The Dissertation Committee for Hye In Jeong Certifies that this is the approved version of the following dissertation:

Examining Kindergarten Teachers' Beliefs and Practices in Science Education

Committee:

Christopher P. Brown, Supervisor

Stuart Reifel

James Barufaldi

Jill Marshall

Marilla Svinicki

Examining Kindergarten Teachers' Beliefs and Practices in Science Education

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Hye In Jeong, B. A.; M. A.

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Dedication

To my parents and sister

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Examining Kindergarten Teachers' Beliefs and Practices in Science Education

Hye In Jeong, Ph. D.
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Supervisor: Christopher P. Brown

This dissertation investigates kindergarten teachers' beliefs and their teaching practices in science education through a qualitative case study. This study addresses these topics by exploring two key issues: First, it illustrates how kindergarten teachers think about teaching science to the students. Second, this study demonstrates how the teachers' beliefs about teaching science affect the teaching practices in the classroom. The qualitative data was obtained through formal and informal interviews with four kindergarten teachers from a public elementary school. In addition, observations of the science lessons were also conducted.

The teachers' beliefs about science education were classified based on Calderhead's (1996) categories about teachers' beliefs: 1) beliefs about students in science classes, 2) beliefs about teaching science classes, 3) beliefs about science as a subject, 4) beliefs about learning to teach science, and 5) beliefs about teachers' roles in science classes. Based on the categories of teachers' beliefs, this study found a relationship between teachers' beliefs and how they teach science. In particular, the participant teachers preferred hands-on science activities and focused on children's interest in

science. Their personal learning history and past schooling experiences appeared to inform their beliefs. However, this research also shows that some of the teachers' beliefs did not match the teaching practices in science lessons. As evidence, contrary to their beliefs, some of the participant teachers did not include as many hands-on activities because of the limited time allowed for science and the characteristics of the topics in science classes.

Finally, the findings suggest there are differences between experienced and inexperienced teachers' in the beliefs and practices. For instance, experienced teachers believed that they were able to effectively manage the science classes, whereas inexperienced teachers showed concerns regarding managing the science class. Moreover, the experienced teachers actually demonstrated their expertise in successfully managing the class, while the inexperienced teachers experienced difficulty. Summary of findings, limitation, implications, and future research are discussed.

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Chapter 1: Introduction

PROBLEM STATEMENT

In early childhood education, the study of science education has become an important topic (Anderson & Helms, 2001; Eshach, 2011; Ginsburg & Golbeck, 2004; Hadzigeorgiou, 2001; Kallery, 2004). Science education is being framed as an important vehicle to assist with developing young children's understanding of the world around them (Eshach & Fried, 2005; Kallery, 2004). The realization of the need for science education in early childhood education can be triggered by several essentials, such as the children's natural curiosity and enjoyment regarding the natural world (Eshach, 2011), and their propensity to inquire from their family members about science-related topics, e.g., plants and animals (Callanan & Jipson, 2001; Fleer & Cahill, 2001; Kallery & Psillos, 2001). Such situations indicate valuable opportunities to teach science when its instruction can be most effective. However, children's initial positive feelings towards science, which include their curiosity about and motivation to learn more about scientific topics, often diminish after the first or second year of school (Patrick, Mantzicopoulos, Samarapungavan, & French, 2008). One reason this occurs is that many kindergarten teachers have difficulty teaching science and conducting activities with the children in the science domain (Conezio & French, 2002; Kallery, 2004; Watters, Diezmann, Grieshaber, & Davis, 2001; Yates & Chandler, 2001). For instance, it was found that teaching science was burdensome to teachers because of their inherent anxiety about science and their low self-efficacy with respect to teaching science (Roehrig, Dubosarsky, Mason, Carlson, & Murphy, 2011). In addition, playing with children as part of science lessons can be problematic as well, since teachers often did not participate in science play when they were students (Roehrig et al., 2011).

Yates and Chandler (2001) showed that teachers tend to form negative beliefs and attitudes such as fear, anxiety, and resentment about science. Teachers' negative attitudes can be a critical issue in early childhood science education. Because of those attitudes, teachers frequently attempt to avoid science and would rather focus on literacy and language. Since it has been shown that teachers are one of the most effective factors to support young children's science learning (Erden & Sonmez, 2011; Harlan & Rivkin, 2004; Harlen, 2000; King, Shumow, & Lietz, 2001), if those teachers do not support children's science learning, the consequences are that students do not get the opportunity to learn about science topics (Early et al., 2010; Eshach, 2011; Greenfield et al., 2009; Roehrig et al., 2011). Consequently, the approach taken by teachers can have a direct effect on what the students learn. This is a critical issue because firsthand science experiences for children should start in early childhood education (Erden & Sonmez, 2011).

The teachers' attitudes toward science and their approach to it also influence the children' long-term attitudes toward science (Erden & Sonmez, 2011; Harlan & Rivkin, 2004). Thus, not only do early childhood teachers' attitudes toward science and science education influence young children's exposure to science learning, but those attitudes also affect their students' attitudes toward science. Unfortunately, the students' negative attitudes toward science can influence their science learning in future situations. Yet, in the field of early childhood education, there are fewer studies oriented toward beliefs and attitudes in science education when compared to other grades (Erden & Sonmez, 2011; Eshach, 2011; Fleer & Robbins, 2003). While a plethora of studies have covered science education in relation to elementary school (Pappas, Varelas, Barry, & Rife, 2003), or middle and secondary schools (Eick & Reed, 2002; Fleer & Robbins, 2003; Luft, 2001), the studies in early childhood education settings are quite modest in number (Kallery & Psillos, 2001). Therefore, there is a need for empirical research to understand kindergarten teachers' attitudes and beliefs about science education for young children, as well as the practices in their classes.

In addition, teachers' beliefs about how young children learn and how teaching practices influence children's learning play an important role in teachers' interactions with their students (Maxwell, McWilliam, Hemmeter, Ault, & Schuster, 2002), since, according to Bandura (1997), beliefs can be the best predictors of the decisions people make throughout their lives. Especially in early childhood, the quality of teachers' teaching is based on their beliefs about learning and teaching, and, therefore, those beliefs affect the teachers' support of their students' learning achievement (Smolensky & Gootman, 2003). Early childhood teachers have significant roles as they not only provide appropriate learning environments in which young children can have opportunities to observe, explore, and discover natural objectives, but the teachers also support their learning of science through asking questions of students, answering their students' questions, listening to their discussions, and observing their involvement in science activities (Harlan & Rivkin, 2004). Hence, it is worthwhile to investigate how kindergarten teachers' beliefs about learning and teaching science may have a crucial impact on children's learning achievement through the science activities that the teachers provide in their science lessons. Therefore, this study aims to investigate kindergarten teachers' beliefs and their teaching practices in science lessons. In sum, this study provides early childhood educators with additional understanding with regards to how kindergarten teachers think about learning and teaching science, as well as the impact of their beliefs about teaching and learning on classroom practices and, therefore, on young children's learning science. Specifically, this study examines the following questions, as presented in the next section.

RESEARCH QUESTIONS

In this dissertation, the results involve the kindergarten teachers' beliefs about teaching science. The results are organized based on Calderhead’s (1996) five categories about teachers' beliefs: 1) teachers' beliefs about students learning science; 2) teachers' beliefs about teaching science; 3) teacher's beliefs about science as a subject; 4) teachers' beliefs about learning to teach science; and 5) teachers' beliefs about their roles in science classes. In addition, to the study on teachers' beliefs, this study also examines how these teachers’ beliefs about science were demonstrated in their teaching of science lessons.

To investigate the teachers’ beliefs about teaching science, with a sample of kindergarten teachers, a qualitative case study is carried out to obtain a deeper understanding of the complicated nature of individuals (Creswell, 2007). For that sake, this study investigated two research questions:

1. What do a sample of kindergarten teachers believe about teaching science?

2. How do these kindergarten teachers demonstrate their beliefs about science teaching in their practices?

To examine how the kindergarten teachers believed about teaching science to the young students, in-depth interviews are conducted, guided by Calderhead's (1996) categories about teachers' beliefs. Second, observation of the classroom sessions is undertaken to see whether there was a connection between their beliefs about science instruction and their actual teaching. This practice was necessary since prior research has shown that there are important relationships between teachers' beliefs and the actual teaching; teachers' beliefs affect their thoughts, judgments, and behaviors as they teach (Pajares, 1992). Studies investigating teachers' beliefs are critical to comprehend their action agendas as they attempt to apply teaching and learning practices (Haney & McArthur, 2002; Pajares, 1992). Also, kindergarten teachers' science teaching is an important indicator of young children's participation in science activities (Sackes, Trundle, Bell, & O'Connell, 2011). Therefore, understanding what kindergarten teachers' beliefs are and how the beliefs contribute to not only their science teaching practices, but also the children's learning science is of particular interest in this study.

SIGNIFICANCE OF THE RESEARCH

Science education in early childhood is meaningful and of great significance, as it applies to children's lives and contributes to their cognitive development as they attempt to understand natural phenomena and to develop science process skills (Eshach & Fried, 2005; Kallery, 2004; Sackes et al., 2011). For instance, by "doing science," children learn to “question, observe, classify, communicate, measure, predict, infer, experiment, and construct models,” thereby developing various skills and knowledge (Yoon & Onchwari, 2006, p. 419). However, researchers have shown that science lessons often receive less attention from teachers than other subjects (Mantzicopoulos, Patrick, & Samarapungavan, 2008). As a result, young children have fewer opportunities to experience science education than other subject areas, a situation that can lead to a decline in children’s natural interest and motivational beliefs about science (Eshach, 2011; Patrick et al., 2008). Therefore, the teachers’ role in supporting science education is essential for children to learn science (Harlen, 2000; Yoon & Onchwari, 2006).

In addition, teachers’ beliefs have an influence on the quality of science learning in classrooms (Bryan & Atwater, 2002). For example, researchers found that teachers’ beliefs influence their teaching practices (Barros & Elia, 1998; Bryan, 2003; Bryan & Abell, 1999; Calderhead, 1996; Clark & Peterson, 1986; Gess-Newsome, 1999; Helms, 1998; Luft, 2001; Nespor, 1987; Pajares, 1992; Simmons et al., 1999) and students’ science learning (Cobren & Loving, 2002; Eshach & Fried, 2005; Keys & Bryan, 2001; Pajares, 1992; Patrick et al., 2008), as well as efforts to reform science education (National Research Council [NRC], 1996; Yerrick, Parke, & Nugent, 1997). Teachers' beliefs about learning and teaching science directly influence various aspects of their teaching practices, such as lesson planning, assessment, evaluations, and classroom interactions with the students in science classes (Bandura, 1997; Bryan & Atwater, 2002; Pajares, 1992). For instance, teachers' beliefs about their roles in science instruction influence how they teach science to young children (Bryan & Atwater, 2002). In addition, there is a relationship between science education reform and teachers' instruction decisions, which are based on their beliefs; this relationship appears to be stable or resistant to change (Lumpe, Haney, & Czerniak, 2000).

In this study, kindergarten teachers' beliefs about science teaching and their teaching practices in science lessons are examined. This research is meaningful in terms of its focus on teaching and learning science in early childhood education (Chen & Klahr, 2008; Eshach, 2011; Klahr & Nigam, 2004). In previous studies, the relationships between teachers' beliefs and teaching practices have shown contrasting results. A handful of earlier research support the case that teachers' beliefs are reflected in their teaching practices (Bai & Ertmer, 2008; Borg, 2001; Calderhead, 1996; Levitt, 2001; Mansour, 2009; Mori, 2002; Nespor, 1987; Pajares, 1992; Schraw & Olafson, 2002; Stuart & Thurlow, 2000; Yilmaz-Tuzun & Topcu, 2008), but others have found no link between beliefs and practices (Calderhead, 1996; Flores, Lopez, Gallegos, & Barojas, 2000; Gahin, 2001; Goelz, 2004; Kelly & Berthelsen, 1995; Mansour, 2009). Therefore, this research realizes the discrepancies in findings from past research, and attempts to find the linkage between beliefs and practices within the science domain.

As a result, this study about teachers' beliefs and teaching practices in early childhood science education contributes to understanding how teachers think about teaching science, as well as whether and, possibly, how their actions in teaching science lessons conform to their beliefs. Moreover, this study provides valuable insight in that readers will get a better sense of how kindergarten teachers teach science, what they request to improve in their science instructions, and what problems they are facing from teaching science.

