found out about the solstice (D, Carey’s class).

I have questions of the day get shorter and longer and how do they all know (V, Carey’s class).

Why does the sun set earlier? how does the sun set earlier (A, Carey’s class).

One of the questions I have about science is why is December 21st the shortest day of the year? how do they all know? (L, Carey’s class).

Carey’s naïve views concerning the empirical nature limited student understanding and discussion about this aspect even though both books presented the empirical aspect of science. This example helps to show that the teacher is really the key to the extent of discussion in a read-aloud. Even if the trade book presents an NOS topic, the concept may not be understood without a teachers’ more informed understanding.

For the first read-aloud, Carey read *The Big Rock* (Hiscock, 1999) while sitting on top of a desk among the students in the classroom. Carey showed the picture of dinosaurs in the book to the students and asked whether humans were alive
before dinosaurs and when dinosaurs were around. Some students answered, “Yes,” and yelled out, “Cavemen,” and Carey replied, “Nooo, nooo . . . no no no no no, you watch cartoons where you see them but not in real life.” She then continued to read the book overlooking the opportunity to talk about myths versus science and about having empirical evidence to support scientific knowledge, which is related to the empirical nature of science. It is interesting to note that the book’s text did not directly spark this exchange but rather the pictures in the book. In another instance, the topic of the Ice Age came up, and a student asked, “How did they [animals] even come alive?” and Carey responded by saying

Well that’s something you need to discuss with your family, some people think about the things at church and . . . God did it, and some people think they grew from little . . . perhaps plants on the ground and some people think they came from another planet and nobody’s sure . . . but your families might be sure . . . [students talking inaudible] . . . oh scientists have their own ideas . . .

Both Carey and her students did not hold informed views on theories so it is not surprising that the discussion did not go beyond the simple idea that people have different ideas and students should talk to their families. On her VNOS, Carey did hold an informed view that science is partially based on human creativity and imagination, which showed up minimally in that exchange at the very end (when Carey said scientists have their own ideas). Again, students were still confused about this topic because they asked in their Ticket out the Door how animals came about (the students’ question in the exchange above). Students asked

I liked when she [the teacher] was showing use the pictures. I want to know how the animals came there (K, Carey’s class).

I learned that the Big rock took millions even Billions of years to form. I wonder how the animals came to the Big rock (M, Carey’s class).
Again, Carey’s naïve views on a NOS topic limited her students’ understanding and any further discussion about theories, even when the book sparked students’ interests. This helps argue that the teacher is the key in the extent of NOS topics in a read-aloud discussion. Like *The Shortest Day, The Big Rock* sparked student interest on an NOS topic (theories) but discussion was limited seemingly because of Carey’s less informed understanding of theories.

Carey did express some tentativeness in science (an aspect she scored ‘informed’ on) when she stated, “Nobody’s sure.” However, students held naïve views about tentativeness and this book illustrated very little tentativeness, so the discussion did not extend beyond this point. Students did not overlook the tentativeness aspect though, as they asked again in their ticket-out-the-door questions about how animals came into existence.

In one instance of expressing science with a limited view, Carey asked a series of questions for which she was wanted one specific answer each time:

Carey: Ok so first we had gla . . .?

Students: Glaciers

Carey: Glaciers, then we had?

Students: Mountains

Carey: Heat from under the earth that pushed up the mountains; . . . then we had seas, what was the climate then?

Students: Warm

Carey: Warm seas they told us. And now what happens when this all changes? What do we have now?

Students: Mountains

Carey: We have these mountains, but are they sharp and pointy as they were at first?
Students: No.

Carey: No because so many years have gone by they’re worn down again. They’re worn down again. Would you see this happen in your lifetime?

Students: No . . . yes . . . no

Carey: Do you think people were alive then? [students say “yes” and “no” out loud]

Carey: Some people think yes, some people think no; well, let’s see if they tell us.

Carey looked for one specific answer each time, indicating to students that science has one “right” answer. Questions looking for one answer give students the impression only one “correct” answer for an issue exists in science. As Carey read, she asked many closed-ended questions about the climate and landmasses to elicit more factual responses from students. This method of questioning—looking for one specific answer—illustrates science as rigid and does not indicate the true nature or non-authoritative nature of science.

Carey also asked students whether their winter was a “hard winter,” like the one mentioned in the text, trying to connect the students to the book by socially embedding content in their lives. Many students replied, “No,” and she confirmed their responses, stating the winter was a “soft winter.” Carey, who held informed views of the socially and culturally embedded nature of science, started to make connections as she read about the rock sitting in the Adirondack Mountains. She showed her students, who, at their age level, were not tested on the social and cultural aspects of science, the pictures of the mountains and said, “So here’s the southern edge of the Adirondack Mountains. . . . You have all been there”. She did so again in the following exchange”
Carey: Who knows a park where you can see the rocks showing?

Student: Thatcher Park

Carey: Who’s been to Thatcher Park? Okay, that’s in the Helderberg Mountains.

She continued to give students a contextual relationship concerning where this type of science happens. She showed students pictures of the volcanic rock and stated,

Now take a look, and do you see, how the, that heat made the land bubble up and came up into these big folds that then got hard and turned into the Adirondack mountains. Do you see that? What colors are the mountains M? What other colors . . . ?

The extent of this discussion indicated that, although the book was limited in illustrating the social and cultural part of science, Carey could further this discussion and make sociocultural connections to students. (She held an informed view of this NOS concept.)

In addition, Carey held mixed views of the observational aspect of science, and during this read-aloud was the only time Carey touched on observations—by asking students to note the colors of the volcanic rock. When Carey read the page about the geologists, she read just the text on the page and continued to the next page, overlooking the opportunity to share the significance of the scientists doing work in the field, showing both the observational and investigative aspects of science.

Beyond the ticket-out-the-door questions, students’ questions and comments were related the NOS, possibly because of the students’ own naïve views on the NOS aspects or because of the limited discussion surrounding NOS aspects.

The Shortest Day (Pfeffer, 2003) was the second book Carey read to her students. Unlike with the first book, Carey did not stop as often to ask questions or comment on the book; she did, however, have students take notes as with the first
read-aloud. The few times Carey stopped, she continued asking closed-ended questions:

Carey: but it’s called the shortest day because it has the few hours of?
Students: Daylight!
Carey: Daylight, good job!
Repeatedly asking closed-ended questions continued to emphasize that science has one right answer. This second book showed the human aspect as well as the social and cultural aspects of science, but Carey did not go beyond what was written in the book. This limitation may have occurred because the social and cultural aspects of the book were intertwined with the empirical nature of science (an aspect Carey held naïve views on). She did not have a discussion or emphasize this humanistic aspect of science, suggesting that she did not think it needed to be emphasized because the book presented it (with a high presence of the human aspect of science). It should be noted that part of this human aspect in the book involved people investigating, showing the empirical nature and investigative nature of science. Carey did not hold informed views on empiricism and scientific investigation; therefore, she may not have been aware of these NOS details to discuss them knowledgably.

The ticket-out-the-door questions the students asked after this read-aloud expressed questions students still had after the read-aloud. When students were asked to comment on what they learned from the book, they showed they were confused about some of the ideas presented in the book. Several students were still confused about the concept of the shortest day and wrote,

Why does the sun set earlier? How does the sun set earlier? (A, Carey’s class)
Can you ever see the winter solstice (T, Carey’s class).

One of the questions I have about science is why is December 21st the shortest day of the year? (L, Carey’s class)

The read-aloud did not spark any new or continuing thoughts about the solstice; instead, students were still generally confused about how the solstice happens. It is interesting to note that students seemed confused after this read-aloud, one in which Carey did not explain or further discuss the book, preferring only to read the text. This instance indicates that the presence of ideas or concepts in a book may not be salient or may still be confusing to students if the teacher does not take the time to discuss or explain them.

According to the VNOS answers, Carey held slightly more informed views than students in some cases, but for the most part, both Carey and her students had naïve views of the NOS. The books did make a few connections to the NOS, but the discussions throughout the read-alouds never approached those connections. For example, the book about the winter solstice showed science highly embedded in culture and society, but there were no comments, questions, or discussions about this topic. Both books showed representations of empirical work being done; however, the topic of how scientists do work was never discussed. Many of Carey’s questions were closed-ended, posed with one specific answer in mind. Such questioning indicated the lack of teacher awareness of the NOS or its importance. Overall, Carey used these read-alouds as a tool to teach scientific facts to her students rather than to discuss the nature of science.
Classroom 3

Rachel’s Case

Classroom 3 was a small third-grade class in a private school in Upstate New York. The teacher, Rachel, was a novice teacher with an undergraduate degree in atmospheric science and a master’s degree in adolescent education, 7-12. Rachel took largely science courses in her undergraduate work, and before teaching, she worked at the National Weather Service and the Atmospheric Science Research Center. She originally wanted to go further and pursue a graduate degree in atmospheric science, but from her experience working, she felt isolated, so she was wanting to interact with other people; thus, she became a teacher:

I actually did get a full scholarship to go to grad school but decided not to go and become a teacher. And I love science so much I want everyone to love science, so I want to talk about it all day long. . . . One day I realized that’s definitely what I needed to be doing, interacting with people, teaching the subject that I love so much.

Of all the participants in this study, Rachel had the most extensive background in science. She was also the only teacher in the study who was exclusively teaching science. All her students had a classroom teacher but came to her room to learn science. She felt the school was very supportive in teaching science:

This school is actually very supportive in science. They . . . umm . . . provide, well first of all they have 77 acres of land and yesterday we went outside and they really encourage us to use the property for science to do observations, and studies, and make stream samples and stuff like that. So they really really encourage us to do that, this school is kind of . . . has a high emphasis on science, more than other schools I’ve been in.

Rachel was very enthusiastic about science and the fact that the school was so responsive and accommodating to her teaching needs.
Rachel’s Classroom and Use of Trade Books

Rachel stated she regularly read books aloud to her students and she used “regular questioning techniques” (Survey, 2/27/2012) when reading. She liked to use the read-aloud activity as a way to reiterate a concept and found the activity to be an approachable and manageable way to learn topics. She selected trade books that were aesthetically pleasing with “good language and accurate science” (Survey, 2/27/2012). In her interview, she added,

I do enjoy reading aloud because I think it provides them a different perspective on things, it’s not just, you know, me telling them what’s going on, they can form their understanding by themselves, and it’s more on them to understand what’s going on. So I do, I like them . . . it gives them another perspective that I might not be able to offer by myself.

Rachel was the only teacher hesitant to say that read-alouds can teach science. I asked her whether she thought students could learn science from read-alouds, and after a long pause, she replied,

I think that they can learn about science and get their inquisitive characteristics going, but I’m not sure that . . . to me I feel like science is more, they need to, you know, manipulate things and experiment for themselves. I think it provides an excellent basis for teaching them, but I think for actual learning how to think critically and stuff like that has to come from actual experimentation umm in the classroom our outside experimenting with umm different different objects and thinking about that . . . and it might depend upon the type of book. I mean it, it would definitely depend up on the type of book. If it was more of like a book that provided open answered questions and really generated them to start thinking, then yeah, then they could learn science. But if it’s just a story about the river, like I taught, like I did, they might learn about you know, pollution and science like that, but I don’t think they’re learning . . . umm more of like a critically thinking analysis type of skill.

Rachel understood that there is a place for read-alouds in the science classroom; however, she thought they were limiting in the type of science learning that could
occur for students. The following subsections describe Rachel’s students and how the NOS was negotiated during the two read-aloud sessions.

**Rachel and Science**

Rachel had one of the most informed understandings of the NOS among all the teachers (Table 4.3). This finding is not surprising because of her substantial background in science in comparison to the other teachers. She was one of only two teachers to score an informed view for the empirical nature of science. She defined *science* as “The study of the world around us through observation and experimentation” (Rachel VNOS, 2/27/12). She again was one of only two teachers who scored an informed view on the investigative process and developing scientific explanations aspects of the NOS. When asked about how certain scientists are about the structure of the atom, she responded, “Scientists are relatively certain of the structure of an atom. This is a good example of an evolving theory. It first started with plum pudding model and through the gold foil experiment refined into our modern structure” (Rachel VNOS, 2/27/12). This response also showed Rachel’s understanding of the tentativeness of science. Question 6 also addressed tentativeness by asking whether theories ever change, and Rachel acknowledged that theories are “ever-changing” (Rachel VNOS, 2/27/12). Rachel was also the only teacher able to describe the difference between theories and laws with some accuracy: “A law is a unifying and universal concept that provides insight into a topic. A theory seeks to explain scientific phenomena. Many theories exist which describe phenomena at any one time” (Rachel VNOS, 2/27/12). Although it cannot be concluded that Rachel’s
science background caused her to know the difference between theory and law, it is the only aspect for which all other teachers were given the same rating of naïve.

The last few questions on the teacher VNOS dealt with creativity, human imagination, and the social and cultural influence on science. Rachel scored mixed views on these questions. In response to one question she wrote, “[C]reativity should not be used in data analysis which should be objective” (Rachel VNOS, 2/27/12). She acknowledged that interpretations can result in different theories when she wrote, “The interpretation of the data is different . . . so is the interpretation that has resulted in different theories” (Rachel VNOS, 2/27/12). When asked about cultural and social values reflecting in science, she stated, “Science is universal. If cultural and political views are included than it is not science. Science should be objective” (Rachel VNOS, 2/27/12). This last statement was the only one receiving a naïve scoring on her VNOS. It was interesting that Rachel had the most background in science and scored the highest in the aspects of science having to do with investigating, developing theories, and the evolving nature of science but held naïve views on how culture, society, and politics affect science. She believed science could be true only when it was “objective.” Overall, Rachel seemed most comfortable when talking about science, and her informed scores on the VNOS reflected her understanding of science.