DISSERTATION OVERVIEW

This study presents results from an investigation of kindergarten teachers' beliefs and teaching practices in science instruction.

In Chapter 2, the research questions along with an overview of the relevant literature in the areas of teachers' beliefs and early childhood science education are provided. This literature review highlights prior studies on kindergarten teachers' beliefs about science education and science instruction. Within this review, the concept of the teachers' beliefs is explored through Calderhead's (1996) categories about teachers' beliefs, and the framework for investigation of the beliefs and practices of kindergarten teachers is presented.

After reviewing the literature, in Chapter 3, the research methodology details the qualitative approach taken for this study. The chapter discusses the data collection procedure including details about approaching the school for the study, the biographical information about the teachers, the characteristics of the employed school. In addition, a description of the in-depth interview and observation is included. Finally, the analysis procedure of the in-depth interviews and observations is discussed.

Chapter 4 presents and organizes the findings of this study, based on Calderhead's (1996) categories of teachers' beliefs: 1) teachers' beliefs about students learning science; 2) teachers' beliefs about teaching science; 3) teacher's beliefs about science as a subject;

4) teachers' beliefs about learning to teach science; and 5) teachers' beliefs about their roles in science classes.

Chapter 5 examines the connection between the participant teachers' beliefs about science teaching, as categorized by Calderhead (1996), and their teaching of science in their classrooms. In short, the teachers in this study used various strategies and methods in teaching science, and it appears that these instructional decisions followed their beliefs about science teaching.

Chapter 6 presents major discussion points of the participant teachers' beliefs and the teaching practices, along with implications for kindergarten teachers, teacher educators, and administrators. Finally, limitations and future research are discussed.

Chapter 2: Literature Review

This dissertation specifically investigated two research questions:

1) What do a sample of kindergarten teachers' believe about teaching science?
2) How do these kindergarten teachers demonstrate their beliefs about science teaching in their practices?

Understanding kindergarten teachers' beliefs and teaching practices in science lessons requires information about what teachers think about science education and how they teach it. Therefore, this literature review begins by examining research on science education in early childhood education, and then it presents an investigation of the research on teachers' beliefs and how it influences the teaching practices and the subsequent learning of science for young children.

To accomplish the goals, the following topics are covered: 1) science education in early childhood; 2) teachers' beliefs about science in relation to teaching and students learning; 3) teachers' roles in science instruction; and 4) the relationship of teachers' beliefs and classroom practices. These four lines of literature review provide insights into previous research on science education in early childhood education, how teachers perceive teaching science for young children, and evidence about the influence of teachers' roles in teaching science relative to the children's science learning. Reviewing this work will demonstrate the empirical need for this study.

Finally, concluding this chapter involves discussing the conceptual framework used for this study. This framework incorporates the work of Calderhead (1996) for the purpose of categorizing teachers' beliefs about teaching science to young children. In outlining the framework, it will show how teachers' beliefs can be categorized.

SCIENCE IN EARLY CHILDHOOD EDUCATION

In early childhood education, science education is an important area (Anderson & Helms, 2001; Eshach, 2011; Ginsburg & Golbeck, 2004; Hadzigeorgiou, 2001; Kallery, 2004). One of the reasons this topic has gained so much attention is that researchers are beginning to show that early childhood is a very important time for science learning (Eshach & Fried, 2005; Howes, 2008; Smith, 2001; Yoon & Onchwari, 2006). Because of young children's natural interest in and enthusiasm about science (Brenneman, Stevenson-Boyd, & Frede, 2009; French, 2004; Peterson & French, 2008; Tu, 2006; Worth & Grollman, 2003; Yoon & Onchwari, 2006), what children learn in the early childhood years can better prepare them for science learning in elementary and secondary school (Eshach & Fried, 2005). Eshach and Fried (2005) have provided key reasons why young children should learn science. These include:

1. Children naturally enjoy observing and thinking about nature.
2. Exposing students to science develops positive attitudes towards science.
3. Early exposure to scientific phenomena leads to better understanding of the scientific concepts studied later in a formal way.
4. The use of scientifically informal language at an early age influences the eventual development of scientific concepts.
5. Children can understand scientific concepts and reason scientifically.

6. Science is an efficient means for developing scientific thinking (p. 319).

Additionally, early childhood years are an important time for shaping children's attitudes toward science (Erden & Sonmez, 2011; Tu, 2006). For instance, Tu (2006) noted, "children's long-term attitudes toward science begin with their earliest exposure to science" (p. 251).

Moreover, science is about young children's own world, and studying science helps them understand the natural surroundings by developing reasoning skills (Chalufour & Worth, 2003; Eshach, 2003, 2011; Eshach & Fried, 2005; Eliason & Jenkins, 2003; French, 2004; Kallery, 2004; Kallery & Psillos, 2001; Tu, 2006). These early childhood years are also an important period for young children to learn science because science, through scientific concepts, helps young children understand how the world operates (Chalufour & Worth, 2003; Eshach & Fried, 2005; Howes, 2008; Tu, 2006). According to Chalufour and Worth (2003), young children develop an admiration for and understanding of the world around them through experiences in science. That is, science helps young children interpret the world through use of science inquiry skills, such as "wondering, questioning, exploring, investigating, discussing, reflecting, and formulating ideas and theories" (Chalufour & Worth, 2003, p. 4; Greenfield et al., 2009).

According to previous research, there are several reasons to teach science in early childhood (Sackes et al., 2011). Children have a natural enjoyment of and curiosity for observing and thinking about natural phenomena (Eshach, 2011; Eshach & Freid, 2005; Samarapungavan, Mantzicopoulos, & Patrick, 2008). With scientific knowledge and skills including questioning, observation, classification, communication, measurement, and prediction, children explore and learn to explain nature (Sackes et al., 2011; Yoon & Onchwari, 2006). Moreover, through scientific experiences with teachers in early childhood classrooms, young children can be motivated and become more interested in learning science (French, 2004; Patrick, Mantzicopoulos, & Samarapungavan, 2009a). These positive attitudes toward science in early childhood can influence young children's science achievement (Eshach, 2011; Eshach & Fried, 2005; Osborne, Simons, & Collins, 2003; Patrick et al., 2009a).

The next section presents an overview of literature about how and what teachers believe about science education and how their beliefs influence the teaching and students' learning of science.

Teachers' beliefs about the teaching and learning of science

Nespor (1987) stated that teachers' beliefs are the most important factors that influence their classroom teaching. Teachers' beliefs are more powerful and effective predictors than their knowledge in terms of influencing how and what teachers teach in science education (Bryan, 2003; Bryan & Atwater, 2002; King et al., 2001; Levitt, 2001; Lumpe, Czerniak, Haney, & Beltyukova, 2012; Mansour, 2009; Watters et al., 2001; Yilmaz-Tuzun & Topcu, 2008). According to Levitt (2001), "teachers' beliefs about science and the teachers' beliefs about his or her role" in science affect their "decisions about the teaching of science" (p. 4). For instance, empirical evidence has indicated that teachers held beliefs that science classes should be student-centered; specifically, some teachers believed that students should engage in hands-on activities and be active participants in learning science, whereas others believed that learning science is a meaningful process for students to have positive attitudes toward science (Levitt, 2001). Furthermore, researchers have found a correlation between teachers' beliefs and students' learning achievements, as well as students' attitudes in science (Cobren & Loving, 2002; Jones & Carter, 2007; Keys & Bryan, 2001; Lumpe et al., 2012; Osborne et al., 2003; Patrick et al., 2008). Thus, what teachers believe about science can possibly affect how the students perform academically in science.

However, teachers in early childhood education are oftentimes afraid of teaching science (Levitt, 2001; Yilmaz & Cavas, 2008), and they report having trouble teaching science to the students (Minstrell & Van Zee, 2000; Yates & Chandler, 2001). For example, Conezio and French (2002) noted that many early childhood teachers are hesitant or unwilling to teach science in their classrooms. This could be explained by the fact that teachers did not have enough and appropriate knowledge about the content of science materials, making it more likely experience difficulty in teaching the subject (Diffily, 2001; Erden & Sonmez, 2011; Garbett, 2003; Kallery & Psillos, 2001; Nayfeld, Brenneman, & Gelman, 2011; Tu, 2006; Watters et al., 2001). Yilmaz and Cavas (2008) and Seefeldt and Galper (2007) also found that teachers spent less time with preparing for science classes than other subjects. This perception of lack of preparedness among teachers for the teaching of science has influenced their reluctance to teach science due to their low self-efficacy (Seefeldt & Galper, 2002). Eshach (2003) studied the science-teaching efficacy of kindergarten and elementary school teachers and found that teachers' efficacy, beliefs, and attitudes influence their teaching ability in science. Thus, teachers' beliefs or attitudes have a significant relationship to the success or failure of a science curriculum (Cobren & Loving, 2002) because teachers' beliefs or attitudes about teaching science are an important reason for early childhood teachers to devote less time to teaching and preparing science (Sackes et al., 2011). Considering the connections between teachers' beliefs and the possible failure of their science curricula, teacher insecurity can translate into a major obstacle to the success of a science curriculum.

In addition, Nespor (1987) pointed out that beliefs often have emotional and evaluative aspects such as feelings, moods, and subjective evaluations. For instance, how teachers believe the value of the course content can affect how they teach it to students (Bryan & Atwater, 2002). According to previous findings, kindergarten teachers tended to report negative emotions about science, describing it with words such as "boring," "meaningless," "scared," and "impossible" (Tosun, 2000, p. 376). Among those negatives emotions is the fear about teaching science to children in their classes (Yates & Chandler, 2001). Moreover, teachers' dislike of teaching science, often attributed to insufficient professional knowledge of the subject, leads to additional problems in terms of teachers' low levels of self-confidence, self-identity, and self-esteem, which can, in turn, negatively impact their students' learning (Diffily, 2001; Kallery & Psillos, 2001; Zembylas, 2004). Consequently, young children frequently have more limited opportunities to learn science concepts and knowledge than any other subjects in early childhood, even though science experiences at early ages help children to develop positive attitudes toward science that are linked to science achievement (Early et al., 2010; Eshach, 2011; Eshach & Fried, 2005; Greenfield et al., 2009; Osborne et al., 2003; Patrick et al., 2008).

Although the role of teachers in science education for young children is important, King, Shumow, and Lietz (2001) observed that K-8 teachers have limited professional and content knowledge, and this may occur because teachers are not adequately prepared academically. Additionally, early childhood teachers are often hesitant about teaching science because they lack confidence in their own conceptual knowledge and understanding about the teaching of science (Conezio & French, 2002; Diffily, 2001; Kallery & Psillos, 2001; Watters et al., 2001). For example, Kallery and Psillos (2001) showed that kindergarten teachers can be quite nervous about teaching science, and they want help to overcome their fears. Specifically, kindergarten teachers are concerned about their responses to children's science questions and about new topics in science (Kallery, 2004). Annetta and Minogue (2004) contend that current pre-service programs for students who will be elementary school teachers do not adequately prepare them for the teaching of science to their students, and that the inadequacy of pre-service training makes professional development programs more important for elementary school teachers. Other researchers also pointed out that appropriate professional development programs impact teachers' beliefs, attitudes, confidence, practices in teaching and learning science, and even children's science achievement (Eshach, 2003; Furtado, 2010; Goddard, Hoy, & Hoy, 2004; Levitt, 2001; Louck-Horsley, Love, Stiles, Mundry, & Hewson, 2003; Lumpe et al., 2012; Mansour, 2009; Wayne, Yoon, Zhu, Cronen, & Garet, 2008). Moreover, how teachers themselves were taught influences the teachers' own teaching, because “teachers teach as they are taught” (Kubota, 1997, p. 137). Sometimes, the subjects of science themselves present problems for kindergarten teachers. For example, kindergarten teachers may believe physics and astronomy to be the most difficult topics in their science curricula (Kallery, 2004).

Also, Nespor (1987) discerned that teachers' beliefs are influenced by their own experiences as students first, and then by their own teaching in their classrooms. For example, during teachers’ own science education, they accumulate images of science that become profoundly ingrained as educational beliefs about what science education “should be”; consequently, those beliefs shape teachers’ own educational practices (Levitt, 2001). Teachers tend to teach as they are taught in their classrooms (Eshach, 2011; Kubota, 1997). In other words, the teachers' personal learning history and past schooling experiences appeared to inform their beliefs and practices of teaching and learning science (Calderhead, 1996; Mansour, 2008, 2009; Nespor, 1987).