Table 4.3

*NOS Views and Portrayals in Rachel’s Class*

<table>
<thead>
<tr>
<th>NOS theme</th>
<th>Teacher views</th>
<th>Student views</th>
<th>Book 1&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Book 2&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Present in discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Empirical</td>
<td>Informed</td>
<td>Naïve</td>
<td>Highly present</td>
<td>None</td>
<td>Highly present</td>
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</tbody>
</table>

104
<table>
<thead>
<tr>
<th>Observation</th>
<th>Mixed</th>
<th>Mixed</th>
<th>Slightly present</th>
<th>None</th>
<th>Book 1: slight; Book 2: none</th>
</tr>
</thead>
<tbody>
<tr>
<td>Myth of scientific method</td>
<td>Mixed</td>
<td>Naïve</td>
<td>Slightly present</td>
<td>None</td>
<td>Slightly present</td>
</tr>
<tr>
<td>Methods of investigation</td>
<td>Mixed/ informed</td>
<td>Mixed</td>
<td>Highly present</td>
<td>None</td>
<td>Book 1: highly present</td>
</tr>
<tr>
<td>Human imagination/ creativity</td>
<td>Mixed</td>
<td>Mixed</td>
<td>Slightly present</td>
<td>Slightly present</td>
<td>Book 2: Slightly present</td>
</tr>
<tr>
<td>Theory driven and theory/law</td>
<td>Informed</td>
<td>N/A</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tentativeness</td>
<td>Informed</td>
<td>Mixed</td>
<td>Present</td>
<td>Present</td>
<td>Book 2: Present</td>
</tr>
<tr>
<td>Sociocultural embeddedness</td>
<td>Mixed</td>
<td>N/A</td>
<td>Highly present</td>
<td>Slightly present</td>
<td>Books 1 &amp; 2: Highly present</td>
</tr>
</tbody>
</table>

Note. Views from VNOS answers.

*Storm Chaser* (Greenburg, 1998).
*A River Ran Wild* (Cherry, 1992).

**Students’ Understanding of the NOS**

For the most part, Rachel’s students tended to have largely naïve and some mixed views on the NOS (Table 4.3). When asked about the empirical and investigative nature of science, many students wrote science is learning about “things” around them (n = 5, 5 students answered this total). A few students also drew some small pictures that looked like an Erlenmeyer flask and some other laboratory glassware. The students had a lot more to say about the other NOS aspects, such as imagination, creativity, and tentativeness. For example, when asked whether scientists’ knowledge changes the future, M wrote, “Yes because scientists are smart and what do we know about the future.” The assumption of many students
(n = 12, 13 students answered this total) was that scientists are always right because they are scientists.

Several students understood that scientists use equipment to collect data or gather information in part of their processes. Students shared their thoughts on how certain weather people are about the pictures they present on television and why:

Sure. They use cameras that they put in space (O, Rachel’s class)
because they have spicshle stuff that they can use for the weather (M, Rachel’s class)
Thier are satalite’s that are abov the erth that tell them (R, Rachel’s class)
Pritty sure. Because they a wether instermints to help them see the sky’s (L, Rachel’s class).

The overall student score for imagination and creativity was mixed because some students had developing views of the role of imagination in science, and some students held completely naïve views. The following are some answers to the question “Do you think scientists use their imaginations when they do their work? If No, why? If Yes, then when do you think they use their imaginations?”

[Yes] When there finding a new way for a new canser medisine or when there doing a test (E, Rachel’s class).

[Yes] When thay are trying to figure out what something lookes like when thay do not have a clue (B, Rachel’s class).

[No] Your imagination is not always true (O, Rachel’s class).

[No] No because they want to know the real facts, the true facts, the not wrong facts. if they want to know how Dinos Died they should use the real facts not made up facts (S, Rachel’s class).

It is evident from the answers that some students understood that scientists use their imaginations when trying to fill in missing information or when they do tests or create something new. The negative answers showed the opposite to be true, that
using imagination has no place in science. Students giving those responses equated using imagination in scientific work with fraud. In addition, questions focused on creativity showed some students to have more developed views than others. When asked, if all scientists have the same data, why do they have different ideas about how dinosaurs died, some answers were as follows:

- because they have different kinds of minds (N, Rachel’s class).
- they have diferent epenyens (Pr, Rachel’s class).
- Because they have diferent opinions (P, Rachel’s class).

Several students understood that scientists are individuals with individual thoughts while others did not understand this difference and suggested their differences were because some scientists were “right” and others were “wrong.” According to the students’ VNOS assessments, students in Rachel’s class had a slightly better understanding of creativity and imagination than the other NOS concepts.

**Books Chosen by Rachel**

Rachel read two books to her students, *Storm Chaser: Into the Eye of a Hurricane* by Keith Elliot Greenburg (1998) and *A River Ran Wild: An Environmental History* by Lynne Cherry (1992). *Storm Chaser* (Greenburg, 1998) was a book about a pilot, Brian Taggart, who used a hurricane tracking system run by the National Oceanic and Atmospheric Administration (NOAA). The book followed Brian and a group of scientists as they flew into a hurricane and collected data. Hedges were used to describe how hurricanes affect data collection and the characteristics of hurricanes: “Because hurricanes often rock the plane, the scientists are strapped into their work stations” (p. 20). “This area [eye of the storm], usually
between 2 and 20 miles wide, is often marked by clear, blue sky. The feeder bands that surround the eye of the storm can be dangerous” (p. 23). “Winds in the eye will frequently blow at more than 100 miles per hour” (p. 25). “The strength of the weather can vary from one feeder band to another” (p. 25). “Though there are band of dangerous weather swirling around the storm’s center, the ‘eye’ is often perfectly calm” (p. 22).

Such hedges showed that the science of hurricanes is not always precise. How hurricanes look, their speed, what the eye of the storm could look like, and the devastation they can potentially cause are not standard for every hurricane. Without having to explain this variation, hedging allowed the reader to see that the facts given were tentative; that is, they were uncertain.

The idea that science is a human endeavor was a major theme that emerged from Storm Chasers (Greenburg, 1998). People “doing” science or directly being affected by science was a main idea presented in this book. The reader learned about Brian’s schooling and his training to become a pilot for NOAA:

After high school, Brian attended the Florida Institute of Technology. There he continued with his aviation training. He also studied math and science, which were required for all aviation students. “Knowing these subjects makes you a better pilot” Brian says. “If you take an airplane off the ground, you have to respect the laws of nature. Without math and science, you can’t really understand the laws of nature. (p. 13)
The idea that science is an empirical process—that is, it demands evidence—was evident in this book in the pictures and descriptions of data collection. The book described activities being conducted by scientists, who either gathered evidence or analyzed data. Two pictures were of scientists in front of computers and screens collecting data. The caption stated, “Scientists aboard the P-3 [the airplane] use computers and other machines to record data on the weather” (p. 8). It also stated,

Once the pilot reaches the center of the storm, the scientists on board can tell how fast the disturbance is moving, and in what direction. Because hurricanes often rock the plane, the scientists are strapped in to their work stations. They must wear headsets to communicate with each other. (p. 20)
Science was shown as a way to explain or describe phenomena, and readers were able to see how actual data are gathered. This transparency gave the students the ability to scrutinize and evaluate practices. The data collection piece of the scientific investigation was evident and did not remain mysterious. The reader could see the pictures and read the descriptions of what scientists and pilots were doing. The book also showed the sense of community in science among those collecting data and how having this knowledge can help protect members of society:

Brian’s 18-seat plane also carries several scientists. The data they collect during the flights may help save lives. “The whole thrust of hurricane research is predicting where a storm is going to hit,” explains Jeff Hagan, an NOAA pilot and spokesperson. “When you have that information, you can evacuate people if they are in danger.” (p. 8)

The data and information about hurricanes were presented in the book beyond the “factoids.” In other words, the information about how hurricanes formed was shown to the reader, thereby personalizing science. The data did not simply appear in a textbook, but how the data were gathered was explained.

In Storm Chasers (Greenberg, 1998), technology was shown as being helpful to scientists, allowing them to collect data. The book indicated that satellites help scientists learn how fast and in what direction a hurricane is moving. Other technology was also described to show how it helps scientists do their work:

An important piece of equipment is the “radome”—or radar dome—which is connected to the underside of the plane. Another radome is placed on the tail, and another on the nose. The radar helps the scientists figure out the strength of the storm. It also helps the pilot find patches of sky where the rain is less severe. It is through these patches that Brian tries to fly, as he guides his plane to the center of the storm. (p. 20)

Again, the symbiosis between technology and science was shown in this text because the scientists were relying on hurricane technology to collect data for their
The book presented technology as being an integral part of science and, like science, it required imagination. The technologies presented in the book were described as creative solutions or advancements for society. Therefore, there was a slight connection illustrated between science and technology.

Additionally, in *Storm Chasers* (Greenberg, 1998), science was shown as useful in helping keep society safe:

It’s during these times [helping homes wrecked by hurricanes] that Brian realizes the true importance of his job. ‘It’s not easy flying through hurricanes,’ he says. ‘But when you’re back on the ground, with your plane and crew safe, you think about how the information you collected is going to help people, and maybe save some lives. That when you feel satisfied.’” (p. 31)

The scientific data being collected by the scientists aboard the plane help provide society with hurricane information, allowing them to better protect themselves from hurricane disaster.

The other book Rachel read, *A River Ran Wild* (Cherry, 1992), was a story of restoration and renewal of a river in New Hampshire, following the river’s history with settlers, descendents, and pollution. Hedges were also present in this book:

“The paper mills continued to pollute the Nashua’s waters. Every day for many decades pulp was dumped into the Nashua, and as the pulp clogged up the river, it began to run more slowly” (p. 17). “Many new machines were invented. Some spun thread from wool and cotton. Others wove the thread into cloth. Some machines turned wood to pulp, and others made the pulp into paper” (p. 13).

The story also presented the notion that change was taking place: “These were times of much excitement, times of ‘progress’ and ‘invention.’ Factories along the Nashua River made new things of new materials” (p. 20). The book continued to
explain how this time of progress and invention was exciting, yet plastics and chemicals were continuously dumped into the river, so “Nashua’s fish and wildlife grew sick from this pollution” (p. 20), and “[t]he Nashua was slowly dying” (p. 21).

Thus, the book also showed the negative effect of technology and its effect on society:

At the start of the new century, an industrial revolution came to the Nashua’s banks and waters. Many new machines were invented. Some spun thread from wool and cotton. Others wove the thread into cloth. Some machines turned wood to pulp, and others made the pulp into paper. Leftover pulp and dye and fiber was dumped into the Nashua River, whose swiftly flowing current washed away the waste. (p. 13)

Doing so allowed the reader to see clearly science and technology’s effect on society.

The book also illustrated examples of how society can affect science. In the story, the Nashua River became highly polluted because of the factories and industries near it. The book then explained the human action:

People listened and imagined a sparkling river, full of fish. They imagined pebbles shining up through the clear waters. They signed petitions and sent letters. They protested to politicians and showed them jars of dirty water. They convinced the paper mills to build a plant to process the waste. They persuaded the factories to stop dumping. Finally, new laws were passed and the factories stopped polluting. (p. 21)

This book showed students that science can be a highly social activity influenced by culture and personal beliefs.
How the NOS Views Shaped the Read-Aloud Experience

In the second read-aloud, Rachel read *Storm Chaser* (Greenburg, 1998) and started asking students what they know about hurricanes. She briefly explained the book before reading and said:

Rachel: What this is about is, is this man, this scientist flies his plane into hurricanes to get data. To get really important data, you know, temperature data, precipitation data, all that stuff.

Students: [inaudible]

Rachel: These are all great questions that will hopefully be answered in the book. So he flies a plane, he’s a very very good pilot, he’s very talented, he flies into the hurricane and gets data for us, so we can better . . . [students talking] so we can understand these storms better.
The local people that lived near the Nashua demanded that the paper mill process the waste instead of dumping waste into the river, thus demonstrating that society could influence the direction of science. The wants and needs of society also guide the direction of science and technology.

Figure 4.6. Protestors in A River Runs Wild.

Rachel held informed views of the empirical nature of science and mixed and informed views of the methods of investigation aspect. Therefore, it is not surprising that, even before she started reading the book, she focused her discussion on how the scientist in the book flew into the storm to collect data (breaking the stereotype that scientists collect their data in the laboratory). *Storm Chaser* (Greenburg, 1998) also showed a high presence of data collection and the empirical nature of science. It is interesting that, while students did not hold informed views about these aspects, their
presence in the book and the teacher’s developed views helped lead to the discussion about how scientists collect data:

Rachel: And that’s a picture, “it says the cockpit of a NOAA [National Oceanic and Atmospheric Administration] plane, contains many special devices for recording and analyzing the storm”. Ok, so it’s a very special plane, it has many different instruments on it

Student 1: Instruments?

Student 2: Not instruments like that.

Rachel: Not musical instruments, but scientific instruments

Student 2: Scientific instruments, like measuring devices, like measuring temperature and . . .

Rachel: Maybe that was a better word I should have used, I like that measuring devices

Again, Rachel focused her discussion on the picture with the caption describing the devices used for data collection. These actions are evidence that the teacher really was an agent in deciding the extent to which the discussion about the NOS would occur. Both books had a range of NOS topics present, and Rachel was able to expand the discussion surrounding them because of her informed views of the NOS. Students lacked many NOS understandings, but Rachel was able to use the books as background for furthering their understanding of the essence of science.

Rachel also read *A River Ran Wild: An Environmental History* (Cherry, 1992). There were several instances during the read-aloud that touched on the sociocultural aspect of science. In one illustration, Rachel read about the Nashua people who lived near the river and how they used the resources of the land and river to provide themselves with necessities, including killing animals to eat and keep warm and how they asked the forest creatures to “forgive them.” The following discussion ensued:
Student 1: How could they make someone forgive them for killing them?

Rachel: They were just being very spiritual about it.

Student 1: Yeah but I don’t agree; how are you supposed to convince an actual person to forgive you when you actually kill them?

[Other students start talking]

Rachel: Boys and girls, listen. They killed the animals because they needed them. They needed to eat, they needed their fur to stay warm. They needed the animals they didn’t have a grocery store to go to . . . so they were very grateful that these animals gave up their lives. So that’s what they mean that they thanked the animals: they were thankful the animals sacrificed their lives so that they could eat and have clothing.

At the end of the book, Rachel asked the students what they learned in the book and how it was connected to their class. One student answered that pollution can hurt animals, and another student mentioned they had a debate about pollution and factories.

Rachel also asked the students about what the water was like before the people settled there, what it looked like after, and why the settlers needed the water. Students said the people needed drinking water and a place to put their garbage. The people saw its beauty, and they could make some money from it. Rachel concluded the discussion:

Rachel: So my last question for you guys, so this book was about how we affected the environment many many years ago?

Student 1: Is this a true story?

Rachel: Yes, this a true story. Raise your hand and tell me why you think or don’t think we’re polluting the environment.

Student 2: I think it’s both

Student 3: Probably sort of polluting
These exchanges illustrated that Rachel did acknowledge and briefly discussed the sociocultural issues that surrounded the pollution of the river.

Rachel’s NOS views of sociocultural issues were mixed (Table 4.3), her students were not asked about this aspect of science (it not being on the student VNOS), but this book showed a high presence of sociocultural issues. Although the book presented many sociocultural issues, the discussion was not very lengthy or in depth. Rachel asked a few questions about how people were polluting the environment and why the river was polluted. The lack of a more extensive conversation about pollution and other sociocultural issues involving the river may be because of Rachel’s mixed views, however the book aided the discussion because it presented some explicit connections to the NOS. As the read-aloud of *Storm Chasers* (Greenberg, 1998) showed, when Rachel had informed views on a NOS aspect and a book presented much of one NOS aspect, the discussion went into more depth. This finding may be because of Rachel’s background in science, her more developed views of the NOS, both books’ demonstration of NOS aspects, or a combination of these.

**Classroom 4**

**Emily’s Case**

Classroom 4 was a third-grade classroom in a small private school in an urban area of upstate New York. The teacher, Emily, completed her undergraduate work in elementary education and English and her graduate work in literacy. Emily said she loved teaching science because of the many hands-on experience opportunities and she liked reading and writing. She said she enjoyed making connections between
science and ELA, such as learning to make comparisons and doing activities like read-alouds.

Emily said they used read-alouds for every single subject and had a “pleasure read-aloud” as well. She stated she enjoyed reading aloud to her students and the same types of skills were used in all read-alouds, regardless of subject, such as listening skills and asking thoughtful questions. When reading books to her students, Emily tried not to select books that had very difficult vocabulary and looked for books with nice pictures that could help illustrate the concepts. In describing her class, Emily said there were a few different minority students but it was largely White. She stated, in general, her students were very conscientious; that is, they liked to take care of each other and wanted to help each other, and most students in the class were above grade-level in reading. The following subsections describe Emily and her students’ understandings of the NOS and explore the ways in which the NOS was negotiated during the two read-aloud sessions that took place in Emily’s class.

**Emily and Science**

Emily, like most teachers in the study, held naïve views about science, viewing science as absolute or about proving something to be true; her VNOS scorings are shown in Table 4.4. Emily stated, “Scientific disciplines have theories that are proven or disproven. Religion or philosophy’s theories aren’t absolute” (Emily, VNOS, 3/6/12). Also like the other teachers in the study, Emily held naïve views about the distinction between scientific theory and scientific law. For example, Emily stated, “A scientific theory is an idea that has not been proven or disproven because of insignificant evidence. A scientific law has been proven and stood the test
of time” (Emily, VNOS, 3/6/12). Emily did, however, hold informed views of other aspects of science. Although, in response to other questions, she focused on the idea of science being proven or disproven, when asked about the structure of the atom, she stated, “Scientists are relatively certain about an atom’s structure. They have used experiments and microscopes to support their findings. They haven’t actually seen one” (Emily, VNOS, 3/6/12). Later, when asked why scientists come to different conclusions with the same set of data, Emily answered that part of the reason is because of individual scientists’ beliefs and that “there are grey areas” (Emily, VNOS, 3/6/12). She also was informed about sociocultural values affecting science; when asked whether society affects science, she replied, “It certainly does” (Emily, VNOS, 3/6/12).

Emily also held mixed views of many of the NOS concepts on the VNOS. Emily held mixed views about the tentative nature of science as shown in one of her answers: “Science is a changing field filled with trial and error and temporary yet strong solutions to some problems/questions” (Emily, VNOS, 3/6/12). She focused on the idea that science changes because of new information, where an informed answer would also describe the reanalysis of old data. Emily hinted at creativity being used in analyzing the data but did not explain what she meant. She wrote, “They use [creativity and imagination] during planning and design and after collection. They need to be able to draw conclusions” (Emily, VNOS, 3/6/12). Of the NOS topics Emily responded to on the VNOS, Emily had the best understanding of the sociocultural effect on science.
Students’ Understanding of the NOS

As a whole class, the students in Emily’s class held mixed views of all the NOS aspects (Table 4.4). There were, however, some answers that helped give some insight into students’ understandings of the NOS. A few students (n = 4, 11 students answered this total) understood the tentative nature of science, and when asked whether they thought what scientists know will change in the future, they answered, “Yes because they did it in the past,” and “I believe so because a long time ago they thought there was no cure for scarlet fever.” Several students also acknowledged that scientists have their own views and that not all knowledge is “factual.” One student wrote, “The facts that they have don’t exactly tell how dinosaurs grew extinct.”

Table 4.4

NOS Views and Portrayals in Emily’s Class

<table>
<thead>
<tr>
<th>NOS theme</th>
<th>Teacher views</th>
<th>Student views</th>
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<td>None</td>
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<td>Informed</td>
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<td>None</td>
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<sup>a</sup> Views from VNOS answers.
Another trend that appeared in this class as it did in other cases was the idea of creativity and imagination being “fake” in science. When students were asked whether they thought scientists use their imaginations when doing work, many students related imagination and creativity to being “fake” and, therefore, should not be used:

“They use facts not there imaginations” (B, Emily’s class).

“Scientists do not use their imaginations because they are doing real things” (G, Emily’s class).

“[No] Because scientists do real thing and because sciences is non-fiction” (F, Emily’s class).

[No] Because if scientics use there imaganations people wacting a history chanel and weather chanel would laught” (N, Emily’s class).

A few students did acknowledge scientists’ use of imagination in their work:

“Because if they see new objects they won’t know what it is or does so they need to use there imagination to guess what it is or does” (Z, Emily’s class).

“When they do scienice experaments they might use there imaginations” (I, Emily’s class).

“I think they use their imaginations because if they find an object that looks strange, they use their imaginations to figure out what they do” (A, Emily’s class).

As with previously discussed cases, students associated imagination and creativity with being fake and not “realistic.” Students understood those terms (imagination and creativity) to mean the facts are not real but make-believe, as opposed to a few students who understood that imagination and creativity had to do with the thinking and analyzing processes used in science (for this question, n = 4 for students who scored ‘naïve’, n = 7 for students who scored ‘mixed’, no students scored ‘informed’).
Books Chosen by Emily

The first book Emily read aloud to her students was about animals: *How Many Ways Can You Catch A Fly?*, by Robert Jenkins and Robin Page (2008). The book was primarily filled with facts about different kinds of animals and did not express many NOS qualities. Although there were no humans in it, the book did have appealing illustrations and showed the creativity of animals—such as adaptations they have made to eat and protect themselves. The other read-aloud was about pulleys and simple machines. Emily read two books *What are Pulleys* by Helen Frost (2001) and *Simple Machines: Pulleys* by Kay Manolis (2010), as well as a small part of a third book *Mighty Machines* by Shar Levine and Leslie Johnstone (2006). *What are Pulleys* (Frost, 2001) is a small, basic book, filled with pictures of pulleys and short facts about pulleys. *Simple Machines: Pulleys* (Manolis, 2010) was also filled with pictures and showed how pulleys are used (Figure 4.7). Because these first two books had no NOS aspects, the third book was focused on in this study because of the minimal presence of the NOS and because Emily was the only teacher to read multiple books in one read-aloud session.
Emily read only two pages on pulleys in *Mighty Machines* (Levine and Johnstone, 2006), which included a short description of how pulleys were invented. Although the book did not go into details about Archimedes’ research of pulleys, it did indicate historians believe a different, lesser known scientist, Archytas, discovered the pulley along with some other items, such as a screw and baby rattle. This information showed a small amount of human creativity in science. While the
creativity aspect was not explicit, the idea that someone invented or created the pulley was implied when the origins of the pulley were highlighted (as opposed to not giving any background or context for the pulley). In addition, there was another implication of technology. Although the word technology was never used to describe the pulleys, they were discussed in terms of being a simple machine. The assumption that they are a piece of technology was evident. In this case, the connection between science and technology was implied. Science is used to help create simple technology to help people. Technology is not listed on the table for the examination of trade books but is described in the broad definition of the NOS in Chapter 1.

The Views of the NOS and the Read-Aloud Experience Relationship

While the students sat on the floor, Emily first read How Many Ways Can You Catch A Fly? (Jenkins & Page, 2008). As shown in Table 4.4, there were no instances of the NOS represented in the book. In addition, both the teacher’s and students’ views of the NOS were generally naïve and mixed (very few informed views). Therefore, it is not surprising that no discussion involved NOS concepts during this first read-aloud. A few students did ask questions about the animals, and Emily did ask students questions about animals’ adaptive abilities. Although this book was lacking NOS concepts, it should be noted that teachers do select trade books to read that do not have any NOS qualities in them.

The second read-aloud involved several small books: What are Pulleys (Frost, 2001), Simple Machines Pulleys (Manolis, 2010), and a small part of a third book, Mighty Machines (Levine and Johnstone, 2006). There were no instances of referring to scientific creativity or scientists using creativity, but there was a significant
instance in which one student made a connection from the reading about pulleys to something she created at home:

Student: The levers just reminded me, I have something at my house, I made it, it’s from my bed to my radio, my animals can go on it, and to pull them back up, you have a different rope that connects to the objects that go up.

Emily: So do you have a lever or pulley?

Student: Pulley

It is not clear exactly what the student was talking about, and the book reading continued immediately after the comment. Although the comment was slightly connected to creativity in NOS concepts, because both Emily and the students did not hold informed views on creativity, it is not surprising that there was no further discussion on the creativity of using or creating pulleys.

Besides this one interaction, the read-aloud discussion was focused on the facts about pulleys and information related to English language arts. This one interaction also illustrated the main questioning type, that is, closed-ended questioning Emily used when reading to her students. None of the books Emily read to her students had many NOS aspects present. Additionally, like Carey, many of Emily’s questions were closed-ended because she looked for one specific answer from her students. The questioning style, selected books, and VNOS answers suggested the lack of NOS awareness by the teacher. Also like Carey, Emily used these read-alouds as a tool to teach facts and give general knowledge to her students, with very little discussion related to the NOS. Again, this is not surprising because Emily’s VNOS indicated she held largely naïve NOS views. This fact, in addition to the book lacking the NOS, did not give students an opportunity to explore NOS issues. This lack was evidenced in the ticket-out-the-door activity:
I liked it [pulleys] because it can help you move things. Can people go on pulleys? (R, Emily’s class).

I liked the book because it really explained how pulleys work. I wish is told you who invented the pulley (C, Emily’s class).

I liked the book. How do people use pulleys? (B, Emily’s class).

From these ticket-out-the-door comments, it is evident that students learned about pulleys at one level but wanted to learn more about them, including their connections to the NOS. The comments and questions discussed above all focus on the connection of pulleys in society: How do they work? How can people use pulleys? Even though Emily held more informed views in the sociocultural aspect of the NOS, she held largely naïve and mixed views on the NOS overall. In addition, she used a book with almost no references to or depictions of NOS in it; therefore, she apparently did not see the need or connection to discuss pulleys in society. A book with no reference to NOS in it or only implied NOS aspects in it may not be enough to trigger significant discussions. It is also interesting to note that the books Emily used had very few or no hedges in them, failing to show the tentativeness in science. Unlike Matthew, Emily did not compensate for this lack during her discussion because she rarely used hedges.

Classroom 5

Mallory’s Case

Mallory taught in Classroom 5, a third-grade class at a rural school in upstate New York. Mallory had 3 years of teaching experience, all at the elementary level. Her undergraduate degree was in special education in Grades 1-6, and her graduate degree was in literacy. Mallory stated she usually had students fill out a graphic organizer or a KWL (know, want to know, learned) during a read-aloud discussion.
She also said she liked students to take notes during the read-aloud using “seven keys to comprehension type activities” (Mallory Survey, 2/1/12). She described the seven key strategies to be building background, visualizing, inferring, making connections, determining importance, asking questions, and using fix-up strategies. Mallory stated she liked to read to her students to give “background knowledge or more facts on a topic or to give a varying opinion” (Mallory Survey, 2/1/12). She said she worked science into her reading lessons in addition to hands-on experiments. She also added that her new principal was very interested in science and she felt supported by her school to combine literacy with science.

**Mallory and Science**

Mallory held largely mixed with some naïve views of the nature of science (Table 4.5). She stated, “Science is different than other inquiry disciplines because (for the most part) science is based off of facts and things that can be proven” (Mallory VNOS, 3/5/12). Another question that asked whether sociocultural issues affect science brought a similar response from Mallory, who stated, “While people may have different beliefs, science can be proven to be true” (Mallory VNOS, 3/5/12). From her answers, Mallory seemed to hold to the naïve idea that science can always be proven, that regardless of who is doing the science or what people’s opinions are, science will always be based on objective data taken as fact. She saw science as tentative only to a certain point when she wrote, “Scientific theory is what is thought to be true based on the evidence of the scientists have at the time. Scientific law is when all possible evidence has been gathered and no other theories are possible” (Mallory VNOS, 3/5/12).
Mallory also expressed some conflicting views because she wrote, “Both groups [of scientists] can use the same data but be able to interpret them differently,” a statement that seemed to conflict with her idea that science can be proven to be true. She showed more conflicting views when she stated, “Data can be skewed to fit the purpose it is being used for” and “Science is universal, we know different aspects of science to be facts and it can not be argued” (Mallory VNOS, 3/5/12). There seemed to be some conflict in these statements because Mallory viewed science both as being facts that can be proven and as having some room for interpretation and manipulation.

Mallory’s views illustrated many other views represented in the study; that is,
scientists are people with different opinions and ideas, but ultimately, there are facts that are “proven” to be true.

**Students’ Understanding of the NOS**

The whole class in Classroom 5 held largely naïve views on the NOS (Table 4.5). One question asked what science is, and several students replied,

- Exspieramenti facts and learning (N, Mallory’s class).
- Idets pelpdl have about things and test it (A, Mallory’s class).
- In science you test things (A, Mallory’s class).

Most students had the idea that science was about “testing” things and that it related to facts. Like the other cases, most students held the idea that thinking or doing work in science cannot include creativity or imagination (all students scored ‘naïve’ or ‘mixed’, no students scored ‘informed’). The last question on the student VNOS asked whether students think scientists use their imagination and asked them to explain their answers. Many students answered:

- [No] I thik they wold want to be ture and be right (Q, Mallory’s class).
- [No] because they use fackts (O, Mallory’s class).
- [No] Becouse they can’t make up things (T, Mallory’s class).
- [No] they are smart they dont use there Imagination (N, Mallory’s class).

Only one student seemed to understand the idea that scientists are individuals and think differently and use imaginations. To the same question, she answered, “[Yes] I think it is this because they are not always sure.” She also answered that weather people are not sure about the weather predictions they present on television because “they are not always sure.”
When asked why scientists have different opinions about how dinosaurs died (even though they have the same set of facts), she answered, “Because there different from each other.” This student seemed to be an exception to the class as a whole though. The word *imagination* was considered by most students to mean being fake or made up, instead of thinking of it as being closely related to creativity.