For example, Smith (2003) studied two teachers who had different beliefs about teaching and learning science. The differences were based on their experiences of learning science during their own childhoods. For example, as one of the teachers progressed through school, she learned science in her classes where teachers taught with lectures and discussions; she became successful at memorizing science content. As a result of her learning experiences, she preferred learning through expositive teaching and listening to information transmitted by a teacher, and, thus, she taught science in the same way. On the other hand, the other teacher used constructivist practices in her science instruction and described her interest in science as beginning with her participation in a science fair. The second teacher and her family spent time together reading science books, learning to use microscopes and telescopes, and exploring geological features along a river. She described her best experiences in learning science in school as being when she was applying science to real life, thus, deepening her understanding of science.

The different experiences of those two teachers during childhood affected their beliefs about learning science and continued to affect the ways they taught science. Teachers who believe that knowledge is a set of facts tend to give sets of facts to their students (Yerrick et al., 1997) while "teachers who believe in the importance of students' interpretation of knowledge, focus on the process of transformation of knowledge among students" (Choi & Ramsey, 2009, p. 315). In a similar fashion, Gilbert (2009) found that teachers in early childhood education had difficulty practicing inquiry-based science instruction, including hands-on science activities because they had learned science during their childhoods by a traditional approach, such as teacher-directed science lectures. Thus, teachers' past experiences as students are an important factor in teachers' beliefs and teaching practices (Calderhead, 1996; Eick & Reed, 2002; Eshach, 2003; Mansour, 2008, 2009; Nespor, 1987; Olson & Appleton, 2006; Plevyak, 2007; Smith, 2003; Tsai, 2002).

Additionally, the teachers' childhood experiences along with more recent experiences, such as professional development experiences, influence their beliefs about teaching and learning science. Eshach (2003) found that teachers' self-efficacy and attitudes became more positive after, rather than before, a science workshop, and that taking the workshop was positively related to the teachers' expectations of good teaching outcomes. In other words, through professional development programs, such as science workshops or conferences, teachers are able to develop more positive attitudes with respect to science and to come to expect that they will become better science instructors (Furtado, 2010; Goddard et al., 2004; Levitt, 2001; Lumpe et al., 2012; Mansour, 2009; Moore, 2008). In all, the teachers' background, their personal histories in science classes when they were students and the acquiring of science material in the latter years determine how they teach science (Eshach, 2003).

Teachers' roles in science instruction

Children have innate interest in and curiosity about science and their natural enjoyment of science, such as observing and thinking about nature, is a significant asset for science learning (Eshach & Fried 2005; French, 2004; Patrick et al., 2008; Ross, 2000; Tu, 2006; Worth & Grollman, 2003). According to French (2004) and Sackes et al. (2011), young children are naturally prepared and motivated to learn about natural phenomena, and this condition can be cultivated from science experiences in early childhood by providing motivations and eliciting positive attitudes toward science.

To enhance young children's science interest and learning, the role of the teacher is crucial (Harlan & Rivkin, 2004; Harlen, 2000; Tu, 2006), because young children learn science not only through "what they can do on their own," but also "what they can do when provided with assistance" (Eshach, 2011, p. 438). In particular, early childhood teachers can provide learning environments that offer young children opportunities to observe, explore, and discover scientific materials and objectives. Creating such an environment enables teachers to assist children in developing their intellectual abilities, by observing the children's activities, listen to what the students discuss, and answer their questions (Harlan & Rivkin, 2004). For example, Harlen (2001) emphasized the importance of children's posing questions, because those questions allow teachers to access students' ideas, as well as demonstrate the students' understanding of the subject matter.

There are numerous studies that have examined how teachers help their young students to learn science effectively. Findings from these studies show that, first of all, kindergarten teachers' scientific questions and their responses to the students' questions are important (Hus & Abersek, 2011). According to Harlen (2000), when teachers ask open-ended questions in order to gather information about the students' scientific ideas, it allows the children to change their ideas in ways that lead to more advanced scientific thinking. In those situations, the teachers ask questions that invite children to say what they think, rather than to guess the "right" answers (Harlen, 2000). Previous studies have also shown the importance of teachers encouraging children to explain problems, ideas, actions, misunderstandings, agreements, questions, and possible solutions with regards to science. As a result of teachers' using appropriate questions and responses, the teachers and the children are jointly in discussion about the scientific content (Jurow & Creighton, 2005).

Second, previous studies have found that teachers should have positive attitudes toward science to support the children's science learning, because the positive emotions that emerge among teachers and students serve to develop and maintain the teachers' self-confidence, self-identity, and self-esteem; also, those same emotions are transferred to the students’ learning (Zembylas, 2004). More specifically, early childhood teachers' attitudes toward science influence the students’ long-term attitudes toward the learning of science because young children experience science in concert with early childhood educators (Erden & Sonmez, 2011; Harlan & Rivkin, 2004). That is, kindergarten teachers' attitudes and beliefs about teaching science mainly inspire their students' attitudes toward science through science experiences in early childhood education (Erden & Sonmez, 2011).

In multiple ways, early childhood teachers play a crucial role in science education (Harlan & Rivkin, 2004). Teachers assist children to conduct science through manipulating materials and by encouraging students to discuss their thoughts and ideas with other students and teachers, as opposed to teachers’ merely transmitting knowledge to their students (Chaille & Britain, 2003). According to the NRC (1996), one of the most important roles of kindergarten teachers in science activities is to help students become involved in "doing science" because children learn science through handling, manipulating, and observing a scientific process that guides science hands-on activities (Erden & Sonmez, 2011). "Doing science" is to generate and validate scientific knowledge where "individual acts of observation and explanation are seen to gain their scientific meaning from collective processes of communication and public criticism" (Ziman, 2000, p. 4).

Harlan and Rivkin (2004) suggested four roles that early childhood teachers provide in science teaching. First, teachers serve as facilitators, by offering an appropriate learning environment for children to observe, explore, and discover the nature of materials and objects. Young children learn such concepts as physical, life, and earth science concepts from interactions in the daily experiences with nature (Baldwin, Adams, & Kelly, 2009; Siry & Kremer, 2011). Therefore, the teachers' provision of an appropriate environment for children to interact with nature and scientific materials can be an integral part of how young children understand the natural world.

Second, teachers help children recognize their intellectual abilities by letting the students be thinkers and problem-solvers. According to the Science as Inquiry Standards of the National Science Education Standards (NRC, 1996), in science instruction, teachers at all grade levels need to provide students opportunities to improve their investigative thinking and use scientific inquiry skills, such as asking questions, thinking critically, explaining logically, and communicating in scientific discussions. Therefore, to support children's thinking abilities and inquiry skills, teachers should offer inquiry-based science activities in which young children develop the investigative thinking which is associated with inquiry (Eshach, Dor-Ziderman, & Arbel, 2011)

Third, in early childhood science instruction, teachers observe what the children do, listen to their conversations, and answer their questions. Providing young children with opportunities to discuss about science can show their perspectives and interpretations about science phenomena (Robbins, 2005). In early childhood education settings, there are many conversations and discussions between the children and teachers, and, in these dialogues, the teachers' observations, while they listen to and interact with children, can provide teachers with understanding of how the students think about science phenomena (Harlan & Rivkin, 2004; Siry & Kremer, 2011). Moreover, when teachers focus on children's conversations, they can consider how to facilitate and support children's learning of science concepts (Jurow & Crdighton, 2005; Samuelsson & Pramling, 2009).

Finally, teachers are role models who show curiosity, appreciation, persistence, and creativity in science lessons. In kindergarten, the first formal school, children have opportunities to learn science with the assistance of early childhood teachers (Erden & Sonmez, 2011; Ray & Smith, 2010). Thus, kindergarten teachers' behaviors, from which children generally gain their first science expressions, influence children's long-term attitudes toward science (Harlan & Rivkin, 2004). For instance, in classrooms, teachers act as significant role models of the thinking process, because they thereby scaffold students into science activities (Venville, Adey, Larkin, Robertson, & Fulham 2003). This scaffolding students' scientific thinking is one of the most important elements to teach thinking skills (Kirch, 2007), such as asking questions, communicating ideas, making predictions, and testing hypotheses (Kirch, 2007; Schauble, 2003). Thus, as role models, teachers actively participate in these processes (Erden & Sonmez, 2011).

Relationship of teachers' beliefs to classroom practices

Teachers hold various beliefs and, in particular, their beliefs about science teaching and learning influence their teaching in early childhood science (Bryan, 2003; Mansour, 2009). Richardson (2003) examines beliefs from a broader perceptive and emphasizes the role that beliefs play in addressing an individual's understanding, premise, or proposition about the world. Moreover, beliefs are important because it exerts an influence on attitudes that is predictable (Nespor, 1987).

Among the personal beliefs that teachers bring to their classrooms when teaching young children, teachers' beliefs relative to their teaching practices have emerged as a controversial research topic (Calderhead, 1996). Some researchers found positive relationships between teachers' beliefs and their teaching behaviors (Albarracin & Wyer, 2005; Bryan & Atwater, 2002; Jones & Carter, 2007; King et al., 2001; Levitt, 2001; Watters et al., 2001; Yilmaz-Tuzun & Topcu, 2008), while others did not find such correlations (Calderhead, 1996; King et al., 2001). For example, some teachers say they believe their role is to serve as facilitators and that hands-on science is important, but in actual classroom practices, they may not engage in inquiry-based science instruction (King et al., 2001).

Researchers have tried to explain the differences between teachers' beliefs and their teaching practices through consideration of the external and internal constraints that pressure teachers (Ajzen, 2002; Flores et al., 2000; Gahin, 2001; Goelz, 2004; Mansour, 2009). For instance, Ajzen (2002) suggests several reasons for differences between beliefs and teaching practices, including factors such as learner behaviors, time, resources, and course content as having an influence on the degree of belief-practice consistency. In other words, the relationship between teachers' beliefs and practices is complicated (Poulson, Avramidis, Fox, Medwell, & Wary, 2001). Moreover, it is not easy to investigate teachers' classroom instructional practices. For example, according to Stigler and Perry (1999), although what takes place in classrooms is one of the most important factors that influences students' learning, insufficient evidence is found regards to the practices.

Therefore, a comparison between what kindergarten teachers believe about teaching young children science and how they actually teach science in their classrooms offers opportunities for insights into understanding the possible correlation between kindergarten teachers' beliefs and actual practices; such insights may serve to assist in the improvement of the quality of science teaching (Mansour, 2009; Martin, 2003).

In addition to differences between teachers' beliefs and their behaviors, there was occasionally a strong positive correlation between teachers' beliefs and their teaching practices. For example, there is the train of thought that all teachers have their own beliefs, and these beliefs influence their practices (Bai & Ertmer, 2008; Borg, 2001; Calderhead, 1996; Levitt, 2001; Mori, 2002; Stuart & Thurlow, 2000) because beliefs are regarded as the foundation of action (Borg & Al-Busaidi, 2012). According to Calderhead (1996), "teachers hold many untested assumptions that influence how they think about classroom matters and respond to particular situations" (p.719). As a result, in education research, teachers' beliefs are a significant issue for understanding teachers' thoughts, perceptions, behaviors, and attitudes (Settlage, Southerland, Smith, & Ceglie, 2009) because beliefs are regarded as important indicators of their decisions, choices, and behaviors in their classrooms (Borg, 2001; Eley, 2006; Ertmer, 2005; Jones & Carter, 2007; Keys & Bryan, 2001; Nespor, 1987; Pajaras, 1992). Thus, as strong predictors of behaviors, teachers' beliefs are considered likely to influence how they teach their students and how teachers behave in their classrooms (Bryan, 2003; Bryan & Abell, 1999; Calderhead, 1996; Gess-Newsome, 1999; Luft, 2001; Simmons et al., 1999; Nespor, 1987; Pajares, 1992). Consequently, insights into the potential connection between teachers' beliefs and behaviors may advance future efforts to reform science education and teacher education because teachers may not implement those reforms unless they have developed strong beliefs about the value of the new instruction (Yerrick et al., 1997). In summary, science instruction in early childhood can offer essential opportunities for young children to develop basic understanding of natural phenomena and scientific process skills, such as observing, inferring, and exploring (Sackes et al., 2011). In addition, science experiences in early years enhance not only young children's interest and positive attitudes toward science due to their natural enthusiasm and curiosity about science (Brenneman et al., 2009; French, 2004; Peterson & French, 2008; Tu, 2006; Worth & Grollman, 2003; Yoon & Onchwari, 2006), but also enhance their science achievements in upper grade school (Eshach & Fried, 2005). Thus, early childhood teachers can play a significant role in science education to assist children's science learning by providing appropriate learning environments, being a good role model by showing curiosity and active involvement in science activities, and facilitating children's observations, explorations, and discoveries of scientific phenomena (Erden & Sonmez, 2011; Harlan & Rivkin, 2004).

According to numerous researchers, teachers' beliefs are especially important and effective indicators in terms of influencing how and what teachers teach in science education (Bryan, 2003; Bryan & Atwater, 2002; King et al., 2001; Levitt, 2001; Lumpe et al., 2012; Mansour, 2009; Nespor, 1987; Watters et al., 2000, Yilmaz-Tuzun & Topcu, 2008). According to Calderhead (1988), in early childhood science education, teachers' beliefs significantly affect their perceptions and judgments about their own teaching, as well as their interpretation and development of professional knowledge. Moreover, prior researchers noted that teachers' beliefs are influenced by their past or current experiences, such as learning science as students or participating in science professional development programs (Calderhead, 1996; Eshach, 2003; Mansour, 2008, 2009; Nespor, 1987; Smith, 2003).

According to Ginsberg and Golbeck (2004), in teaching science, there are many issues for future research because “we know little about what actually happens and what can happen when teachers teach mathematics and science to young children” (p. 197). Therefore, it is significant to "investigate what teachers understand about the nature of students’ learning and thinking and what teachers understand” about science (Ginsberg & Golbeck, 2004, p. 197). In addition, it would be beneficial to ascertain how teachers’ feelings with respect to science influence the manner in which they present these subjects (Ginsberg & Golbeck, 2004). Therefore, kindergarten teachers’ beliefs about science education for young children and their practices in their classes can be important (Ginsberg & Golbeck, 2004).

THEORETICAL FRAMEWORK

To examine kindergarten teachers’ beliefs about and practices in teaching science, Calderhead's (1996) categories of teacher's beliefs are adapted into the science context. The following sections provides the description of Calderhead's (1996) categories.

Calderhead's categories of teachers' beliefs

Teachers' beliefs consist of various categories (Uztosun, 2013). Calderhead (1996) suggested that "there are five main areas in which teachers have been found to hold significant beliefs" (p. 719). He created these categories "to identify a variety of contents and forms that teachers' beliefs can take" (p. 715) because he believed that teachers' beliefs influence the ways that they think about their classroom matters and how they respond to their students. The five categories about teachers' beliefs suggested by Calderhead (1996) are: "beliefs about learners and learning," "beliefs about teaching," "beliefs about subjects," "beliefs about learning to teach," and "beliefs about self and teaching role." Below the researcher provides a brief summary of each category.

Beliefs about learners and learning

Teachers have beliefs about the students and the ways their students learn, which influence how they think about teaching and how they interact with their students (Calderhead, 1996). For example, Kallery (2004), who examined the kindergarten teachers' teaching of science, found that in situations where kindergarten teachers could not give correct and immediate answers when their young students asked them scientific questions about a particular topic, the children would lose interest in that same topic over time. That finding exemplifies one way in which teachers' beliefs about their students' learning affect the teachers' instruction in the classroom.

Beliefs about teaching

Teachers hold various beliefs about the objectives of teaching (Calderhead, 1996). Some teachers think that teaching serves to convey their knowledge to their students, while others consider that the purpose of teaching is to guide their students' inquiries. Moreover, “some teachers may view teaching more in terms of developing social relationships and a classroom community; others may see their task in much more academic terms” (Calderhead, 1996, p. 720). According to Smith (2003), some teachers think that learning science through expositive teaching and listening to information transmitted by a teacher is very important. Others believe that learning science in school should consist of their students’ application of science to real life and the deepening of their understanding of science.

Beliefs about subject

Calderhead (1996) noted that each subject has its own meaning and what students know about the meaning of each subject is important. Researchers have shown that a few kindergarten teachers do not have appropriate orientations about what constitutes science and appropriate ways to teach science to young children. For example, Kallery (2001) found that many kindergarten teachers cannot distinguish between science and pseudo-science. In that research, many kindergarten teachers (59.3%) considered both astronomy and astrology to be science, although astrology is a pseudo-science (Kallery, 2001). This indicates that kindergarten teachers may not have appropriate scientific concepts firsthand, but nonetheless, their task is to teach science to the students.

Beliefs about learning to teach

Teachers have beliefs about learning to teach. According to Calderhead (1996), teachers usually consider that "teaching is largely a matter of personality together with a few managerial tactics that can be learned from observing other teachers" (p. 720). Calderhead (1996) noted that teachers hold their own beliefs about their professional development, and how they teach subjects to their students is usually based on their beliefs, which were created when the teachers were learning to teach. That is, teachers' beliefs are related to their "professional development" (Loucks-Horsley et al., 2003); those beliefs may aid or hinder such development.

Beliefs about self and the teaching role

Teachers are inclined to have rather consistent beliefs about themselves, especially in relation to the role of teaching. Those beliefs about their roles as teachers can significantly affect the style of classroom activities that teachers prefer (Calderhead, 1996). Calderhead (1996) noted that "The act of teaching requires teachers to use their personality to project themselves in particular roles and to establish relationships within the classroom so that children's interaction is maintained and a productive working environment is developed" (p. 720). That is, when teachers teach their students, to ensure that their lessons proceed smoothly, teachers depend on their own personalities and on their instructional abilities, which they have developed in their personal relationships with their students (Calderhead, 1996).

The positive as well as the negative emotions of teachers and students about the subjects being taught affect the development and maintenance of the teachers' self-confidence, self-identity, and self-esteem, and those emotions are related also to students' learning (Zembylas, 2004). Among those emotions, teachers' beliefs are related to students' attitudes and learning achievements in science education (Jones & Carter, 2007; Patrick et al., 2008). Therefore, what teachers believe about their roles as they teach science is important.

SUMMARY

In this chapter, a review covering the literature of teaching science in early childhood education is provided, as well as the theoretical framework of this study: 1) the importance of science education in early childhood, 2) teachers' beliefs about the teaching and learning of science, 3) teachers' roles in science instruction, and 4) the relationship of teachers' beliefs to classroom practices. The theoretical framework presented includes a theory about teachers' beliefs, as proposed by Calderhead (1996). The framework explains teachers' beliefs and suggests ways to categorize teachers' beliefs about teaching science for young children.

Teachers' beliefs may significantly influence teachers' classroom instruction; those beliefs have also been found, by some researchers, to be more powerful and effective than their knowledge of science in terms of how and what teachers teach in science education. The first category of teachers' beliefs includes their own beliefs about learners and learning. As Calderhead (1996) explained, teachers have strong beliefs about their students and how they learn, and those beliefs are likely to affect how they teach and interrelate with their students and what kinds of activities they provide in class. Second, in the category of beliefs about teaching, teachers have various beliefs about the nature of teaching. According to Calderhead (1996), those beliefs, in particular, rarely change. Third, beliefs about subjects mean that teachers have beliefs about a subject they teach and what that subject is about. Fourth, teachers hold beliefs about learning to teach. Calderhead (1996) noted that teachers hold individual beliefs about their professional development, and that how they teach subjects to their students is based on their beliefs, which were created when they were learning to teach. Finally, beliefs about the self and the teaching role are beliefs about which teachers tend to be rather consistent. The teachers' beliefs about their roles as teachers can be important in terms of influencing the style of classroom activities that teachers prefer to use (Calderhead, 1996).

The next chapter involves the research methodology of this dissertation. The qualitative approach includes formal and information interviews, and observations of participant kindergarten teachers' science lessons. Those methods were employed to better understand the teacher participants' beliefs about science education for young children and how those beliefs did or did not manifest themselves in their teaching of science.

Chapter 3: Research Methodology

In this chapter, the research methodology is presented, including the research paradigm, the research design, the processes of teacher recruitment, the professional background of the participant teachers, data collection procedures, data analysis, and ethical issues associated with this study.

RESEARCH PARADIGM

Interpretivist paradigm

Research paradigms are the lenses used by researchers to understand the world (Beyer & Bloch, 1996). Qualitative researchers handle multiple concepts or make connections between categories (Corbin & Strauss, 2008), thereby developing a means to understand complex relationships. A paradigm is one of the tools researchers adopt for those purposes (Corbin & Strauss, 2008). Because what researchers see oftentimes differs, depending on what kind of paradigms or theoretical perspectives they choose, different outcomes can occur.

This study is informed by the interpretivist paradigm. According to the ontological perspective of this paradigm, "reality is socially and discursively constructed by human actors" (Grix, 2004, p. 61). It is "apprehendable in the form of multiple, intangible mental constructions, socially and experientially based, local and specific in nature, and dependent for their form and content on the individual persons or groups holding the constructions" (Guba & Lincoln, 1998, p. 206). By using the interpretivist paradigm, researchers seek to understand situations from the point of view of those who experience those situations (Crotty, 2003).

Under this paradigm, the social world cannot be universalized, only comprehended, because it relies on social actors who cannot be generalized to other contexts. Therefore, interpretivists believe that knowledge is something individual, particular, and exclusive (Cohen, Manion, & Morrison, 2007). This constructionist epistemological position leads to studies that aim to present personal worldviews that can lead to a better understanding of the social world (Crotty, 2003). Interpretivism believes that cultures can be understood by studying what people think about, their ideas, and the meanings that are important to them (Crotty, 2003). That is, the world is considered to be constructed by each knower or observer, according to a set of subjective principles peculiar to that person. Consequently, individuals' beliefs, values, and attitudes are one of the important points of interpretive studies (Uztosun, 2013).

According to Hatch (1995), many researchers in early childhood education use an interpretivist framework to concentrate on what participants mean as they generate knowledge. This approach further suggests that the participants' voices are important because they influence the creation of theory. That is, the theory of the research develops from what participants think and how they make meanings, based on the significance of individual and social constructions of knowledge (Beyer & Bloch, 1996).

Tobin and Davidson (1990) noted that, in interpretivism, researchers consider how participants interpret their experiences, along with the researchers' own interpretations and assignment of meaning. Several interpretivist theories specific to educational practice have incorporated the social or cultural contexts that surround schools as important factors that affect educational practices (Beyer & Bloch, 1996). Recently, educational researchers have directed a greater emphasis on the cultural, historical, anthropological, and cross-cultural or cross-national contexts of participants in their studies. In other words, in studies of educational settings, researchers recognize there are many individual factors that influence participants' thoughts and behaviors, and that the participants' contributions are as important as the researchers' own views regarding the studies.

In this current study, the framework of interpretivism is applied to observe and interview participants. That approach, through the teachers' own understanding and thoughts based on their individual and social constructions of knowledge (Beyer & Bloch, 1996), provides an understanding of how the kindergarten teachers in the investigation thought about teaching science, as well as how they actually taught the young students in science lessons.

RESEARCH DESIGN

Qualitative case study

To study kindergarten teachers' beliefs on science education, a qualitative case study is undertaken, in which the researcher focused on "a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident" (Yin, 2003, p. 13). Munby (1982, 1984) noted that the qualitative research methodology is especially appropriate to the study of beliefs because it allows to understand behavior from the participants' own structure of reference (Baker, 2006; Flick, 1998). Duffy (1987) further describes qualitative research as “a vehicle for studying the empirical world from the perspective of the subject, not the researcher” (p. 130). Instead of providing broad, generalized results, employment of the case study method offers detailed, in-depth understanding of particular circumstances (Stake, 1995). The characteristics of the qualitative case study method fit the purposes of this study that sought to understand these kindergarten teachers’ beliefs and the actual teaching practices about science. Pajares (1992) states that “beliefs cannot be directly observed or measured but must be inferred from what people say, intend, and do” (p. 207). This method provided an opportunity to conduct in-depth investigations into what a sample of kindergarten teachers believe about teaching, as well as about the student learning and the nature of science.

Within the interpretivist paradigm, a case study methodology (Yin, 2009) provided an in-depth understanding of a sample of kindergarten teachers’ beliefs and practices in science lessons. By drawing on various sources of information, a case study facilitated an intense investigation of what these kindergarten teachers believed about teaching and learning science. The case study approach is the research methodology used for this study to cover contextual conditions, such as the school and the community. This approach offers the opportunity for deliberate inclusion of the context and multiple sources of evidence (Yin, 2003) to develop insights about the teachers and their practices in both local and global contexts (Erickson, 2004). Therefore, it was also an appropriate research methodology to investigate the complexity of kindergarten teachers’ teaching practices in science lessons.