**Books Chosen by Mallory**

Mallory read two books to her students: *Water: A Resource Our World Depends On* by Ian Graham (2005) and *Bartholomew and the Oobleck* by Dr. Seuss (1976). The first book, *Water* (Graham, 2005), had very few personal pronouns but was filled with “factoids” about science, leaving the reader as an “outsider” to science:

Ice floats on water because water behaves differently than most substances. Most liquid substances shrink as they cool down and become solid. These solid pieces are heavier than the liquid and so they sink. Water is different. Just before it freezes, it expands and becomes lighter, so it floats. If water inside a pipe freezes, it can burst the pipe. (p., X)

However, the book did mention engineers creating the water wheel, water being used in astronauts’ suits, firefighters using water, and people drinking water and sweating it from their bodies and included some pictures for these examples (Figure 4.8). Therefore, although the book did not include personal pronouns to help students feel included in science, the human endeavor was illustrated in the book by showing people who helped create and investigate science (in this case, engineers and astronauts).

*Water* (Graham, 2004) did not highlight the creative nature of science but did describe the many ways water is used in the world. For example, the book showed and described water being used for washing, heating, fighting fires, and irrigating
crops, as well as in its role as an energy source and in space suits. In a sense, these examples illustrated the creative ways water is used in society, but like other books in this study, the creative element was implicit and not specifically highlighted. The book did make a connection to society and culture because it showed water being used to help improve society:

People have used waterwheels for about 3000 years. They were mainly used to turn millstones that ground corn into flour for making bread. Today we used water to make electricity. Engineers use water rushing through a pipe to spin a turbine. The turbine drives a generator, a machine that makes electricity. (p. 8)

![Image of firefighters and crops]

*Figure 4.8. People in the book Water.*

Science was shown as creation and improvement of technology. Additionally, the book illustrated how science evolves over time through technology. Water was first used to create a waterwheel, and now water is used to create electricity. The
book showed that society makes progress and advances through science and
technology functioning together and guiding each other. The book also showed the
connection between society and technology when it explained how the astronauts’
space suits keep cool:

   It is very hard for an astronaut wearing a space suit to keep cool. When an
astronaut gets hot and sweats, the sweat is trapped inside the suit. . . .
Astronauts keep cool in a different way. Inside their space suits, astronauts
wear tight-fitting vest and pants with 300 feet of plastic tubes sewn into them.
Water is pumped through the tubes. (p. 9)

Furthermore, in Water (Graham, 2004), society was described as building
dams and using water to irrigate crops and heat homes. These examples showed that
science is embedded within society and that science is done to improve the society
surrounding it. Science is done within a context of society or culture that helps direct
the path of future scientific investigations.

The book expressed tentativeness in science through hedges used to express
some vagueness about water: “It [water] is usually found in liquid form, but it can
also be a solid or gas” (p. 4). “Ice floats on water because water behaves differently
than most substances” (p. 5). “Most substances shrink as they cool and become a
solid” (p. 5). “It [water] also dissolves, or breaks down, some substances. Water and
grease do not mix, but hot water can melt grease and it can be washed away” (p. 6).
“When you feel hot, glands in your skin produce sweat, which is mostly water” (p. 7).
“People have used waterwheels for about 3,000 years. They were mainly used to turn
millstones that ground corn into flour for making bread” (p. 8). “Most plants and
animals are made from tiny cells that contain water” (p. 11).

Although there were descriptions of water in the book, some vagueness was
expressed through the use of hedges. Water was described as how it usually is, how it
typically acts, and how it behaves compared to other substances. There was a lack of preciseness in the details about water. Without having to go deeply into the uncertainty that exists in science, hedges allow for information to be passed while open or subject to change.

The other book Mallory read was *Bartholomew and the Oobleck* (Dr. Seuss, 1949). The book is commonly read to elementary students along with making “oobleck” (a gooey mixture of cornstarch and water used to teach about Newtonian and non-Newtonian fluids). The book is a fiction book about a king and his pageboy, Bartholomew. The king grows tired of the same types of weather and asks his magicians to make something new fall from the sky. When oobleck eventually does fall, the king’s wish backfires because the oobleck starts to destroy the kingdom (Figure 4.9). Although the book was fiction, the book hinted at the empirical nature of science by showing the unpredictable nature of science. While no “data collection” was shown, the book did show that, when doing science, scientists do not always know what will happen or what will be the result. The book showed both the human aspect and empirical nature of science. The book may arguably show the changing views of science. At first, the King wished for something like oobleck to exist in his kingdom. When it first appeared, everyone initially liked it. They then realized it was not good for their world and tried to get rid of it. (This story could be analogous to initial excitement over new technology followed by the detrimental effects that may unexpectedly cause.)
How the Views of the NOS Shaped the Read-Aloud Experience

While sitting on the floor with notebooks in hand, students sat and listened to Mallory read both read-alouds. The first book she read, *Water* (Graham, 2004), primarily contained facts, and therefore, it was not surprising that many of the discussions that took place during the read-aloud were about water facts. A few times Mallory asked the students whether they had ever seen things like condensation on glass or what elements make up water. The only presence of the NOS in the discussion was brief exchanges between Mallory and students about the way water affects society, such as how water is used to irrigate crops and to heat homes, how the class used water to grow plants, and how water is used in the dam to create electricity.

Mallory: How does water help us do work?
[Students raise hands, asking to be called on]

[Mallory motions to put their hands down and continues reading]

Mallory read the book questions aloud but tended to continue to read the book, answering the questions or sharing her own views. The teacher, leaving little room for students to share their own ideas, led most of the exchanges. In this case, even with the book illustrating the sociocultural embeddedness of science, the teacher did not hold informed views on sociocultural aspects in science, and the discussions were very short and insignificant. The students were not tested on the sociocultural aspect on the student VNOS.

While reading *Bartholomew and the Oobleck* (Seuss, 1949), Mallory periodically stopped to ask students whether they had questions about the story. In one instance, a student raised her hand:

**Mallory:** Any questions, connections or scientific ideas?

**Student:** Why is now the king not wanting the oobleck?

**Mallory:** So he asked for it, but why is he not wanting it now? Can you kind of answer that question?

**Student:** Because it’s like glue.

**Mallory:** Okay.

This exchange did not go further to discuss how views in science can change, but it is not surprising because Mallory held largely naïve and mixed views of all the NOS aspects. The book illustrated some of the empirical nature of science (Table 4.5) because it presented the notion of unexpected results and how changes have to be made. Mallory held naïve views on the empirical nature of science; the students held mixed views, and the book had a moderate presence of the empirical nature of
science. Therefore, it is not surprising to see that when the first book showed this aspect and a student asked a question related to this empirical nature, Mallory did not elaborate on the idea. Even when the book showed NOS aspects in it, discussion of the idea of getting unexpected results in science was never raised, seemingly because of the limits Mallory set. A student attempted to highlight this idea, but the teacher did not hold more developed views of the same NOS concepts and, therefore, the discussion halted. The ticket-out-the-door activity for this case focused largely on facts and did not connect to any NOS aspects:

I learned that a thing can be a solid and a liklwid (T, Mallory’s class).

that thing can both be a solid and a lickwid (A, Mallory’s class).

That any kind of, some sort of slime. Can be a solid AND a liquid at the same time! (S, Mallory’s class).

That Oobleck is a solid and a licquid. I liked it because it was scientific (O, Mallory’s class).

In the book about water, it was evident that students wanted to know more about water and its connection to society. The ticket-out-the-door questions from this read-aloud showed students understood they learned facts but wanted to make connections to the NOS:

Why is water so inportin? It [the book] has facts about the earth (N, Mallory’s class).

Why does rain sometimes taste like salt water (K, Mallory’s class).

It [the book] tate me alot oubot new factis about water (K2, Mallory’s class).

How Do you get electrisidy from water? (O, Mallory’s class).

Questions from students focused on the significance of water in society and its connection to the students’ world, yet the discussions during the read-alouds largely focused on the facts about water. This case helped to show that, when the teacher is
lacking in NOS understandings, the discussions on the NOS will not significantly develop, even when the read-aloud book presents the NOS.

**Classroom 6**

**Vanessa’s Case**

Classroom 6 was very similar to Classroom 5: Both were third-grade classrooms in the same school. Classroom 6 was taught by Vanessa, a third-grade teacher with 5 years of teaching experience. Vanessa studied elementary education for her undergraduate degree, and in graduate school, she studied literacy for Grades K-6. While an undergraduate student, Vanessa took several science courses, including Biology 1, Biology 2, Botany, and a class called *Teaching Science to Children Through Inquiry* (Vanessa Survey, 3/1/12). She stated she really enjoyed math and science classes the most throughout her education.

Vanessa used read-alouds for the beginning of a lesson or sometimes during the middle of a unit so students could investigate what they learned in the read-aloud. She stated she liked to ask open-ended questions of students during the read-aloud, such as “Why do you think . . . ?” and “How does this happen?” She watches students during inquiry experiments to see who is implementing information from the books they read aloud together. She stated she liked doing read-alouds because, on a large part of the state tests, students must listen to a story read aloud, take notes, and answer questions. She said she enjoyed reading to her students aloud because they were very engaged (Vanessa Interview, 3/8/12).
Vanessa and Science

Vanessa held some informed views of science as well as some naïve views. When asked what science is, Vanessa replied, “Science is the study of the things around us. Science is different from religion + philosophy because you can experiment and investigate the things around us”. When asked whether scientists’ theories ever change and why, Vanessa wrote, “Yes! It can if they find a new discovery. Scientist keep studying the topic and they find out new things to change their theories” (Vanessa VNOS, 3/1/12). However, like other teachers in the study, Vanessa also mentioned proving things to be true when she answered some questions on the VNOS. When asked whether she thought science is universal, to defend her answer, Vanessa wrote, “I believe this is because so many things around us are definite and can be proven or investigated through experiments. Ex: Universal-A rock will sink in water” (Vanessa VNOS, 3/1/12). This was scored naïve on the VNOS because the question asked about science being infused with sociocultural views and Vanessa replied, “I think different science theories do, such as evolution some people don’t believe in it because its not what their religion says about how we were created” (Vanessa VNOS, 3/1/12). She seemed to state that she thought science is universal because of what she first stated but then also seemed confused because of her statement about religion and evolution.

Vanessa also scored naïve on the question that asked about scientists’ certainty of what the atom looks like. She wrote, “They are certain as they have used the way electricity and magnetism work to identify how they all work” (Vanessa VNOS, 3/1/12). The next question asked the difference between theory and law, and
Vanessa answered, “A law is definite where a theory might not be true.” Both answers included the idea of certainty, whereas science is actually tentative.

Table 4.6

<table>
<thead>
<tr>
<th>NOS theme</th>
<th>Teacher views</th>
<th>Student views</th>
<th>Book 1(^a)</th>
<th>Book 2(^b)</th>
<th>Present in discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Empirical</td>
<td>Informed</td>
<td>Naïve</td>
<td>Very little</td>
<td>Present</td>
<td>Book 2: Very little</td>
</tr>
<tr>
<td>Observation</td>
<td>Mixed</td>
<td>Naïve</td>
<td>Very little</td>
<td>Very little</td>
<td>Book 2: Very little</td>
</tr>
<tr>
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<td>Mixed</td>
<td>Mixed</td>
<td>None</td>
<td>Present</td>
<td>None</td>
</tr>
<tr>
<td>Methods of investigation</td>
<td>Mixed/naïve</td>
<td>Naïve</td>
<td>None</td>
<td>Present</td>
<td>None</td>
</tr>
<tr>
<td>Human imagination/creativity</td>
<td>Mixed</td>
<td>Naïve</td>
<td>Very little</td>
<td>Present</td>
<td>Book 2: Very little</td>
</tr>
<tr>
<td>Theory driven and theory/law</td>
<td>Naïve</td>
<td>N/A</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Tentativeness</td>
<td>Informed</td>
<td>Naïve</td>
<td>Very little</td>
<td>Present</td>
<td>Book 2: Briefly</td>
</tr>
<tr>
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<td>Naïve</td>
<td>N/A</td>
<td>Present</td>
<td>Present</td>
<td>Book 2: Present</td>
</tr>
</tbody>
</table>

*Note. Views from VNOS answers.*

\(^a\)The Magic School Bus (Cole, 1997).

\(^b\)A Wizard From the Start (Brown, 2010).

**Students’ Understanding of the NOS**

For the most part, Vanessa’s students held largely naïve views of the NOS aspects. When asked what science was, one student drew a scientist saying, “At last,” and a man with a humpback saying, “It’s alive,” and a creature/monster saying, “Rah.” Another student said what scientists know will not change the future; she wrote, “No well you can perdicet the future but realy you never know what hapen.”
Although a few students did seem to hold slightly developed views of the NOS, many students’ answers were scored naïve. As seen in the other cases, many students associated imagination with “making up knowledge” or even lying. When asked whether scientists use their imaginations, answers included the following:

[No] Because they do research (K, Vanessa’s class).
[No] Cause there all about knowing the right thing (L, Vanessa’s class).
[No] No Because they have to be sure to tell the tureth (M2, Vanessa’s class).
[No] they hafto really think no imagen (I, Vanessa’s class).
[No] They should think about there work (M, Vanessa’s class).
[No] Because they wouldn’t say that there was a meteor when they are fibbing (S, Vanessa’s class).

Students held the idea that using one’s imagination is not real, and there is only room for “real” things in science (11 students scored ‘naïve’, 6 students scored ‘mixed’ and only 1 student scored ‘informed). The understanding of imagination in science, to many students, was that scientists who imagine falsify information, as though they are “cheating.”

**Books Chosen by Vanessa**

Vanessa read two books to her students: *The Magic School Bus and the Electric Field Trip* by Joanna Cole (1997) and *A Wizard From the Start: The Incredible Boyhood and Amazing Inventions of Thomas Edison* by Don Brown (2010). In *The Magic School Bus* (Cole, 1997), students went with their teacher, Ms. Frizzle, to a power plant to learn how electricity is formed. Although that field trip was the main part of the book, there were a lot of side cartoons with descriptions, such as how magnetic poles work, what atoms are made of, how motors work, and so
forth. In one of the side cartoons, alternative sources of energy were described, and another cartoon showed electrical workers putting up electrical wires. These pictures illustrated the sociocultural embeddedness of science, how science is used and created in society. This was the only significant NOS representation in this book; the rest of the NOS concepts were either not present or implicitly expressed.

Figure 4.10. Page from The Magic School Bus.