SETTING AND PARTICIPANT SELECTION

The research data collected for this study was verified by The University of Texas at Austin, and was collected at a public elementary school located in Central Texas. However, the names of the school district, the elementary school, and individual participant teachers have been masked to protect the teachers and the school from public criticism, as explained in the section on ethics at the conclusion of this chapter. In addition, all numbers and percentages about the school district, the school, and the classes are approximated to protect their identities and maintain confidentiality.

The first step to recruit participants was to identify public kindergarten teachers who were willing to take part in this research. Initially, emails were sent to superintendents of several school districts in Central Texas to request permission to conduct research and collect data. After several days, permission was granted to conduct research from the Green Wood Independent School District (ISD), along with a list of elementary schools where it would be possible to work with kindergarten teachers. Then, emails were sent to principals of all of the elementary schools on the list and explained the purpose of the research and asked permission from each principal to work with several of the school's teachers. Within the emails, the researcher wrote the title, purpose, and methods of this research and requested four participants for this study, including experienced and inexperienced kindergarten teachers. The principal stated that several of the kindergarten teachers at Pine Tree Elementary School were interested in participating in this study about science education. After visiting the school in person, four of the five kindergarten teachers agreed to participate in this study and signed the necessary consent forms to participate.

To broaden the understanding, in general, about kindergarten teachers' beliefs on science education, the researcher requested two different types of participants, based on their teaching experience: two participants with extensive experience and two participants with limited experience teaching in public kindergartens (Merriam, 2009). In education research, teachers who have five years or less of teaching experience are considered inexperienced teachers, while those with more than five years of teaching experience are experienced (Peske & Haycok, 2006). The inexperienced participants were selected because teachers' beliefs and teaching styles are considered to be constructed and influenced by their professional experience (Nespor, 1987). This purposeful selection process allows to obtain data on beliefs about science and teaching science held by two different types of kindergarten teachers. It also offers me a broader overview of teachers' beliefs, in general, thus yielding more conceptually dense and potentially useful data (Merriam, 1998).

Green Wood Independent School District

This study was conducted during the spring of 2011 in Green Wood ISD, an urban district, located in Central Texas. Green Wood ISD has an enrollment of approximately 45,000 students. In Green Wood ISD, there are multiple high schools, almost a dozen middle schools, and over 30 elementary schools. The district has a diverse ethnic base with a student population that is African American, Asian or Pacific Islander, Hispanic, Native American, and Caucasian with 77 languages spoken throughout the district. Among the majority of students enrolled in the district, more than 70 percent are of Caucasian and Asian ethnic backgrounds.

Pine Tree Elementary School

Pine Tree Elementary School is a public school in Central Texas that includes kindergarten through 5th grade. There are five kindergarten classes at Pine Tree Elementary School, and four out of the five kindergarten teachers chose to participate in the study. These four teachers worked together as a team to plan their science lessons.

In Pine Tree Elementary School, there are approximately 700 students including 90 kindergartners. The demographics of teachers and students at Pine Tree Elementary School is with more than 52 percent Caucasian students, 31 percent Asian, 12 percent Hispanic, and about 5 percent of the students being of African American, Native American, and other ethnicities. Most students spoke English, and 5 percent were bilingual students. The majority of the teachers at Pine Tree Elementary School were Caucasian, in addition to a few Asian and Hispanic teachers.

All of the teachers who participated in this study were Caucasian females and Texas residents. A description of the professional backgrounds of each participant is as follows.

The Participants

Ms. Parry

At the time of this study, which was the spring semester of 2011, Ms. Parry had been a kindergarten teacher for 36 years, the longest of the four participant teachers. After graduating with a bachelor's degree from a state university in Texas, she was hired to teach kindergarten at Pine Tree Elementary School, where she has continued to teach for 36 years. When Ms. Parry was a high school student, she had an opportunity to work with several Head Start children, an experience that she enjoyed very much and that influenced Ms. Parry to become a kindergarten teacher.

Ms. Jane

At the time this study was conducted, Ms. Jane had been a teacher for 22 years at Pine Tree Elementary School. She taught second grade for six years and then first-grade students for four-and-a-half years before she asked to move to kindergarten, where she has been teaching for 13 years. Ms. Jane graduated with a bachelor's degree from the same university as Ms. Parry. Later, Ms. Jane earned a master's degree, also in Texas.

Ms. Nora

In this study, Ms. Nora was one of the two inexperienced teachers with five years or less experience. As a teacher, she taught fourth grade students in Blue Bird Elementary School for one year and then became a stay-at-home mom for the next eight years. Then, she was hired as a kindergarten teacher at Pine Tree Elementary School. As a university student, Ms. Nora earned a bachelor's degree in education and was certified to teach first through eighth grades, but not kindergarten. However, when she "started [to teach] preschool and watching the preschool" (Interview, 02/01/2011), Ms. Nora realized that, if she "had some preschool experience," that "would add kindergarten on my certificate to open up my opportunities for getting back into the field" (Interview, 02/01/2011). Since obtaining the certificate, Ms. Jane had two-and-a-half years of experience as a teacher and had taught kindergartners for one-and-a-half years at the time of the study.

Ms. Sandy

Ms. Sandy had the least amount of experience. At the time of this study, it was her first year to teach kindergarteners at Pine Tree Elementary School. Ms. Sandy had previously worked for a local Methodist church, where she "was putting together meetings and organizing all of the things …[as]…administrative assistant to the district superintendent" (Interview, 02/08/2011). However, Ms. Sandy always wanted to be a teacher, so she "did an alternative certification program" (Interview, 02/08/2011). For five years before working at Pine Tree Elementary School, Ms. Sandy taught children who were from two to five years old in a preschool.

DATA COLLECTION

Recent studies about science teacher education have suggested new approaches to the content of teachers' beliefs in order to gather a better understanding of the images and ideas that teachers hold about science education (Bryan, 2003), because teachers sometimes need help to understand and think about teaching science for young children.

However, it is also necessary to examine teachers' beliefs and practices in a physical setting, such as a classroom, a school, a community, or a curriculum (Barnes, 1992; Hamilton & Richardson, 1995). The environment would be more familiar and comfortable to the teachers. Therefore, the researcher visited the school and the classroom to collect the data. In detail, to investigate the kindergarten teachers' beliefs and thoughts on science education for young children, three sets of data sources were used: 1) teacher interviews; 2) classroom observations; and 3) educational materials. According to Levitt (2001), it is difficult to investigate people's beliefs by observation. "People may not be able to accurately or adequately represent their beliefs; consequently, beliefs cannot be directly observed" (Levitt, 2001, p. 7). Even though it is not easy to observe people's beliefs directly, they can be assumed through what people say, intend, and behave (Pajares, 1992). Therefore, interviews constitute the main sources of data for this study, which investigated the teachers' beliefs, while observations and teachers' educational materials, such as their lesson plans, supported the data collected from the interviews.

Data collection for this study was undertaken in two phases. The first phase, which occurred at the beginning of this study, in January 2011, included initial interviews with each participant, which were tape-recorded and lasted for approximately one-and-a-half hours each. These semi-structured interviews (Merriam, 2009) provide insight into a "way for [teachers] to explain their unique perspectives on the issues at hand" (Hatch, 2002, p. 23). During the interviews, which are described in more detail in the following section, the participant teachers explained the teaching process and their beliefs underlying the practices in relation to actual science lessons in the classrooms. The teachers' answers in the interviews were meaningful and important because their beliefs were found through observation to be related to their classroom practices (Levitt, 2001). The second phase, the fieldwork phase, which took place from January to May 2011, included classroom observations, follow–up interviews, and final formal semi-structured interviews with each kindergarten teacher. This phase of the study linked the teachers' beliefs and practices relative to science education. During the observation sessions, field notes were taken, which included descriptions of the science lessons in the classrooms. In addition, educational materials used in the science classes were collected. After collecting the materials and data, the teachers' beliefs about science and classroom practices were analyzed.

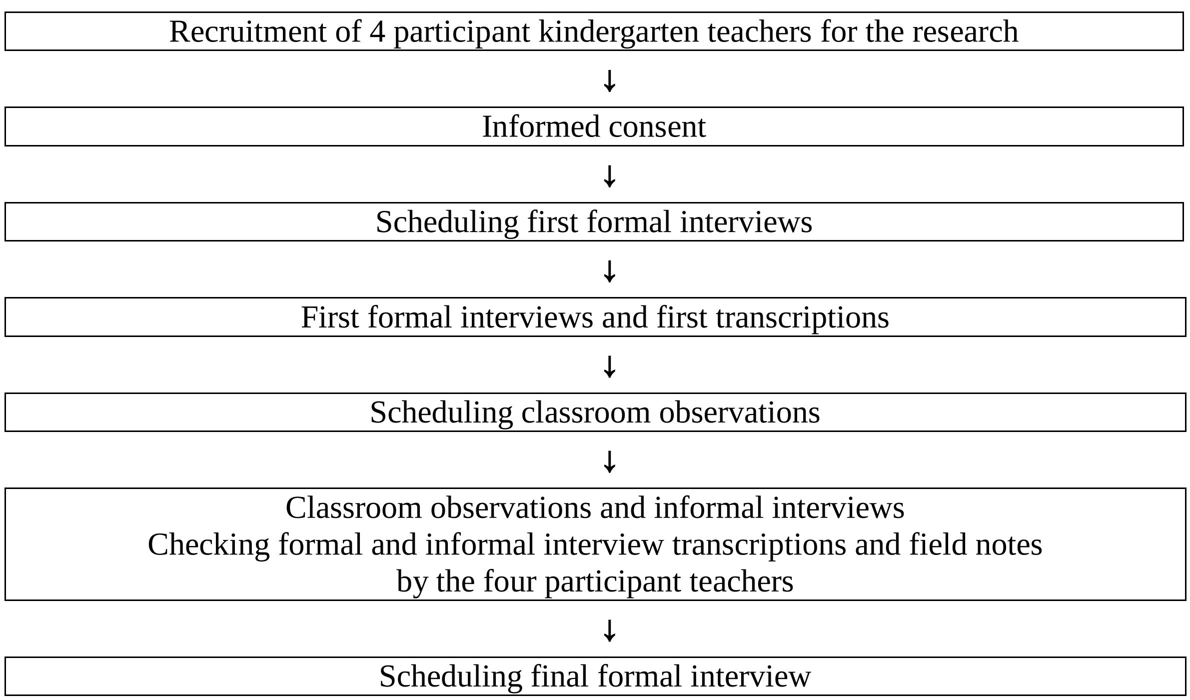

Figure 1: full caption next page.

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Final formal interview and transcripts
Checking formal and informal interview transcriptions and field notes by the four participant teachers

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Analysis of data from interviews,
classroom observations, and educational materials

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Review of the data analysis by researcher

Figure 1: Flowchart of data collection and analysis.

Teacher interviews

An interview is defined as “a purposeful conversation, usually between two people but sometimes involving more, that is directed by one in order to get information from the other” (Bogdan & Biklen, 1998, p.93). Interviews are commonly employed to investigate research participants’ in-depth perspectives regarding their thoughts, feelings, and behaviors (Bartels, 2005). In this study, the teachers were asked to speak about their teaching and beliefs, which were fundamental to the teaching practices and related to actual episodes in their classrooms (Levitt, 2001). The interview responses, therefore, are essential and appropriate to the four teachers, because their beliefs are directly related to the specific classroom practices (Levitt, 2001). In order to comprehend the kindergarten teachers’ beliefs and perceptions about science education, several interviews were conducted with each teacher, including two formal individual interviews at the beginning and the end of the data collection, plus several informal interviews conducted at various times during the research period.

The formal interviews were semi-structured (Merriam, 2009), meaning that the interviews were composed of a series of pre-planned, open-ended questions rooted in the topic under investigation. The pre-structure format offered opportunities for both the interviewer and the interviewees to explore topics in greater detail. The interviews were flexible, allowing the interviewer the freedom to bring up new questions during the interview as a result of what the interviewee said or was asked by the interviewer to elaborate upon (Kvale, 1996).