However, the second book displayed many of the NOS concepts. In A Wizard From the Start (Brown, 2010), almost all of the NOS concepts on the scoring sheet were illustrated in the book. The book described a young Thomas Edison and how he grew up curious and inquisitive about the world, experimenting on his own and eventually becoming famous with his inventions. The book showed the empirical and investigative nature of science. The book showed Thomas investigating, first, as a
young boy in his family’s basement with chemical experiments and then later spending time developing inventions:

He read history and philosophy books. He read books on mechanics, electricity, and chemistry. They inspired Tom to make a laboratory in the Edison’s’ cellar. With a pal, he experimented with acids and chemicals. Poor Mrs. Edison worried that they would “blow [their] heads off.” (p. 6)

The book also described Thomas Edison’s experiments and how they changed the course of society, such as the famous light bulb that showed the tentative nature of science.

![Young Thomas Edison experimenting.](image)

The book also showed Tom to be always curious, wanting to be challenged, tenacious even when projects failed, creative, and hard working. This is one of the few books of the group that centered on the scientist; therefore, it was easier to see the NOS elements present because of the focus on the person in science. The
creativity, empirical nature, observational nature, and so on, are all more apparent in books when the scientist is depicted “doing” the work.

**How the Views of the NOS Shaped the Read-Aloud Experience**

Vanessa brought her students to the reading corner of her classroom while she read the books to her students for the read-alouds. The first book she read, *The Magic School Bus* (Cole, 1997), followed a class and teacher to an electrical power plant to learn about electricity. While reading, Vanessa asked both closed-ended (“What does electricity travel through?”) and open-ended questions (“How do you think the fan is working?”). Of all the teachers in the study, Vanessa was one of the more informed concerning NOS concepts, so it is not surprising that she asked a significant number of open-ended questions, giving students the opportunity to participate in science and explain their understanding in their own words. This approach is a stark contrast to the other questioning type; closed-ended questioning teaches students that science is looking for one “right” answer and was used by most of the other teachers in the study.

There were several instances when Vanessa stopped to discuss parts of the book with her students. In one section titled, “Cleaner Ways to Make Electricity,” the book had pictures showing different sources of energy connected to the sociocultural aspect of science. Vanessa briefly stopped after reading the section:

Vanessa: Because the sun, boys and girls, is the biggest source of energy for the whole entire world. . . . The sun is very important and creates a lot of energy. How many of you ever saw those things on top of houses they’re um, solar panels.

Students: Yeah yeah I have, I saw them on my friend’s house

Vanessa: Okay and what do you think solar panels do?
Student: It’s for the electricity. When it’s sunny out, it gives electricity.

Vanessa: I have these little lights outside my house, and you never have to light them up, it gets power during the day and at nighttime they are lit because of the sun’s power. . . . Windmills use energy! They can run a whole town, who’s ever been skiing at jiminy peak? At the top of the mountain they have huge windmills and they run the whole mountain! ...We’re not doing any damage to the sun by having solar lights, we’re not doing any damage to the earth by having solar lights. So maybe you want to ask your mom if you can use solar lights around your house. It’s a good thing for you to see how they work and you’re not saving electricity and you’re saving money and it’s better for the earth.

This teacher-led exchange was interesting because Vanessa scored naïve on the sociocultural aspects of the NOS on her VNOS but stopped and discussed these socio-scientific issues with her students. This particular book was explicit with its connection to the NOS; it had both pictures and descriptions of alternative energy. This book provides evidence for the argument that a book with explicit pictures or text related to the NOS has a good potential in bringing the NOS into read-aloud discussions. Even with naïve views, Vanessa was able to discuss this NOS issue with the help of a book that made clear connections. It should be noted that the above exchange was not so much a discussion as it was a teacher-led dialogue. However, this exchange stayed in students’ minds as shown in some of the ticket-out-the-door questions and comments:

I want to know what solar lites do (N, Vanessa’s class).

I learnt that if a power tower fell down one of the wiers is dead and one is alive. I like that can learn more about electricity and its power source. I like learning about the solar stuff (G, Vanessa’s class).

Do the windmills make energy at jimny? I liked learning about the windmills (K, Vanessa’s class).
These comments indicated that, even when a teacher holds a naïve view of a NOS topic, a book with explicit pictures and text about the NOS can help to initiate thoughts related to the NOS.

While reading the second book about Thomas Edison, Vanessa stopped to ask students what they think Thomas Edison was like as a person, and students answered, “He enjoys to read.” Vanessa added that maybe he was “educated.” The book gave the opportunity to talk about the human aspect of science easily. Vanessa also discussed the human endeavor aspect of science when she read the section about Thomas Edison’s failed inventions and his determination still to succeed. She asked students whether they had ever made something that did not turn out the way it was supposed to, and several students could relate. This question also helped to bring students into the field of science, illustrating that, even when imagination and creativity are used, failure can result, but successful scientists keep on working.

Some of the comments for the ticket-out-the-door activity for this read-aloud showed that using a book with explicit NOS connections helped students see an aspect of the NOS (even when the teacher had a naïve score for that particular aspect).

I liked the book. I didn’t like how rude people were to him. I liked that he still invented the bulb (I, Vanessa’s class).

I learned that Tom was hard working and I learned more about Tom and his way of life (G, Vanessa’s class).

How did tom make the light bulb. how did he get the letresity get in the light buld (M, Vanessa’s class).

Vanessa held largely mixed views of creativity, methods of investigation, and sociocultural connections to science, but the book showed explicit NOS in both text and pictures. The book aided in helping the students think about the connection
between science (the light bulb) and the NOS (the experience and struggles of the
scientist on his path to inventing the light bulb). This case helped show that, even
when the teacher has mixed or naïve views on an NOS topic, books with clear and
explicit connections to the NOS can aid in bringing in these issues into discussions
with students.

Trends Among Cases

Examination of the data revealed some trends that showed how teachers either
introduced the NOS or hindered the discussion of the NOS in read-aloud discussions.
One major trend in the cases was that the read-aloud could become an even more
involved discussion when the teacher held informed views and the book highlighted
an NOS topic. One of the two—book presentation or teacher view—is not enough to
involve the NOS concepts in discussion. The students’ views of the NOS had very
little effect on the discussions during the read-alouds; the teacher did most of the
guiding and discussion and usually restricted the discussion to certain boundaries.
For example, Carey did not discuss collecting data and scientific practices, and the
book she used did not show explicit science data collection; therefore, the students
had lingering questions after the read-aloud as illustrated in their ticket-out-the-door
questions and comments. This effect was also evident when Rachel, with the most
informed NOS views, selected trade books with the most NOS presentation and then
asked her students questions regarding NOS topics, such as data collection and the
human endeavor, and even led the class in an activity related to the sociocultural
issues of science. Matthew also held informed views of the creativity of science and
was able to lead a discussion with students, getting them to think about how they 
would test for electricity.

Teachers who held naïve views were not able to lead a discussion about NOS 
topics when the books were only implicit in their NOS portrayals. Teachers who held 
mixed or naïve views were able to further discuss NOS connections when the trade 
book showed explicit NOS aspects. Vanessa, who held largely mixed and naïve 
views, was able to talk to students about alternative energy sources because the book 
explicitly showed and discussed alternative energy. This example was in contrast to 
that of Emily who held largely naïve and mixed views but whose books had very little 
or no NOS presentations. Subsequently, discussion in Emily’s read-alouds did not 
focus on any NOS topics.

Another trend was that, even if teachers held informed views of an NOS topic, 
they seemed to need guidance on how to lead topics or discussions concerning the 
NOS. Most of the explicit topics discussed (sociocultural issues) were limited, and 
teachers mentioned that students should talk to their families about them. Carey 
asked students to talk to their families regarding different theories on how animals 
arrived on earth, and a solar panel discussion ended with Vanessa telling her students 
to ask their mothers about installing solar panels. It appeared that teachers saw these 
ideas as being on the fringe of scientific issues and they should be left to students to 
talk with their families about. Such examples support the idea that teacher 
professional development is needed to help teachers understand not only what the 
NOS is and what it entails, but also how to guide a discussion or lesson surrounding 
the NOS.
Another trend seen is the idea that the discourse used in read-alouds is connected to the NOS understanding. Teachers using personal pronouns, such as you, gave the implicit message to students that they were involved in science. Doing so helps connect to the idea that science is a public affair, including not only specialists but regular citizens (AAAS, 2009). It also is connected to the idea that science is a human endeavor, that it includes all different teams of people as well as individuals (NRC, 1996), and that it is a highly social activity. Closing students out by not including them in discussions regarding science gives the impression that science is done by others, communities of people to which students do not belong.

Another part of discourse related to using personal pronouns is the types of questions teachers used with their students. Using closed-ended questions gives the impression that science is looking for one “right” answer. This belief goes against the NOS idea that science is tentative, that answers may change, or that they may be open to criticism. It may also give the false impression that culture, personal beliefs, or individualized thinking does not affect science. Therefore, providing teachers with the opportunity to discuss and consider various types of questioning may be essential in helping to establish more developed views of the NOS, for both teacher and student.

Teachers or a book also hedged in these cases, giving the impression science is tentative. For example, Matthew’s books had very few hedges in them, instead portrayed everything as fact. Matthew may have compensated for this presentation by using many hedges while talking to his students. Many of the other teachers also hedged, showing tentativeness in science when discussing the books with the
students. Whether such hedges were deliberate or not, helping teachers see how the discourse used in their classes is closely connected to the NOS is essential in improving students’ NOS understandings.

Another trend seen in all of the cases is the idea that many students thought scientists do not use creativity or imagination. Students saw imagination as open to anything, not just specifically to science, so when asking them about imagination, they may not have restricted their thinking to science. They may have thought about the make-believe and fictional creativity that also exists, making the issue confusing to students. Students may also associate the word imagination with imaginary, which could lead to such confusion. Teaching students what imagination means may be necessary to have a better understanding of students’ views on this aspect, or the VNOS may need to include the definition or an example of imagination to avoid confusing students. Furthermore, discussing the idea of imagination in science or relating it to creative ways of thinking may help clarify students’ understanding of imagination in science. Students may not have had the vocabulary to understand fully or to discuss their views on this topic. The answers shown in the study called for more clarification as to the differences between creativity and imagination in science. Again, clarification of creativity and imagination and their place in science may be needed to better understand students’ expressions of their thoughts. While this argument may not be new, it was a part of the data that stood out and is, therefore, worth highlighting. Together these themes were identified as the major facets in the relationship between the NOS and the discourse that took place in elementary science read-alouds.
CHAPTER 5

DISCUSSION, IMPLICATIONS, AND FUTURE RESEARCH

Overview

In this last chapter, I discuss and review the outcomes of the study. The first section is the discussion that is organized into subsections; each subsection focuses on a research question from the study. This discussion section incorporates the findings from this study, draws on current research of the NOS in elementary science classrooms and science read-alouds, and includes the conclusions of the study. The following sections focus on the outcomes of the study in terms of the theoretical framework, research limitations, and classroom implications. The chapter then closes with suggestions for future research.

Discussion

Research Question 1

The first research question in the study asked, “How do elementary teachers who practice science read-alouds view the NOS?” Most of the teachers in the study, with the exception of Rachel, held naïve and mixed views of the NOS. Rachel was the only teacher with a background in science, having both an undergraduate degree and research in the field. One main misconception that many of the teachers held is the idea that science is objective and is always “proven” to be true. For example, Mallory wrote, “Science is different than other inquiry disciplines because (for the most part) science is based off of facts, and things that can be proven,” and Emily wrote, “Scientific disciplines have theories that are proven or disproven. Religion or philosophy’s theories aren’t absolute.” Other research has shown this misconception
to be common as well. Teachers tend to think of science and scientists as purely objective and not influenced by backgrounds, culture, and knowledge of content (Abd-El-Khalick et al, 1998; Akerson, Morrison, & McDuffie, 2006 Lederman, Schwartz, Abd-El-Khalick, & Bell, 2001).

Many teachers in this present study also held naïve views of the difference between a scientific law and a scientific theory. Five of the six teachers in the study seemed confused about the distinction; for example, Emily stated, “A scientific theory is an idea that has not been proven or disproven due to insignificant evidence. A scientific law has been proven and stood the test of time.” The other four teachers answered in a similar fashion, distinguishing a theory from a law because a theory still does not have enough “proof” to become a law. These findings are consistent with those of other researchers who looked at elementary teacher NOS understanding and found that teachers tend to think of theories as weaker and believe that, after more substantiation, a theory becomes a law (Abd-El-Khalick et al, 1998; Akerson and Abd-El-Khalick, 2003; Lederman et al., 2001).

All the teachers in this present study understood to a certain extent that creativity and imagination existed in science. However, they seemed confused about the role of creativity and imagination. They acknowledged there was a place for them in science but could not explicitly describe how they exist in science. They implied that, while creativity and imagination are used in science, scientists should not or cannot alter the final results. Matthew wrote, “Creativity and imagination are important to all stages of scientific discovery . . . the core of scientific studies always produce similar results regardless of who performs the experiment.” Similarly,
Rachel wrote, “The only time creativity should not be used is in data analysis,” but also wrote, “[The scientist’s] interpretation of the data is different . . . so it is the interpretation that has resulted in different theories.” The teachers acknowledged the individuality of scientists and how it may influence their interpretations but still believed that the “facts” come out to be true or proven at the end, regardless of individual scientists. Again, this finding is consistent with those of prior studies that showed teachers are not clear about their understanding of creativity and imagination in science. Such studies have shown that elementary teachers tend to think of creativity and imagination as being in the design stages of science but not in the development of knowledge (Abd-El-Khalick, 1998; Akerson and Abd-El-Khalick, 2003, Lederman et al., 2001).

The findings in this present study indicate that improving the NOS understanding of elementary science teachers is imperative. The results of this study are similar to those of other studies that have examined elementary teachers’ NOS understanding and showed that most elementary teachers do not have sufficient understanding of the NOS (McComas, 1996). The struggle to improve teachers’ NOS understandings is not new (Akerson, Abd-El-Khalick, & Lederman, 2000; Akerson and Abd-El-Khalick, 2003, 2000 Barufaldi, Bethel, & Lamb, 1977; Bianchini & Colburn, 2000; Meichtry, 1995). Although it is still not clear whether teachers’ NOS views are reflected in his or her teaching practice, it is accepted that teachers need more developed NOS views to help students improve their NOS views (Abd-El-Khalick et al, 1998; Abell & Smith, 1994; Akerson and Abd-El-Khalick, 2003, McComas, 1996).
Research Question 2

The second question of the study asked, “How do elementary students who participate in science read-alouds view the NOS?” Students held a wide range of NOS conceptions, but most of their understandings were naïve and mixed. Students held many misconceptions about the tentative nature of science (Question 3 on the VNOS had 100% ‘naïve’ or ‘mixed’, no informed views). They viewed scientific knowledge as fact, that is, as something absolute and unchanging. When asked about scientific knowledge and changing the future, D from Carey’s class wrote, “No I don’t think what scientists know will change in the future because it’s like a fact trapped in thier head,” and other students indicated facts do not change because “scientists are smart.” Students seemed to view science as strictly black and white; that is, the knowledge that does exist is final and is a result of a purely objective experiment.