The first formal set of interviews (See Appendix A) was designed for the purpose of getting to know the professional background of each teacher. This process was undertaken to obtain a basic understanding of the teachers' orientations toward science education. For example, the participant teachers described their science lessons, typical science activities, their roles in science lessons as kindergarten teachers, and included what they thought about teaching science and what they wanted to change in their science lessons. The teachers also explained what science meant to them and their students. In addition, the teachers provided information about their educational backgrounds and experiences of learning science as students. During the second set of formal interviews at the concluding stages of the study (See Appendix B), the focus was on the teacher's belief along with questions related to what the research has observed from the science classes.

Each of the formal interviews lasted about one hour. Before the formal interviews, questions were set by conducting a pilot test with two graduate students who had teaching experience in kindergarten (Mansour, 2007). Additionally, based on the observation sessions, questions were developed and modified to obtain in-depth responses from the teachers.

In addition, information interviews were frequently conducted before or after classes, when the teachers gave me permission to do so (See Appendix C). During the informal interviews, the researcher approached the teachers to get a better picture of what they plan or what happened in the science class. The informal interviews were specially based on observations of the participant teachers' classes, such that the researcher can gather meaningful evidence about their beliefs. The participant teachers were asked to describe "their own teaching and their beliefs underlying their teaching in relation to an actual episode in their classroom" (Levitt, 2001). The formal, as well as the informal interviews, were audio-taped (Yin, 2009). The recording was approved by the four teachers.

Classroom observations

Historically, observation has played an important role in qualitative research (Flick, 1998). The value of observation is that it permits researchers to study people in their natural environment, or in the context of an authentic educational environment, in order to understand issues and events from the participants' perspectives (Baker, 2006). Classroom observations provide important sources and contexts about how the participant teachers' beliefs on science education are enacted (Levitt, 2001). For purposes of observation, the researcher visited the participant kindergarten teachers' classrooms five to six times during the spring semester of 2011, when the teachers were scheduled to teach science. In the observation sessions, the researcher took field notes on the kindergarten teachers' science lessons and, sometimes, audio-recorded the discussions, which are techniques commonly used in education research (Griffee, 2005a; 2005b). Bogdan and Biklen (1998) define field notes as "the written account of what the researcher hears, sees, experiences, and thinks in the course of collecting and reflecting on the data in a qualitative study" (pp. 107-108). Observation field notes also help "the teachers' responses to the interview questions" (Levitt, 2001, p. 7).

Teachers' educational materials

To strengthen the understanding and interpretation of the teachers' science activities, copies of the teachers' science educational materials (e.g., students' science journals or notebooks) and copies of the teachers' lesson plans and any worksheets (e.g., science books for kindergarten teachers) were collected in order to uncover meanings. This practice was to improve the validity of the study using multiple data sources to confirm the emerging findings based on interviews with the participant teachers, observations of their science lessons, and obtained copies of educational materials (Merriam, 1998). The researcher also took digital photos of the various materials that teachers used for their science activities, such as manipulatives, pictures, or drawings, as well as the teachers' science journals. For example, when observing Ms. Jane's temperature activity on February 1st, the students classified hot and cold objectives, such as a snowman, the sun, and ice cubes. They cut out pictures of hot and cold things and glued them onto a sheet of paper that was divided into categories of hot and cold. Then they colored or wrote the names of the things that they had classified.

DATA ANALYSIS

The analysis of the data proceeded concurrently and interactively during the collection phase. That process of analysis addresses “the identification of essential features and the systematic description of interrelationships among them” (Richards, 2003, p. 270). In this research, “data analysis is a systematic search for meaning” (Hatch, 2002, p.148). In qualitative studies, a rich and meaningful analysis of the collected data should be regarded, according to Merriam (1998), as qualitative research that is part of a holistic process; a rich and meaningful analysis of the data should be an interactive process of data collection, analysis, and even reporting carried out at the same time. That approach was beneficial in this study because it allowed for shaping the direction of future data collection based on what the researcher was finding or not finding (Hatch, 2002). Based on that approach, all the observations and audio-taped data were transcribed (Strauss & Corbin, 1998), and then audio tapes were reviewed and field notes were developed after each observation.

Each participant’s data set, including interviews, observations, and educational materials, was analyzed carefully and separately and searched for major themes. The researcher coded the data manually, looking for patterns, categories, and themes that emerged from the collected data. Additionally, the researcher compared and contrasted data sets, based on patterns, categories, and themes that emerged, taking into consideration the context of each data set (Strauss & Corbin, 1998). First of all, the researcher broke down all the data into the smallest units or chunks. The researcher reviewed the field notes, transcripts, and the memos, paying attention to the participants' beliefs or behaviors in connection with science education. Once each unit has been labeled, related contents and contexts information were described and interpreted. Second, the researcher labeled all the units and sorted the data into categories that seem to pertain to the same phenomena. From this, category titles were developed. In the third step, the researcher began to integrate categories and find patterns among these categories. The researcher reviewed all the information numerous times to recognize if there were relationships between each category, in order to formulate themes.

At each step in the process of my analysis, the researcher wrote memoranda about the "tentative analysis, thoughts, interpretations, questions and directions for further data collection" (Strauss & Corbin, 1998, p. 110). In the memos in which the researcher wrote the ideas and impressions, reflections and insights were inserted based on the researcher's point of view. The researcher used the memos as a tool to provide "a running record of insights, hunches, hypotheses, discussions about the implications of codes, additional thoughts, what not" (Strauss, 1987, p. 30-31). With the data, including interviews, observations, educational materials and analytic memos, the researcher attempted to develop descriptions, engage in analysis, create interpretations, identify patterns and themes, and discover relationships.

Data were coded using both external and internal codes (Graue & Walsh, 1998; Hatch, 2002). With four external codes, the researcher then generated subcategories as new constructs emerged (Graue & Walsh, 1998). Primarily, the data were coded according to the four categories of teachers' beliefs as proposed by Calderhead (1996). The teachers' beliefs were broken down into the following categories: "beliefs about learners and learning," "beliefs about teaching," "beliefs about subjects," "beliefs about learning to teach," and "beliefs about teaching role." As the study progressed, the researcher generated subcategories based on observations and conversations, which were used for further coding and organization (Graue & Walsh, 1998).

The following table (Table 1) operationalizes the constructs of categories about teachers' beliefs (Calderhead, 1996). The table includes each aspect of teachers' beliefs, an example list of teacher behaviors from observations, and their responses in the interviews. For the category on teachers' beliefs about learning to teach, the content was only interpreted based on teachers' interviews, as observing the phenomenon pertaining to this category was not possible.

Construct	Observations of the participant teachers in science lessons	Interviews with the teachers
Teachers' beliefs about students in science lessons	The teachers try to give opportunities for the students to have discussions in order to support learning "how to think."	Through science lessons, the students need to learn "how to think." The teachers wanted to support children's interest in science.
Teachers' beliefs about teaching in science lessons	The teachers have hands-on activities, such as observations of plants, animals, and rocks, cooking ice cream, investigations. To manage science classes, the teachers ask for parent volunteers.	Scientific hands-on activity is one of the most important teaching methods in science lessons. When the teachers teach the students in science lessons, they also emphasize classroom management.

Table 1: full caption next page.

Teachers' beliefs about science as a subject	Sometimes, the teachers have unexpected science activities from the students' interests, such as a caterpillar activity from a girl who brought one from her home. Through these activities, the teachers encourage the students' interest in science topics.	The teachers believe that science is in children's surroundings and should be fun. The teachers have negative experiences of learning science as students.
Teachers' beliefs about learning to teach science		The participant teachers believed that science professional development programs needs to be held.
Teachers' beliefs about teaching role in science lessons	The teachers participate in science activities actively as a good role model for the students.	The teachers believe that their most significant role is as a "facilitator."

Table 1: Categories of teachers' beliefs and practices in science lessons

To develop internal codes, the researcher reviewed all data (Graue & Walsh, 1998), paying attention to the participants' perceptions or behaviors in connection with science education. From the data, the researcher identified emerging themes that were common across all the participant teachers.

During the analysis process, all data were broken down and reconstructed, based on the information gathered, in order to make sense of the data. The process served to address "the identification of essential features and the systematic description of interrelationships among them" (Richards, 2003, p. 270). Once each unit of the data was labeled, related content and contextual information was described and interpreted. Next, the researcher labeled all the units and sorted the data into categories that seemed to pertain to the same phenomena and developed category titles. In the third step, the researcher began to integrate categories and found patterns among categories. Finally, a review process of checking the information multiple times was carried out to determine whether there were relationships between the categories in order to formulate themes. These steps were derived from the repeated description and reconsideration of emerging patterns developed from the observation field notes and interview transcripts, rather than from the imposition of predetermined categories (Aubrey, 1996). In addition, in the review process, the researcher was careful to understand the unique aspects of the teachers' work (Goldstein, 2007).

In the analysis stage, the researcher improved the primary categories to ensure that each was related to the research questions and that all relevant data fit into one category (Merriam, 1998). Through these steps, the participants' responses with common or similar expressions were arranged together into general descriptions (Levitt, 2001). As a result, it was possible to generate more themes, such as "teaching how to think" or "teaching to support interest toward science."

TRUSTWORTHINESS AND CREDIBILITY

In order to strengthen the trustworthiness of the data analysis, the researcher used prolonged engagement by testing my interpretations with the participants by asking each participant if the summarized notes accurately reflected their position. Triangulation was also checked by using multiple methods or sources of data, including interviews, observation, and document review (Merriam, 2009). Additionally, one of the primary criteria for establishing credibility is the process of member checking (Mertens, 2005).

As a part of the member-checking process, the researcher asked the participants if they considered that the findings of this study, based on observations, formal and informal interviews recorded in the field notes, interview transcriptions, and memos, accurately reflected their thoughts. The interview transcripts, observation field notes, and memos for each teacher were shared with that particular teacher. In addition, the researcher showed the findings, which were used to develop the descriptions, analysis, and interpretations. Then the researcher asked the participants the following questions: "What stood out to you when you read the findings?"; "Could you please let me know if you have any questions or concerns that you want to share after you read the findings?" The responses that the participant teachers provided to the questions were helpful to evaluate and refine the initial findings.

In those ways, the participants had additional opportunities to share with the researcher any other ideas, concerns, or questions they may have had (Lincoln & Guba, 1985). This procedure enabled the researcher to develop a holistic understanding of the situation and to create plausible explanations about the phenomena that the researcher was studying (Merriam, 1998).

Next, the researcher used the triangulation developed in this study to reinforce the trustworthiness of the qualitative case study method (Hatch, 2002; Lincoln & Guba, 1985; Mirriam, 1998), in accordance with contemporary recommendations for conducting case studies in schools (Maxwell, 1996). “Data were collected by interviews and from observing the same teachers, so as not to bias conclusions by focusing on only one data source” (King et al., 2001, p. 94). The triangulation developed in this study relied on multiple data sources--the participant teachers' formal interviews, informal conversations, classroom observations, and the teachers' educational documents relative to their science lessons--, which were used to create and support descriptions, analyses, and interpretations. During the formal and informal interviews, the researcher asked the teachers questions about what has been observed during their science lessons, in order to confirm my observations. In addition, in the observation sessions, the researcher focused on information collected from the formal and informal interviews, to validate what teacher had mentioned in the interviews.

Additionally, the researcher tried to provide rich and thick descriptions of teachers' interviews and classroom observations to establish external validity, which was "the extent to which the findings of a qualitative study can be generalized to other situations" (Merriam, 1998, p. 218). Through this process, the researcher wanted the readers of this study to "determine how closely their situations match[ed] the research situations, and hence, whether findings [could] be transferred" (Merriam, 1998, p. 211).

ETHICAL CONSIDERATIONS

To protect the participants professionally and in accordance with the regulations of the Institutional Review Board (IRB) at The University of Texas at Austin, the researcher provided each participant with an informed consent form. The details of the study were provided to the teachers. Each participant teacher signed the consent form, and afterwards each was provided a copy.

The researcher was responsible to ensure that all conducts were in a moral and professional manner (Canella & Lincoln, 2006). First, the researcher honored the rights of the participants throughout the data collection procedures. The researcher explained to the participant teachers the purposes of the research, the necessity and procedure of their participation, and the use and security of their data. The researcher also informed them that their participation was on a voluntary basis and that they could withdraw from the research for any reason, at any time, and at no disadvantage. Additionally, the researcher gave them an opportunity to check and ask questions whether their statements were correctly recorded and transcribed (Bhutta, 2004). Second, the researcher attempted to protect the privacy and confidentiality of the participants in several ways. Anonymity is guaranteed by using pseudonyms for the teacher's names, the names and location of their school and the independent school district. Moreover, in describing the school and the independent school district, the researcher did not provide exact information about the number of students enrolled or the exact demographic percentages of various ethnic groups. The researcher assured the participants that the identifying data would not be made available to anyone who is not directly involved in the study. The participant teachers were informed that the researcher would not use any information for the current study if they did not want for me to do so (Helgeland, 2005). All the teacher participants checked and reviewed the transcriptions of their interviews and were asked to inform me if there were any parts they did not want to be publicly identified.

SUMMARY

Chapter 3 described the research methodology used in this study. There are explanations about the methods of this qualitative case study and the interpretivist research paradigms that were employed to investigate kindergarten teachers' beliefs and practices in science education. Next, the researcher explained how the elementary school and the participant teachers were selected for this study. Brief backgrounds of the school along with the teachers are included. This is followed by detailing the data collection procedure: formal and informal interview, classroom observations, and review of educational materials. The data was coded based on Calderhead's (1996) categories about teachers' beliefs: beliefs about students in science lessons, beliefs about teaching in science lessons, beliefs about science as a subject, beliefs about learning to teach, and beliefs about teaching roles in science lessons. Additionally, subcategories are introduced and modified to fit the categories particular to this research study.

Strategies to establish credibility were next discussed, including triangulation, member checking, prolonged engagement, and rich, thick description (Merriam, 1998). Furthermore, the researcher detailed the procedures that were used to avoid potential ethical issues that could possibly arise regarding data collection and the distribution of results.

The next two chapters provide the description of the findings that emerged from the analysis of the collected data. Chapter 4 addresses the participant kindergarten teachers' beliefs, based on categories recommended by Calderhead (1996). Then, chapter

5 examines the participant teachers’ teaching practices in their science lessons, describing how they taught their students and what they did in their classrooms.

Chapter 4: Kindergarten Teachers' Beliefs

This dissertation addresses two research questions:

1) What do a sample of kindergarten teachers believe about teaching science?
2) How do these kindergarten teachers demonstrate their beliefs about science teaching in their practices?

This chapter focuses on findings based on the first research question. Findings related to this research question stem from data collected by interviewing the four teachers, in addition to reviewing and analyzing the teaching materials from their science lessons. Each teacher participated in two formal interviews and numerous informal interviews.

Findings about the teachers' beliefs are presented according to five of Calderhead's (1996) categories about teacher beliefs. Calderhead's (1996) categories are extrapolated in the science education context. Those are: 1) beliefs about students in science classes, 2) beliefs about teaching science classes, 3) beliefs about science as a subject, 4) beliefs about learning to teach science, and 5) beliefs about teachers' role in science classes. Coding the interview content into these five categories provides insights into the teachers' beliefs about science education.

CALDERHEAD'S CATEGORIES ABOUT TEACHER BELIEFS

Calderhead (1996) organized teachers' beliefs into five categories. Extrapolating to the science education context, the first set of beliefs reflects how the student is supposed to learn during science classes. Calderhead (1996) noted that teachers have preconceived notions that children are able to learn in an emotionally secure environment in which failure is allowed, exploration occurs through open-ended activities, and the process involves trial and error. The teachers' observations of students' efforts (Peterson & Barger, 1984) or students' personal characteristics (Rohrkemper & Brophy, 1983) additionally influence the extent to which teachers think about what to teach and what activities to conduct in class. If teachers support students' learning in science, the children become engaged in learning science (Jones & Carter, 2007) and create positive attitudes and academic success in science (Erden & Sonmez, 2011; Harlan & Rivkin, 2004).

The second category relates to teachers' beliefs about teaching (Calderhead, 1996). From a goal-oriented perspective, some teachers think that teaching is the conveyance of knowledge to students and is tied to future academic success (Bryan, 2003), whereas other teachers believe in an interpersonal relationship in which teachers guide students, develop social relationships, and create a classroom community (Calderhead, 1996).

The third category, which deals with teachers' beliefs about science as a subject, is the category that involves Calderhead's (1996) notion that each content area carries its own meanings from the teachers' perspective. Depending on teachers' beliefs associated with a subject area, students can be influenced by a teacher's perceptions. For instance, studies have documented that kindergarten and elementary school teachers' negative attitudes toward science subsequently influenced the teachers' own self-cognition, such as self-identity and self-esteem (King et al, 2001; Levitt, 2001; Watters et al., 2001). Once those teachers incorporated those self-cognitions about science, the students who had to learn from those teachers were also negatively impacted (Bryan, 2003; Zembylas, 2004).

The fourth category is that teachers hold beliefs about learning to teach science. Calderhead (1996) suggested that teachers have their beliefs about professional development when they were learning the processes of teaching. For instance, Eshach (2003) found that the kindergarten and elementary school teachers had positive beliefs toward teaching science after science workshops. The reason was that they could acquire new teaching methods to support and stimulate the students' scientific thinking. Therefore, teachers' beliefs are connected to their professional development (Loucks-Horsley et al., 2003).

The fifth category, which concerns teachers' beliefs about their roles in teaching science lessons, is rooted in the following comment: "The act of teaching requires teachers to use the personality to project themselves in particular roles and to establish relationships within the classroom so that children's interaction is maintained and a productive working environment is developed" (Calderhead, 1996, p. 720). In other words, teachers tend to rely on their own individual differences, such as personalities and teaching abilities, to ensure that class lessons proceed in an efficient and effective manner (Calderhead, 1996).

In this study, five categories of teachers' beliefs set forth by Calderhead (1996) are addressed: beliefs about students in science lessons, beliefs about teaching in science lessons, beliefs about science as a subject, beliefs about learning to teach science, and beliefs about the teaching role in science lessons. Some categories have several supporting sub-categories and are modified to recognize the teachers' beliefs about a specific area, science education, rather than all kindergarten curricula.

TEACHERS' BELIEFS ABOUT STUDENTS IN SCIENCE LESSONS

Calderhead (1996) explained that teachers have strong beliefs about students in general and how the students learn. Those beliefs are related to how teachers teach and interact with the students and what kinds of activities they provide in the classrooms. In this study, the participant teachers' beliefs about students in science lessons consist of two sub-categories: teaching "how to think" and teaching to support the students' interest. The teachers pointed out that, when students learn “how to think” and followed their interests in science lessons, they learned science more effectively.

Teaching “how to think”

Educators who are interested in children acquiring scientific thinking skills view their interaction in children's cognitive development and science education as a way to help the students become better science students (Zimmerman, 2007). In science instruction, it is important to help students acquire ways of thinking that are fundamental to domain knowledge (Samarapungavan et al., 2008). Lotter, Harwood, and Bonner (2007) found that, in science education, teachers believed that effective teaching supports the students' independent thoughts. The teachers who participated in this study also mentioned that they would like to support their students' thinking in science lessons. They believed that, in science lessons, learning “how to think” was important for the students to learn science.

Ms. Sandy stated, “Science is a good one [subject] for them [the students] … to learn to think” (Interview, 02/08/2011). In order for the students to be able to learn "how to think," her approach was to induce questions from the students. She added,

> One of the biggest things [in science lessons] I think is just for them [the students] to be able to think. Just learning how to think… I just think that’s important to be a learner and to grow to be a thinker. (Interview, 02/08/2011)

She explained that “[if students do not think], they don’t [ask] questions or think about things [in science lessons]” (Interview, 02/08/2011). For Ms. Sandy, learning “how to think” was helpful for the students to participate actively in science lessons through asking questions and thinking about topics. In addition, for Ms. Sandy, learning "how to think" was not about special topics by teachers. Instead, it involved students thinking independently about their surroundings; she noted that students needed to develop "think[ing] about their world and their environment” (Interview, 02/08/2011). Her statements are consistent with Seefeldt and Galper’s (2007) claim that the goal behind “sciencing” with students is to build thinking skills in order for them to investigate the world (p. 12). In other words, thinking does not simply involve processing directions from the teacher, but it also requires the students to think for themselves.

Other teachers also emphasized the notion of "how to think" when talking about what they wanted their students to learn in science. Ms. Jane commented, “I feel like we [the teachers] need to teach them [the students] how to think, and all of that is part of the educational process” (Interview, 01/31/2011). For Ms. Jane, once students learn "how to think," they are better prepared for future learning in school and life. She added,

> It's important for kids to think about science because they're our future doctors and our future researchers, and you want them to appreciate and to see things that way now. And I realize that I am teaching those future doctors and scientists, and for them to think about that now – it makes them feel good. They respect science. It's like, “Oh, we are going to be scientists today. We are going to think like a scientist.” And they love that. (Interview, 01/ 31/2011)

Ms. Jane believed that it is important for students to construct meanings based on science by linking their experience in personal life with the learning from science classes. She also believed that "science is just everything in nature," such as "gravity," “temperature," "leaves changing colors," and "soil." Her approach involved "reminding the children to think about that” (Interview, 01/31/2011). Consequently, Ms. Jane believed that her five-year-old students are "very science-minded already" (Interview, 01/31/2011). She believed that her students have a natural interest in and enthusiasm about science and that what children learn in the early childhood years can better prepare them for science learning in future educational processes.

She mentioned the word “scientist” several times during the interviews. In other words, Ms. Jane emphasized that, in science activities, her students learned to think like scientists, and she wanted them to carry that perspective into their everyday lives, so that they would make sense of the world through scientific thinking skills. Similar to Ms. Jane’s belief about science as a subject for young children, researchers noted that students learn science through training to think for themselves in their daily lives (Fleer, 2009; Howe, 1996; Williams, Papierno, Makel, & Ceci, 2004).

Ms. Jane believed that she "need[s] to teach them how to learn [science], and teach them how to think [in science instruction]” (Interview, 01/31/2011). For Ms. Jane, learning "how to think" about science, particularly about the children's natural environment, is helpful to maintain a positive attitude towards science that the children naturally have and prepare for future science learning.

Ms. Parry also mentioned that she wanted to support the students to “be aware of their [the students’] surroundings and to think beyond just what they are being told or what they are doing at the moment” (Interview, 05/03/2011). She stated that that is one of her “main goal[s]”: to help the students to develop thinking skills in the science lessons. Ms. Sandy believed that, through the process of thinking, they acquired scientific thinking skills, such as reaching reasonable conclusions. According to prior literature, scientific thinking skills include the children making predictions from their observations and deriving conclusions (Carey, 2004; Kuhn & Pearsall, 2000; Opfer & Siegler, 2004; Zimmerman, 2000). Additionally, various other researchers have found that, through learning how to think in early childhood science education, children develop scientific knowledge and inquiry skills that are related to not only their cognitive development but also current and later science achievement (Eshach & Fried, 2005; Patrick et al., 2009a; Samarapungavan et al., 2008; Sackes et al., 2011). According to Sackes, Trundle, & Flevares (2009), children who had opportunities to improve scientific thinking skills in early childhood science education show better understandings of complicated science concepts in upper grades.

Ms. Nora also said, “It [learning how to think] helps to develop their brain and their thinking and allows for more in-depth thinking” (Interview, 02/01/2011). Ms. Nora believed that “science allows for more in-depth thinking versus just regurgitating information, memorization… the higher thinking skills” (Interview, 02/01/2011). Ms. Nora’s statement appears to reflect a belief held by all the teachers interviewed: that science is an appropriate subject for learning "how to think". As observed by Venville, Adey, Larkin, Robertson, and Fulham (2003), “thinking can be taught or trained and that improvement in thinking can realize the greater intellectual potential of a person” (p. 1315).

Teaching to support interest toward science

Teachers’ beliefs about teaching and learning are related to students’ learning and interest in the subject (Levitt, 2001). Indeed, one of the most important roles for teachers is to realize what maintains students’ interest in science (Jones & Courtney, 2002; Smith, 2001). In this study, a second sub-category also found in the teachers’ statements of beliefs about students in science lessons centered on promoting and/or supporting students’ interest in science.