Like the teachers, the students also viewed science and scientists as concerned purely with facts. X from Emily’s class wrote, “I don’t think they [scientists] should disagree at all because if they all have the same facts then they should put there facts together to figure out more.” Some students acknowledged that individual scientists have their own opinions, but they still believed that those opinions and individualities would not and should not affect the final results of an experiment. Along the same lines, a major trend seen in this study dealt with student misconceptions about the use of imagination in science (Question 7 had 96% of students scoring ‘naïve’ or ‘mixed’). Students wrote scientists should report only “the facts” and that using imagination in science would be “untrue.” Similarly, Akerson and Abd-El-Khalick
(2005) showed that, even when teachers had more developed NOS views, students had trouble communicating their understanding of creativity in science. Students in the current study also had trouble seeing how imagination is a part of science, regardless of their teachers’ views. In addition, Akerson and Donnelly (2010) found that students held similar thoughts about creativity in science, responding that “creativity was something that was important for artists but not scientists” (p. 110). Many students tended to think of imagination in the literary science, as in it being fiction and made-up or “not real.” Regardless of their teachers’ views on the NOS, students in general seemed confused at the idea of imagination in science. From these findings it seems pertinent to guide teachers how to lead focused discussions on the topics of the NOS, particularly those that include describing how imagination and creativity are part of the scientific process, as well as the tentative nature of science.

These findings are interesting because both tentativeness and understanding creativity in science are thought to be among the few NOS elements attainable in understanding by elementary students (Smith et al., 2000) and are emphasized in science education reform (AAAS, 2009; NRC, 1996). Therefore, even though students may be expected to understand these concepts because of the findings of prior research and science reform documents, the reality is that they are confused about many NOS concepts. Further, to reach the ultimate goal of producing scientifically literate citizens, research on how to improve student NOS understanding is still needed.

Finally, many of the NOS aspects are conceptually appropriate and relevant to elementary students. There is some disagreement concerning whether the
components of the NOS may be too abstract for elementary students (Akerson & Abd-El-Khalick, 2005; Akerson, Abd-El-Khalick, & Lederman, 2000). However, like the studies that showed elementary students are capable of understanding the NOS (Akerson & Donnelly, 2010; Akerson & Volrich, 2006; Khishfe & Abd-El-Khalick, 2002), this present study showed that elementary students are capable of asking questions, making comments, and implicitly making connections to the NOS. For example, in Matthew’s class, a student asked why Benjamin Franklin would want to know whether lightning was electricity. This question was related to the NOS because it focuses on scientific processes and scientific thinking.

Furthermore, a student in Carey’s class asked about how animals came about after the Ice Age, which is connected to the idea of theories in science and, therefore, connected the NOS. A student in Rachel’s class asked how the people who lived near the Nashua River could ask for forgiveness when they planned to kill animals to eat. This question was related to the sociocultural aspect of science; that is, while studying the river, science was seen as a complex social activity. Students also made comments or questions connected to the NOS on the ticket-out-the-door activity. G in Vanessa’s class wrote in regards to the book on Thomas Edison, “I learned that Tom was hard working and I learned more about Tom and his way of life,” which shows the human endeavor aspect of the NOS. Students in the study asked questions related to the NOS; that is, they asked questions that related to theories, sociocultural issues, and scientific investigation, which were evidence of their implicit conceptualization of the NOS. Although the questions and comments may not have indicated deep and comprehensive understanding of the NOS, they showed the
students were capable of implicitly discussing NOS concepts. This finding is in agreement with that of Abd-El-Khalick, Bell, and Lederman (1998), who argued that K-12 students are able to access the NOS in their daily lives; that is, students are able to make pertinent connections to the NOS.

These findings however, also show that the student version of the VNOS may be too simplistic in understanding students’ NOS views. Students overwhelmingly scored ‘naïve’ or ‘mixed’ on the VNOS but were still able to ask some questions that were related to the NOS on their ticket-out-the-door or during the discussion. Two students who scored ‘naïve’ on the VNOS about the empirical nature of science asked questions on the ticket-out-the-door about the astronomers collecting data in The Shortest Day (Pfeffer & Reisch, 2003), that is they still were able to ask questions related to the empirical nature of science. Their ability to ask these related questions show there is some implicit understanding of the empirical nature of science. Therefore the VNOS may need to be reworked to help illicit these more implicit views students hold about the NOS as the questionnaire did not make these understandings transparent.

**Research Question 3**

The third question of the study asked, “How is the nature of science portrayed in the science read-aloud trade book?” Many of the trade books in the study did not have explicit NOS presentations in them.

**Empirical knowledge.** This study showed that many trade books included very few individuals doing science, and the science they did show seemed vague. Like the geologists illustrated “collecting” data in *The Big Rock* (Hiscock, 1999),
there were no other details associated with the picture, such as explaining the thinking that takes place or any other scientific processes. The processes of science did not go beyond showing these pictures.

In the books in this study, the only instances that showed humans fully involved in scientific work were the ones about Thomas Edison, the hurricane scientists, and water. The Thomas Edison book may be considered an exception because the entire book was specifically about the scientist. Even though the other books showed people, the main focus of their texts was the science and facts that exist regarding the science (such as the water book focusing on the attributes of water). The hurricane book did briefly discuss that scientists were aboard the plane collecting data, but again, it showed and discussed their activities in a vague manner, not describing what information they were collecting and what exactly would they do with it. Furthermore, many of the books were written with few or no personal pronouns, giving the impression that science is devoid of people. People seemed to be tangentially involved in science because they were present in a few pictures, but they were not focused on in the text.

The idea that science is an empirical process, that it demands evidence, was scarce in these selected trade books. By not showing how the scientific community works, these books did not offer the opportunity for students to scrutinize and evaluate practices. Students would have an easier time understanding the empirical nature of the NOS if the books were more transparent about scientific processes.

**Tentativeness.** The trade books did some hedging to show tentativeness but also discussed science in definitive terms, giving the impression that science is
absolute. For example, the hurricane book described hurricanes using the hedges
*often, usually,* and *frequently,* which showed the characteristics of hurricanes can
differ. However, other books, such as the pulley book, had little or no hedges.
Additionally the tentativeness that was shown in the books was not made explicit; for
example, a section in the Thomas Edison book discussed how Edison challenged
Nicholas Tesla; eventually, when Tesla created AC power, it became the better of the
two because of its ease in transmitting signals over long distances. Nevertheless,
science was shown to evolve over time and to be subject to change. Even though this
concept was present in the book, it was a small section in the back, not the main focus
of the book; therefore, the message of tentativeness was implied, not explicit.

**Sociocultural embeddedness.** The sociocultural aspect of the NOS was
present in many of the books, including *The Magic School Bus* (Cole, 1997) and *A
River Ran Wild* (Cherry, 1992), but only implicit connections were made at best. For
example, in *The Magic School Bus* (Cole, 1997), one page showed “cleaner” ways to
make electricity but never explained why it might be a good idea to investigate these
other options. It did not give the context for why alternative sources of energy are
significant in modern society. For example, in *A River Runs Wild* (Cherry, 1992),
science is presented as influenced by the culture surrounding it. In the book, the idea
of pollution is presented, and later people are shown protesting the building of more
factories. Subsequently, the factories stop being built. This section was the most
significant connection to the sociocultural aspect of the NOS, although the main focus
of the book was more focused on the river and its change over time. The awareness
that science is embedded within society and culture was not generally prevalent in the trade books examined in this study.

**Creativity and imagination.** Most of the books read by teachers did not illustrate the link between creativity and science. A few of the books in the study portrayed the creative aspect by showing scientists and how they made their discoveries. *A Wizard from the Start* (Brown, 2010) showed young Thomas Edison tinkering around with objects and ideas, reading books in the library, and then making a discovery. Another book, *Simply Science Electricity* (Stille, 2001), showed Benjamin Franklin discovering electricity in the famous experiment flying a kite in a lightning storm. In both cases, the word *creative* was not used to describe the scientist; however, the books showed scientists working and not following a step-wise method to investigate scientific concepts, but the idea of creativity was not specifically expressed. Similarly, in *A River Runs Wild* (Cherry, 2002), the word *creative* was not used to describe what was happening in the story, but the author alluded to creativity taking place by stating, “These were times of much excitement, times of ‘progress’ and ‘invention.’ Factories along the Nashua River made new things of new materials.” The word *invention* implies some creative thinking, but again, this is only an implicit connection at best.

In this study, books were devoid of the NOS, as was *How Many Ways Can You Catch a Fly?* (Jenkins and Page, 2008), which had no NOS connections; made only implicit connections, like *Mighty Machines* (Levine & Johnstone, 2006), which showed no NOS except hinting at a scientist inventing the pulley (but showing no scientific thinking or process); or had a little more explicit connection that did not go
further into the processes of scientific processes, as in *The Shortest Day* (Pfeffer & Reish, 2003), which showed scientists collecting data in different ways and how the knowledge about winter solstice changed over time yet did not explicitly discuss how the scientific process can differ or the idea that scientific knowledge changes over time.

These findings contribute to the growing research that shows science trade books do not do a good job of presenting the NOS. Abd-El-Khalick (2002) came to this same conclusion. Results of that study showed no explicit presentation of the NOS in trade books and only vague implicit connections at best. In this present study, scientists were seen in several books collecting data, but readers do not know what they were collecting, how they knew what to collect, or what they would do with the data afterwards. These questions were left unanswered, and it was assumed that students would know the answers or that teachers would explain them. In this present study, it was evident that the questions and answers were not discussed, and several students still had questions when leaving the class (as shown in their ticket-out-the-door comments).

**Research Question 4**

The fourth research question in the study asked, “How is the NOS negotiated through the discourse in the read-aloud practice?” It should first be noted that much of the discourse that took place during the read-alouds was teacher-led, so they were not exactly discussions. Many of the teachers in the study asked closed-ended questions, such as “What two things allow electricity to flow through it?” and “What is the name of this simple machine?” The closed-ended questions used in all of the
case studies conveyed the idea that science is about finding one “right” answer, giving students the impression that science is factual and definite, not open to interpretation. This misconception is similar to not seeing science as tentative, but instead seeing it as absolute. Sutton (1996) indicated that many times the NOS is misrepresented to students through classroom teaching, as it was in these instances.

However, teachers’ discourse can also give a more accurate and inclusive impression of the NOS. Teachers in this study also used personal pronouns such as you and we while talking to students during the read-aloud. Personal pronouns can help give students the message that science includes them. Science is a communal action and movement and is not closed to only a few certain people.

These implicit messages transmitted through discourse influence students’ understandings of the NOS (Oliveira et al., 2012; Zeidler & Lederman, 1989). This idea was evident in the study when discussion was not explicit: Students were still confused about the animals in the rock book, about how people use pulleys in the pulley books, and about how electricity is made from water in the water book. The lack of explicit discussion indicated that students would figure out the missing information somehow. These examples and research call attention to making teachers aware of their own discourse and the potential effect on students.

**Research Question 5**

The final research question in this study asked, “How do teachers and students with known NOS views make sense of the NOS portrayed in trade books during the science read-aloud?” The study found that, when a book had some explicit NOS aspects in it, a teacher with informed or mixed NOS views was able to have a more
involved discussion involving the NOS. For example, Rachel held more informed NOS views overall and was able to discuss the effect of people on the river in *A River Runs Wild* (Cherry, 1992) and even created a class activity related to the book (a debate about building factories near the river). Rachel’s NOS understandings helped to make the NOS in the book more explicit. Conversely, a teacher with naïve or mixed views of the NOS was able to discuss NOS aspects when the trade book had very explicit connections to the NOS. For example, Vanessa held naïve understandings of the sociocultural aspect of the NOS, but while reading *The Magic School Bus* (Cole, 1997), she stopped to talk about the pictures and descriptions of alternative energy described in the book. Although the book did not discuss the importance of alternative energy or how it is related to modern society, it did make explicit connections to alternative energy and Vanessa was able to stop and discuss using energy-efficient lights and the use of windmills. In other words, the read-aloud appeared to become an even more valuable instructional tool when the teacher held informed views and the book presented an NOS topic.

In this present study, most of the teachers were not well informed about the NOS; therefore, the degrees to which the NOS was presented in the trade books had more significant effects on how much the NOS was raised during exchanges. This study showed that teachers had an easier time discussing the NOS topics when the books had explicit illustrations or text related to the NOS and when the teachers themselves had informed NOS views. Teachers were able to refer to the book to discuss or talk to students about the NOS; however, neither the books nor the teachers’ views alone may be enough to help change students’ understanding of the
NOS. Previous researchers (Akerson & Abd-El-Khalick, 2005; Akerson, Abd-El-Khalick, & Lederman, 2000) have argued that explicit teaching of the NOS is the best way for students to understand it. This study adds to these findings by showing that, in science read-aloud discussions, trade books need to be explicit in their NOS presentation, and teachers need to have more informed NOS views for students to improve their understanding of the NOS. Relying on just the teacher or just the trade book is not enough for explicit NOS instruction to occur.

Having trade books with well-written and explicit connections to the NOS is essential in helping teachers have NOS-related discussions in class. The students in Carey’s class saw pictures of animals that appeared after the Ice Age in The Big Rock (Hiscock, 1999). It was assumed students knew how the animals happened to appear because there was no explanation in the book, leading to the student asking how the animals came about and questions on students’ ticket-out-the-door activity. Again, this example shows that, when the NOS in trade books is not made explicit—both in text and in pictures—and it is not talked about, students are left with misconceptions and confusion. Prior research has shown that when trade books are read to children, it is assumed that the teachers will help their students understand the meanings and concepts in the book (Smolkin et al., 2009). The findings in this study contribute to and expand on the findings of Smolkin et al. to specifically include the NOS topics. Schussler (2008) also found that, when pictures presented concepts with no explanations, it was assumed students would figure out the meanings.

However, teachers need help in translating their NOS views into meaningful discussion. Teachers in the study who held informed NOS views led discussions that
only touched the NOS surface. In Rachel’s classroom, the discussion about the
scientists and pilot collecting data focused largely on what was happening in the
pictures in the book; the discussion did not go deeper, such as discussing what types
of data the scientists were collecting, why they were collecting data this way, what
happened after data were collected, and so on. Matthew’s discussion of how students
would test for electricity was closely related to the book; there was not a more
explicit discussion of how the scientific process works. Carey briefly discussed the
idea of different theories but then told students to check with their own families about
their understandings and beliefs. The books alone were not sufficient to create
meaningful discussion about the NOS. Most importantly, teachers seemed to need
guidance in how to lead a discussion involving the NOS. This finding is in line with
prior research; that is, teachers need help in taking NOS views and translating them
The teachers in the study had the opportunity to take the topics that arose in the books
and make explicit connections to the NOS but were unaware of the benefits of
discussing them further, were not comfortable discussing them, or thought they were
not important.

Restructuring the Theoretical Framework

Finally, considering the theoretical construct suggested in Chapter 2, the
results from the study help refine the framework. Instead of thinking of the read-
aloud discussion as even triad made up of ideas from the trade book, students, and the
teacher, I found that the teacher-student discussions that took place were mediated by
the trade books used. Therefore, I reconstructed my framework to resemble the results from the study (Figure 5.1).

At the end of the read-aloud, the questions and ideas students were left with seemed to be a result of the teachers’ discourse: the questions teachers asked, the ideas teachers talked about (or did not talk about), and the teacher-led exchanges. In this study, it was apparent that the trade book played a large role in how much the teacher discussed the NOS with his or her students.

Figure 5.1. Restructured theoretical framework.

Limitations

One main limitation to this study is attributable to the nature of a case study design. Merriam (1998) stated that a case study is a part of a larger phenomenon.
My cases were completed with only six teachers in only two grades and, therefore, may not be generalized to other case studies. However, the findings are relevant to science teacher education because of the details that emerged and are pertinent to similar studies on elementary NOS. Another limitation deals with the unequal focus that emerged during the read-alouds. The video-recorded read-aloud discussions were generally teacher-led exchanges instead of teacher-and-student discussions. Therefore, the methods of data collection and analysis centered on teacher discourse more than on student understanding.

Finally, I was not able to observe all of the classrooms throughout the school year, so my data are a sampling of what happened in these classrooms in the given time. I did, however, try to reduce the misinterpretation of data by having participants member-check the data as the analysis process began. Therefore, the findings in the study present my interpretations of the data after having shared impressions with participants in the study.

**Implications**

The results from this study are expected to be significant in several aspects. The implications in terms of policy, practice, and theory are discussed in this section. First, the NOS is thought to be an essential part of the K-12 science classroom learning experience, yet the research in elementary NOS is ongoing and not yet complete. Prior to this study, no known studies examined the NOS in trade books during read-alouds. This present study is the only one that specifically investigates read-alouds in elementary science with regards to the NOS. Some studies have examined the NOS in books and curricular materials for elementary classrooms, but
few studies have addressed how the NOS are enacted with students (Abd-El-Khalick, 2002; Bricker, 2005; Ford, 2006). In addition, while conducting this research, I found very few studies that examined science read-alouds for the science education field (although some were conducted in science education and the literacy field). This study can encourage more science education research in the science read-aloud practice and encourage science teachers to pursue and investigate ways they can improve their NOS instruction in the elementary classroom, such as by being aware of their discourse and selecting better quality trade books.

It is already accepted that explicit NOS instruction can improve student understanding of the NOS (Akerson and Abd-El-Khalick, 2003; Akerson, Abd-El-Khalick, & Lederman, 2000). Thus, focus should be not only on teachers and their NOS understanding but also on the books used and how they are used. Investigating appropriate ways to teach the NOS explicitly or guide a read-aloud with the NOS in mind is essential for our elementary classrooms. This conclusion is in line with that of Khishfe and Abd-El-Khalick (2002), which showed, if teachers want to teach the NOS to students, explicit reference to the NOS is necessary. Akerson and Donnelly (2010) made a similar point, that is, that elementary students are able to understand NOS concepts with the appropriate explicit NOS instruction.

Drawing on this idea, educational policy makers, such as the New York State Board of Regents, may want to consider the role of the NOS in elementary science teacher education. The teachers’ NOS understandings and subsequent read-aloud discussions indicated that teacher education programs may be enhanced by focusing on what the NOS is, its significance, and how teachers can guide discussions about it.
This additional focus can help in achieving scientific literacy, ultimately one of the goals set forth by the AAAS (2009) and NRC (2011). Additionally, Akerson and Abd-El-Khalick, 2003) suggested that another way of helping elementary teachers improve their NOS understanding is by having them contextualize their ideas in instructional activities. I draw on that to add that using a science trade book with well-presented NOS views may be a valuable tool for teachers to contextualize their NOS understandings.

Finally, the findings underscore the significance of increasing elementary teachers’ NOS understandings, finding books with accurate and explicit NOS presentations, and helping elementary teachers become aware of their own linguistic expressions and their implications. Teachers with more informed NOS views who use trade books with accurate NOS descriptions may help students better understand the NOS. Teachers may be more aware of their word choices, such as personal pronouns and questioning techniques, and how they implicitly give messages to students about science.

**Future Research**

While conducting this study, I realized that more understanding is needed concerning teachers’ conceptualization of the NOS, their awareness of the NOS, and how they translate into their instruction. At the same time, more research is needed on elementary science read-alouds and their potential for explicit NOS instruction. One particular issue I would like to examine further is how teachers can receive professional development in the NOS, how to guide discussion involving the NOS, and the subsequent effects in science read-alouds. Using the data from this study and
the checklist for the NOS in trade books, professional development sessions can be
developed to show teachers the opportunities and constraints of trade book selection.
I would like to pilot a professional development piece that helps teachers guide NOS
discussion through a read-aloud and see how it would change teacher and student
discussions about the NOS. While working with these teachers, it was apparent to me
that many teachers did not find many books that they viewed as “quality” science
trade books. It also became apparent that many of the teachers did not see the
connection between the VNOS questions and science. Therefore, further study is
required to improve teacher NOS awareness and understanding. Such efforts are
likely to advance science education research by providing valuable insight into
teachers’ understanding of the NOS, teacher practices, and students’ understanding of
the NOS.
References


Heisey, N., & Kucan, L. (2010). Introducing science concepts to primary students through read-alouds: Interactions and multiple texts make the difference. The Reading Teacher, 63, 666–676.


Newark, DE: International Reading Association.


Appendix A

Call for Participants

Research Study—Participants Needed!
Monetary Stipend for Participation

To:
Elementary Classroom Teachers (grades 3 or 4)
Capital Region of New York State

Dear Teacher,

Little research has been done on the use of children’s literature in teaching science to students.

For this reason, this letter is to ask if you would be willing to participate in a research study examining science read-alouds in your classroom. The study will involve two observations of science read-alouds, interviews and a questionnaire on your views of science.

If you would like to participate, please email back the attached survey with your answers to: Emailseema@gmail.com. Please try and be complete as possible with the survey. If selected for the study following the survey, participants will each receive $100 cash and a $150 gift card to Barnes & Noble.

The results of this study conducted in school districts throughout the Capital Region will provide valuable information for science education courses. The names of participating school districts, school buildings, and teachers will not be stated in any published documents and participation is voluntary.

All contact information will be kept confidential. Thank you for your time and cooperation.

Sincerely,

Seema Rivera
Ph.D. student
University at Albany
emailseema@gmail.com
Appendix B

Survey of Science Read-Aloud Practices and Book List

Dear Teacher,

This survey is part of a research study about elementary teachers’ reading-aloud practices in science. Below you will be asked to (1) to provide your professional and contact information, and (2) describe generally about your read-aloud practices in your classroom.

Professional and Contact Information

Teacher’s Name: ______________________________            Date: ____________

School: ________________________      Grade Level(s) Taught: ________________

Subjects Taught: _______________Years of Teaching Experience: __________

Email: _________________________________

Mailing Address AND Phone Number:

_____________________________________________________________________

_____________________________________________________________________

Science Read-Alouds—Please Answer Questions as Thorough as Possible

1. How often do you read science books aloud to your students? For what purpose(s)?

_____________________________________________________________________

2. Do you incorporate any type of activities during your read-alouds? (such as Questioning the Author or Pair Shares, or any others?) If so, what do you do?

_____________________________________________________________________

___
3. What criteria do you use to select science books for read-alouds?

_____________________________________________________________________

_____________________________________________________________________

4. What is your educational background? (Undergraduate major? Graduate School major?)

_____________________________________________________________________

_____________________________________________________________________

5. What science courses have you taken (if any) after high school? Also, if you had another career or job before becoming a teacher, what was it?

_____________________________________________________________________

_____________________________________________________________________

_____________________________________________________________________

6. How do you incorporate read-alouds into your science teaching?

_____________________________________________________________________

_____________________________________________________________________

_____________________________________________________________________

7. What teaching/learning strategies do you regularly adopt when reading science books aloud to your students? Please describe.

_____________________________________________________________________

_____________________________________________________________________

_____________________________________________________________________

_____________________________________________________________________

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8. Do you assess what your students learn from science read alouds? How and for what purpose?

_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________

9. Would you be willing to be videotaped while reading aloud to your class?

Yes_____  No_____

10. Would you be willing to complete a short survey about science? Yes____

No____

11. Would you be willing to answer several questions on your thoughts about science (while being audio-taped)? Yes______  No______
Appendix C

VNOS-C Survey and Interview for Teacher Participants

*(Given with the initial survey)*

Views of Nature of Science (form C)*

VNOS (C)

* Reference:


Name:_____________________________

Date: //

Instructions

-Please answer each of the following questions. Include relevant examples whenever possible. You can use the back of a page if you need more space.

-There are no “right” or “wrong” answers to the following questions. We are only interested in your opinion on a number of issues about science.

1. What, in your view, is science? What makes science (or a scientific discipline such as physics, biology, etc.) different from other disciplines of inquiry (e.g., religion, philosophy)?

2. What is an experiment?

3. Does the development of scientific knowledge require experiments?
   * If yes, explain why. Give an example to defend your position.
   * If no, explain why. Give an example to defend your position.

4. Science textbooks often represent the atom as a central nucleus composed of protons (positively charged particles) and neutrons (neutral particles) with
electrons (negatively charged particles) orbiting that nucleus. How certain are scientists about the structure of the atom? What specific evidence, or types of evidence, do you think scientists used to determine what an atom looks like?

5. Is there a difference between a scientific theory and a scientific law? Illustrate your answer with an example.

6. After scientists have developed a scientific theory (e.g., atomic theory, evolutionary theory), does the theory ever change?

• If you believe that scientific theories do not change, explain why. Defend your answer with examples.
• If you believe that scientific theories do change:
  (a) Explain why theories change?
  (b) Explain why we bother to learn scientific theories. Defend your answer with examples.

7. Science textbooks often define a species as a group of organisms that share similar characteristics and can interbreed with one another to produce fertile offspring. How certain are scientists about their characterization of what a species is? What specific evidence do you think scientists used to determine what a species is?

8. Scientists perform experiments/investigations when trying to find answers to the questions they put forth. Do scientists use their creativity and imagination during their investigations?

• If yes, then at which stages of the investigations do you believe that scientists use their imagination and creativity: planning and design; data collection; after data collection? Please explain why scientists use imagination and creativity. Provide examples if appropriate.
• If you believe that scientists do not use imagination and creativity, please explain why. Provide examples if appropriate.
9. It is believed that about 65 million years ago the dinosaurs became extinct. Of the hypotheses formulated by scientists to explain the extinction, two enjoy wide support. The first, formulated by one group of scientists, suggests that a huge meteorite hit the earth 65 million years ago and led to a series of events that caused the extinction. The second hypothesis, formulated by another group of scientists, suggests that massive and violent volcanic eruptions were responsible for the extinction. How are these different conclusions possible if scientists in both groups have access to and use the same set of data to derive their conclusions?

10. Some claim that science is infused with social and cultural values. That is, science reflects the social and political values, philosophical assumptions, and intellectual norms of the culture in which it is practiced. Others claim that science is universal. That is, science transcends national and cultural boundaries and is not affected by social, political, and philosophical values, and intellectual norms of the culture in which it is practiced.

• If you believe that science reflects social and cultural values, explain why and how. Defend your answer with examples.

• If you believe that science is universal, explain why and how. Defend your answer with examples.

VNOS Interview Protocol
(Done on day 1 visit with the teacher)

Participants are provided with their VNOS responses to read and review.

1. Could you read your response to question # 1 (2-10) and explain and elaborate on your response?

2. What did you mean by [response, written or verbal]?

3. Could you give an example of what you meant by [response, written or verbal]?

4. How does your response on # X relate to what you said on # Y?

5. Have your views changed since you wrote your response? If so, how?
Appendix D

Student Consent Form for Video Recording of Read-Aloud

ABOUT THIS STUDY
The purpose of this study is to explore elementary school teachers’ beliefs of the Nature of Science (NOS) and making meaning of NOS during science read-alouds. As part of this study, your child’s teacher will be video-recorded while reading science books aloud in your child’s classroom. As a participant, your child and other students in his/her classroom may be incidentally video-recorded while talking to the teacher. Additionally, students will be asked to fill out a survey on their views of science and answer a few questions about the read-aloud. The science read-alouds are part of the regular curriculum. Your child’s grade will NOT BE AFFECTED by this study, nor will any information concerning his/her personal or group performance be released to the instructor or other classmates.

RISKS
There are no foreseeable risks associated with your child’s participation in this study.

BENEFITS
Knowing how to prepare elementary teachers to communicate effectively with their students while reading science books can be used to better prepare future science teachers. There will be no monetary compensation for your child’s participation in this study.

CONFIDENTIALITY
Measures will be taken to preserve confidentiality. First, video-recordings will be made from the back of the classroom in order to avoid recording your child’s face. Furthermore, your child will be assigned a pseudonym on all works and no information concerning his/her identity will be included in reports or videotapes. And, all videotapes and questionnaires will be destroyed once the study is completed.

CONTACT
If you have any questions at any time about the study or the procedures, you may contact the primary researcher, Seema Rivera, at emailseema@gmail.com or her faculty advisor, Alan Oliveira, at aoliveira@albany.edu, at the University at Albany.

You have been informed about this study’s purpose, procedures, possible benefits and risks and you have received a copy of this form. You voluntarily agree to participate in this study.

________________________________________                      __________________
Parent’s Signature                                                  Date

________________________________________          Parent’s Printed Name
Appendix E

Ticket-out-the-Door Questions

1. What did you learn about science in general from that read-aloud?

2. What did you like or dislike about this science read-aloud?

3. What questions do you now have about science after that read-aloud?

4. Did you like the book in the read-aloud? What did you like or dislike about it? How did it help you learn science?
Appendix F

Interview Questions Protocol*

*Adapted from Bricker (2005)

Questions are designed to help guide the interview but are not a script to follow exactly. When recording, start with the following information:

- Date
- Time
- Location
- Interviewee identification
- Interviewer
- Interview number.

**Pre-Read-Alouds**

1. Tell me about your most successful science read-aloud?
2. How do you judge whether your science read-aloud was successful or not? Are there any criteria you use?
3. What are specific ways that you ascertain (make sure) students’ understand or confusion during a read-aloud?
4. Do you enjoy read-alouds? Why or why not?
5. What do you think your students learn about science from the read-alouds?
6. Do you think it’s possible to teach science during a read-aloud? Why or why not?
7. Let’s say there are two stages of doing a read-aloud in teaching science: Planning vs. practice
   a. What do you consider when you plan your read-aloud (Book qualities? Other factors?)
   b. What do you consider when you conduct your read-aloud (activities, questions, etc?)
8. How do you define a “good” read-aloud? What about a “good” read-aloud book?
9. What factors do you consider as important for a teacher to conduct a good read-aloud?
Appendix G

Interview Questions for Teachers After Read-Alouds

Immediately following each read-aloud

1. What did you intend for students to learn during this read-aloud?

2. What do you think the students learned about science from the read-aloud?

3. Do you think this read-aloud gave you an opportunity to teach about science? How so?

4. How did this read-aloud compare to other methods of teaching science?

4. Any other thoughts or reflections on how this read-aloud went?
Appendix H

Informed Consent Form for Teacher Participants

IRB# ____________

Informed Consent to Participate in Research

The University at Albany

You are being asked to participate in a research study. This form provides you with information about the study. The Principal Investigator (the person in charge of this research) or his/her representative will also describe this study to you and answer all of your questions. Please read the information below and ask questions about anything you don’t understand before deciding whether or not to take part. Your participation is entirely voluntary and you can refuse to participate without penalty or loss of benefits to which you are otherwise entitled.

Title of Research Study:

How do elementary teachers and students with known NOS views make meaning of NOS messages in trade books?

Principal Investigator(s) (include faculty sponsor), University at Albany affiliation and Telephone Number(s):

Seema Rivera  
Advisor: Alandeom Oliveira, Ph.D.  
School of Education  
University at Albany  
518-859-3120  
emailseema@gmail.com

Funding Source: University at Albany Faculty Research Awards Program (FRAP)

What is the purpose of this study?

The purpose of this study is to explore elementary school teachers’ beliefs of the Nature of Science (NOS) and making meaning of NOS during science read-alouds. Three to Five elementary school teachers are anticipated to participate in this study. I will conduct semi-structured one-on-one interviews, administer surveys and observe read-alouds. In addition I will also analyze the content of the trade books used for the read-aloud. With consent, I will audio-tape interviews and video-tape observations.
What will be done if you take part in this research study?

By participating in this study, you will be interviewed on your teaching practices, specifically the read-aloud practice and NOS beliefs. At any time you can withdraw from your participation in the study, which will not influence your relationship with the University at Albany.

What are the possible discomforts and risks?

There are no known possible discomforts and risks associated with this study at this time. If you wish to discuss the information above or any other risks you may experience, you may ask any questions now or call the Principal Investigator listed on the front page of this form.

What are the possible benefits to you or to others?

While there are no direct benefits, the indirect benefits are apparent. Specifically, you will gain a better understanding of your own teaching practices.

If you choose to take part in this study, will it cost you anything?

There are no costs to you to take part in this study.

Will you receive compensation for your participation in this study?

You will receive a cash stipend of $100.00 and a gift certificate of $150.00 to a bookstore.

If you do not want to participate in this study, what other options are available to you?

Participation in this study is entirely voluntary. You are free to refuse to be in the study and your refusal will not influence current or future relationships with the University at Albany.

How can you withdraw from the research study and whom should I call if I have questions?

If you wish to stop participating in this research study for any reason, you should contact: Seema Rivera at (518) 859-3120 or Dr. Alan Oliveira at (518) 442-5021. You are free to withdraw your consent and stop participation in this research study at any time.

In addition, if you have any questions about your rights as a research participant, please contact the University at Albany Office of Regulatory Research Compliance.
How will your privacy and the confidentiality of your research records be protected?

Interviews will be audio taped with your consent and read-alouds will be video-taped with your consent. The cassette/files will be coded so that no personally identifying information is visible on them. The cassettes/files will be kept in a locked file cabinet in the Principal Investigator’s home and will be heard or viewed only for research purposes by the investigator and her associates. Pseudonyms will be used to protect your confidentiality. The cassettes/files will be destroyed after five years of non-use.

Will the researcher benefit from your participation in this study?

The researcher will not benefit from your participation in this study beyond publishing or presenting the results.

Signatures:

As a representative of this study, I have explained the purpose, the procedures, the benefits and the risks that are involved in this research study:

Seema Rivera
Signature and printed name of person obtaining consent and date

You have been informed about this study’s purpose, procedures, possible benefits and risks and you have received a copy of this form. You have been given the opportunity to ask any questions before you sign and you have been told you can ask other questions at any time. Your voluntarily agree to participate in this study. By signing this form, you are not waiving any of your legal rights.

Printed Name of Participant
Date
Consent to be Audio taped and Video-Recorded:

I hereby give permission for the interview conducted by Seema Rivera and the read-aloud activity practiced by me to be audio taped and video-recorded, respectively. I understand that both these audiotapes and videotapes will be used for educational purposes, analysis and that only the principal investigator will have access to them. The tapes will be kept for five years beyond non-use and will be stored in a locked cabinet in the home of the investigator.
Appendix I

VNOS-D Survey and Interview for Student Participants

VIEWS OF NATURE OF SCIENCE

ELEMENTARY/MIDDLE SCHOOL VERSION (VNOS D) (Intended for K-4)

Name: ___________________________________
Grade: ___________________________________
Age: ___________________________________
Date: ___________________________________

Instructions

• Please answer each of the following questions. You can use all the space provided and the backs of the pages to answer a question.

• Some questions have more than one part. Please make sure you write answers for each part.

• This is not a test and will not be graded. There are no “right” or “wrong” answers to the following questions. I am only interested in your ideas about the following questions.

1. What is science?
2. How is science different from the other subjects you are studying?
3. Scientists produce scientific knowledge. Some of this knowledge is found in your science books. Do you think this knowledge may change in the future? Explain your answer and give an example.

4. (a) How do scientists know that dinosaurs really existed?
   (b) How certain are scientists about the way dinosaurs looked?
   (c) Scientists agree that about 65 million years ago the dinosaurs became extinct (all died away). However, scientists disagree about what had caused this to happen. Why do you think they disagree even though they all have the same information?

5. In order to predict the weather, weather persons collect different types of information. Often they produce computer models of different weather patterns. (a) Do you think weather persons are certain (sure) about the weather patterns? (b) Why or why not?

6. What do you think a scientific model is?
7. Scientists try to find answers to their questions by doing investigations/experiments. Do you think that scientists use their imagination & creativity in their investigations/experiments?  **YES**  **NO**

   a. If **NO**, explain why

   b. If **YES**, in what part of their investigations (planning, experimenting, making observations, analyzing data, interpretation, reporting results, etc.) Do you think they use their imagination and creativity? Give examples if you can.
Appendix J

VNOS-E Survey and Interview for Student Participants

Views of Nature of Science Elementary School Version (VNOS-E)
(Intended for K-3)

Name: ____________________________________________
Grade Level: ______________________________________
Date: ____________________________________________

Instructions

• Please answer each of the following questions. You can use all the
  space provided and the backs of the pages to answer a question.

• Some questions have more than one part. Please make sure you put
  answers for each part.

• This is not a test and will not be graded. There are no “right” or
  “wrong” answers to the following questions. I am only interested
  in your ideas relating to the following questions.

• If you need, you can draw pictures to explain your ideas.

1. What is science?
2. (a) What are some of the other subjects you are learning?
   (b) How is science different from these other subjects?

3. Scientists are always trying to learn more about our world. Do you think what scientists know will change in the future?

4. (a) How do scientists know that dinosaurs once lived on the earth?
   (b) How sure are scientists about the way dinosaurs looked? Why?
5. A long time ago all the dinosaurs died. Scientists have different ideas about why and how they died. If scientists all have the same facts about dinosaurs, then why do you think they disagree about this?

6. TV weather people show pictures of how they think the weather will be for the next day. They use lots of scientific facts to help them make these pictures.

How sure do you think the weather people are about these pictures? Why?

7. (a) Do you think scientists use their imaginations when they do their work? ______ Yes ______ No

(b) If No, explain why?

(c) If Yes, then when do you think they use their imaginations?
### Appendix K

**Trade Book Analysis Form (To be used for each book read)**

*Adapted from Bricker (2005)*

<table>
<thead>
<tr>
<th>Nature of Science (Check if included)</th>
<th>Book Title</th>
<th>Evidence/Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scientific ideas are subject to change and science cannot completely answer all questions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Science relies on experimental and observational evidence. Inferences are not observations.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Science is a blend of logic, creativity and imagination</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Science does not follow universal recipe-like methods</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Procedures are reported and open to criticism</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Science is a socially embedded human endeavor and is affected by cultural and personal beliefs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The world is understandable and scientific knowledge is durable.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Theories are based on non-observable postulations and are different from laws, which are detailed statements about the world that is visible.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Book Title and Author:**

| Type of Book (Fiction, Non-Fiction, Hybrid of both, Narrative, Informational): |
| Notes relevant to the NOS: |
Potential science to teach about:

Overall Impression:
Hello everyone, my name is Seema Rivera. I am here to request your participation in a study that I am doing. The purpose of this study is to learn how elementary teachers can communicate well with students while reading science books aloud to children. Your teacher will be video-recorded while reading science books aloud in your classroom.

Although the video-camera will be mostly focused on your teacher, you may also be recorded while talking to the teacher. Your grade will not be affected by this study, nor will any information about you be given to your instructor or other classmates.

I also will be asking for you to answer some questions for me. The questions are just to ask you about your opinions in science and about the books you read. Your grade will not be affected by this study and no information from this will be given to other classmates or your teacher.

I am passing out the informed consent statement, one for you and one for your parent to read and sign.

Even if your parents sign the informed consent statement, if you do not wish to participate then you do not have to. All you need to do is tell me. Does anyone have any questions?

__________________________  __________________________
Student Signature                        Date
Curriculum Vitae

Seema Rivera
PhD Candidate
Department of Educational Theory and Practice
State University of New York at Albany

School of Education
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(518) 859-3120

Education:
University at Albany, Department of Educational Theory and Practice, Science Education, PhD 2008-present
The College of St. Rose, M.S. in Adolescent Education in Chemistry May 2005
Binghamton University, B.A. Psychology May 2001

Certification:
New York State Initial Certification in Adolescent Education in Chemistry and General Sciences, grades 7-12

Professional Work Experience:
University at Albany (NY): Course Instructor 2009-present
ETAP 512: Teachers in Context, Instructor Fall 2009 & 2010
ETAP 655 Science/Math: Models and Online Teaching, Instructor & Designer (Summer 2011)
ETAP 614: Science for Children, Teaching Assistant 2011 & 2012
ETAP 614: Science for Children, Instructor Summer 2012 & Spring 2013

Science Education Research Assistantship with Dr. Alan Oliveira 2009-present
Pictorial models & Science teacher discourse
National Professional Development Grant Program:
Technology-Enhanced Multimodal Instruction in Science and Math for English Language Learners U.S. Department of Education, Office of English Language Acquisition

Research Assistant, Research Project “Just for the Kids-NY” Spring 2009, 2011
http://www.albany.edu/nykids/

Chemistry Teacher & Chemical Hygiene Officer 2006-2008
Cairo Durham High School, Regents chemistry
Chemistry lab & applied science
Chemistry Teacher, Germantown Central School 2007-2008
Taught two sections of Regents Chemistry, Lab and Chemistry in the Community along with one section of eighth grade science.

NYC Middle School Science Teacher, (Physical Science & Earth Science) 2003-2004
M.S./H.S. 368 Magnet School for Information Technology, Bronx, NY

PUBLICATIONS
Journals


Conferences

Oliveira, A.W., Rivera, S., Glass, R., Mastroianni, M., Wizner, F (2011, September), Pictorial Representation in Science Read-Alouds, Conference paper presented at the 2011 European Science Education Research Association (ESERA), Lyon, France

PRESENTATIONS
Rivera, S. (2013, January) The Nature of Science (NOS) in Elementary Science Read-Alouds, Paper to be presented at the 2013 Conference for The Association for Science Teacher Education (ASTE), Charleston, SC

Rivera, S. (2013, January) Environmental Agency in Read-Alouds, Paper to be presented at the 2013 Conference for The Association for Science Teacher Education (ASTE), Charleston, SC


Conference for the National Association of Research in Science Teaching (NARST), Indianapolis, IN


**Rivera, S.** (2010, October) ChemMatters Images, paper presented at the 2010 conference of the Southeastern Association of Science Teacher Education (SASTE), Atlanta, GA.


**INVITED TALKS**

October 2010: ACRIDAT Pictorial Models in Read Alouds, SUNY Albany

April 2011: ACRIDAT Reading Pictures Outloud, SUNY Albany

**SERVICE for PROFESSIONAL ORGANIZATIONS**


Equity & Ethics Committee Member, NARST (2011-present)

Reviewer, ASTE, Charleston, SC (2013)


Reviewer, NARST, Indianapolis, IN (2012)

Reviewer, ASTE, Clearwater, FL (2012)

Reviewer, NARST, Orlando, FL (2011)

Reviewer, ASTE, Minneapolis, MN (2011)

**AWARDS**

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Spring 2012 SUNY Albany Graduate Student Organization Travel Grant Award
2011 Dr. H. Craig Sipe Science Education Scholarship Award, SUNY Albany
2011 NARST Jhumi Basu Equity Scholarship Award, NARST
2011 Sandra A. Bell Summer Research Institute Scholarship, NARST
Spring 2011 SUNY Albany Graduate Student Organization Travel Grant Award

**PROFESSIONAL AFFILIATIONS**
The Association for Science Teacher Education (ASTE)
European Science Education Research Association (ESERA)
National Association for Research in Science Teaching (NARST)
National Science Teacher Association (NSTA)
School Science and Mathematics Association (SSMA)