By introducing science activities into the lessons, the teachers' plans involved generating excitement and creating fascinating experiences for the students. These emotions were described as key to the learning process. When discussing the idea of generating students’ interest in science through exciting activities, Ms. Nora mentioned:

> I think what is important is their [the students’] experiences in the classes, in the experiments, their insights, their “Wow! I got it.” Or, “I can do this, if I do this.” And “Look at what I have done.” I think that’s important, because that is going to keep hunger for science. That’s going to keep the interest, if they are the ones finding the information, they are the ones finding the “aha!” moments. My “aha” moments aren’t going to help them. (Interview, 02/01/2011)

Ms. Nora thought that, when students experienced the "aha" moments in the science lessons, they would want to learn more about science. To create the "aha" moments, Ms. Nora designed the science activities to be interesting. By doing so, she thought that this would motivate the students to participate and discover what was pertinent to the science activities. In the beginning, she was apprehensive that, if the activities were uninteresting, the students would become distracted and lose their focus. Ms. Nora commented: “I don’t want them [the students] to be bored. I have got to keep their attention. They are kindergartners. If I don’t, they are going to be running all over the place [laughs]” (Interview, 02/01/2011). Ms. Nora wanted the students to focus and actively take part in the science activities.

Ms. Parry also wanted to support the students’ interest in science, and she remembered a “bubble activity” as an unplanned science activity whereby students “came up with questions that they [the students] had about bubbles.” In the bubble activity, “they made different shapes out of pipe cleaners… and we [the teacher and students] took it outside and tried it.” Then “all kids blow [blew]” and “discover[ed] different shapes of bubbles and they enjoy[ed] it” (Interview, 02/01/2011). She believed that “science is important” and that the students “need to learn that science.” Therefore, if the students would “be interested in it [learning science]” and “they feel that it is not too hard and that it's fun,” then they will “love doing science” (Interview, 02/01/2011).

Ms. Jane's statements reflected a belief that teaching science through engaging activities would foster a positive attitude towards science. By having the students participate in engaging science activities, students are “like little sponges and they pick up everything” (Interview, 05/10/2011). When students were able to "pick up" information as Ms. Jane suggested, they enjoyed the experience of learning science. She commented, “It [science] is fun for me, and so, if it’s fun for me, I hope that I am making it fun for them… I enjoy it like I want them to” (Interview, 01/31/2011).

To support the students’ interest, she occasionally held unplanned activities. For example, during the interview, Ms. Jane recalled a prior activity, stating:

> I can remember a few years ago, just during the middle of the day, this tarantula was walking across our doorway in the hall. Well, there’s a science lesson – most definitely not one that I had planned, but we caught the tarantula and put it in the bug box and looked up tarantula information and printed out tarantula information. (Interview, 01/31/2011)

She called the situations in which she supported children's unexpected scientific topics, "go[ing] where the kids lead you [a teacher]" (Interview, 01/31/2011). In the tarantula activity, Ms. Jane supported the children's interest in tarantulas through observations and questions. First of all, she noted that she and her students observed it and described its color, shape, and hair. During the observation, she asked questions and made comments for the students to think about the research involving tarantulas (e.g., “Oh, my gosh! It's so hairy,” and “Look, it’s brown here and black there. Why is that?”). Then, she stated that the "kids [went] to the library to look up their questions and then printed out information" (Interview, 01/31/2011). Because it was not a planned activity, Ms. Jane did not have prior information about tarantulas. Instead, she suggested to the children how they could get the answers to their questions about tarantulas. The students "immediately went and checked out books from the library" (Interview, 01/31/2011).

Ms. Jane remembered another “unexpected science activity” during which she was following the students' interest, on the morning of the interview day (01/31/2011). She started teaching about media literacy and where students could get information. It was a social studies lesson that was combined with a science activity. Afterwards, Ms. Jane asked the students about meteorologists, which led the students to gather information about meteorologists from the Internet and books. During that process, the students also learned about weather changes and temperature. Ms. Jane noted that was an “unexpected” and “funny” science activity in the middle of social studies. Later, Ms. Jane and the students went outside and talked about the weather forecast. Ms. Jane added

> When we [Ms. Jane and her students] were going outside, I said that we had better really enjoy our time outside because the weather was going to change. And I had kids say, “Yeah, it's going to get really cold, and it's going to be windy.” (Interview, 01/31/2011)

Ms. Jane pointed out “there’s science, right there [in media literacy]” (Interview, 01/31/2011). The reason why Ms. Jane picked the unexpected activities was that she had had “observations” and “discussions” with the students before they focused on the topic. Ms. Jane explained that, during the discussions, she asked many questions, and had “kids do sticky notes on charts about what they [the students] already know about things and questions they have” (Interview, 01/31/2011). Through this process, Ms. Jane was able to recognize “which way they [the students] want to go with the subject” (Interview, 01/31/2011). Through unexpected science activities, Ms. Jane supported the students’ interest in science by choosing topics from the children's experiences, such as tarantulas and weather, and she supported effective science learning by focusing on not only the gaining of knowledge but also children's participation in activities through their observations and discussions.

Therefore, to support the students’ interest in science activities, the participant teachers used various ways to reach the students’ interest levels, such as finding their “aha moments” in science lessons and choosing unexpected science activities related to the students’ interests. The unplanned science activities were initiated by the teachers to take advantage the "aha moments". Through unexpected activities, children have opportunities to discover their own ways of inquiry and to communicate what they have found with other students or teachers (Erden & Sonmez, 2011; French, 2004).

BELIEFS ABOUT TEACHING IN SCIENCE LESSONS

When examining how the teachers discussed their beliefs about teaching science, this study found their primary concern appears to be a need by teachers to support their students' curiosity about science. Hadzigeorgiou (1999, 2001) noted that children’s curiosity is not only vital to learning but also presents challenges to stimulate conceptual development in science education. For instance, hands-on science activities can make students more excited, curious and encourage science skills, such as "observing, describing, recording, and hypothesis testing" (Hadzigeorgiou, 2001, p. 67). To build or sustain curiosity, the participant teachers focused on two teaching strategies: Teaching science through hands-on activities and classroom management in order to effectively teach science.

Teaching through hands-on activities

Hands-on activities in science lessons can enhance improvement of children's curiosity and enthusiasm about science (French, 2004; Hadzigeorgiou, 2001), since young children have an inherent curiosity about the natural world and hands-on science activities are appropriate methods to learn about the functions of everyday life (French, 2004; Ross, 2000; Tu, 2006). Thus, according to the NRC (1996), teachers need to place an "emphasis on guiding students in active and extended scientific inquiry" (p. 52), because it is helpful for promoting children's rigorous and reflective science learning (American Association for the Advancement of Science [AAAS], 1993). Also, the quality of the early childhood environment where children engage in hands-on activities can build an early interest and knowledge base in relevant and important science content areas, as well as provide an introductory familiarity with basic science inquiry skills (Greenfield et al., 2009).

To encourage the students' interest and to awaken their curiosity about science, the participant teachers in this study prioritized the use of hands-on activities in their statements about the beliefs about teaching science. For example, Ms. Nora said that "science for kindergarten should be hands-on" (Interview, 02/01/2011), and Ms. Parry noted "that's important: that they [the students] do hands-on [in science lessons]" (Interview, 02/01/2011). Also, Ms. Sandy "would love to have as many hands-on things as I [she] can do [in science instruction]" (Interview, 02/08/2011), and Ms. Jane mentioned, "Science needs to be hands-on" (Interview, 01/31/2011). As such, all of the participant teachers considered hands-on activities in science lessons to be important.

Ms. Nora strongly believed in using hands-on activities when teaching her students about science. She commented:

> Science consists of hands-on. I really think hands-on is big. It develops more inquiring thinking where they [the students] can … Instead of you just up there telling them that this is the information. So, I mean, I think that a really big part of science is just really truly experiencing it. The best you can. (Interview, 02/01/2011)

Ms. Nora found that hands-on activities were a critical element in her science lessons because “science is an inquiring academic [subject]” (Interview, 02/01/2011). Additionally, she believed that, in science lessons, hands-on activities encourage students to become “really involved in what’s going on” (Interview, 02/01/2011). Ms. Nora believed that students should have “an opportunity to explore on their own thoughts and ideas and go from there [to hands-on activities]” (Interview, 02/01/2011). Ms. Nora’s thoughts about hands-on activities were that they served to “provide enough in-depth exploration of science experiments and science topics” to let the students “share their thoughts and trust their ideas” (Interview, 02/01/2011). In other words, science activities were introduced to include a time for experiments followed by time devoted to discussing the students' thoughts and ideas.

Ms. Sandy believed that offering students hands-on activities was a critical element in designing effective science lessons. She emphasized the importance of hands-on activities with her students because those activities offered a helpful way for students to "really remember" what they learn in class (Interview, 02/08/2011). For Ms. Sandy, hands-on activities allowed students to be “more active and more involved.” She explained, “It’s [hands-on activity] not just me telling them [students] something… they have something they can do with the activity" (Interview, 05/11/2011). Ms. Sandy also wanted to hold more hands-on science activities. She commented, "I just wish we did a lot more hands-on science" (Interview, 02/08/2011). She thought that, through hands-on activities, students "could get a grasp of what is going on [in science lessons]" (Interview, 05/10/2011).

Ms. Parry viewed hands-on science activities as an important part of science lessons. She presented a general guideline for what to do in the activities, and then the students were free to explore, as described below:

> For example, letting them make bubble blowers and letting them try the bubbles instead of me standing there and saying, "Look, I have these different shapes of bubble blowers. Watch me blow the bubbles." They actually got to go outside and blow the bubbles and make their own bubble makers, you know. And I think that's important. They need, they need to be hands-on. They need to do it. We shouldn't just be standing up there and modeling for them. (Interview, 02/01/2011)

Ms. Parry's statement reflected a belief that hands-on activities support children's interest because those activities allow the children "to explore on their own and discover on their own" (Interview, 02/01/2011). Furthermore, when students discover on their own, "they can ask questions and want to learn more about it" (Interview, 02/01/2011). As evidence in the previously mentioned bubble activity, Ms. Parry noted that, after seeing that only spheres emerge, the students "wanted to know why. Why did it only make spheres?" (Interview, 02/01/2011). According to Jorgenson (2005), hands-on activities encouraged students to think about science as "fun" instead of a chore and, as a result, they enjoyed the lessons. Similarly, Ms. Parry supported the students' hands-on science activities, “because they [the students] remember it [what they learned] better, and they learn more if it’s hands-on (Interview 02/01/2011).

Ms. Jane also stated that hands-on science activities were more exciting for the students. She explained that “science is just one of those fun things because it's hands-on” (01/31/2011). She added that the best way for the students to learn science is “by doing it,” “by participating,” “by doing observations,” “by doing experiments,” and “by testing things themselves” (Interview, 05/10/2011). For Ms. Jane, these kinds of hands-on activities in science lessons increase students’ interest and motivation about learning.

In summary, the participant teachers recognized the importance of doing hands-on activities in their science lessons. They believed that, through hands-on science activities, children can become interested in science lessons and maximize their curiosity about science. They noted that, through such activities in science lessons, students are "more active" (Ms. Sandy, 02/08/2011) and have "fun" (Ms. Jane, 01/31/2011), and their excitement makes them "more involved" in the science activities (Ms. Nora, 02/01/2011; Ms. Sandy, 02/08/2011). Additionally, they believed that hands-on activities in science instructions are helpful for young children to learn science effectively. For instance, when students conducted hands-on activities in science lessons, they "ask [more] questions" (Ms. Parry, 02/01/2011), "more remember [what they learned in science activities]" (Ms. Nora, 02/01/2011; Ms. Sandy, 02/08/2011), and understand scientific concepts better. Therefore, hands-on activities were seen by the participant teachers as an important mechanism deployed in science lessons to support the interest and curiosity of the students because they are “pedagogically appropriate,” offering children chances to experience cooperation, actions, and experiments (Hadzigeorgiou, 2001). The emphasis on using hands-on activities is consistent with the movement toward a more inquiry-based approach toward learning (King et al., 2001). All of the participant teachers stated that they would like to employ more hands-on activities in their science instruction.

Obstacles to hands-on activities

As described above, the participant teachers in this study considered the value of doing hands-on activities in science lessons, but they also reported obstacles in scheduling hands-on science activities. A major challenge was the limited time available for science lessons and even less time that they could devote to science activities. Previous research also pointed that, in early childhood education settings, there is not enough time for young children to learn science, even though the children are described as natural scientists (Eshach, 2011; Mantzicopoulos et al., 2008; Worth & Grollman, 2003).

The participant teachers in this study also claimed that less time is allotted in the curriculum schedules to teach science than other subjects, such as mathematics and language arts. For instance, Ms. Sandy mentioned that she had approximately 90 minutes devoted to math and language arts on a daily basis, compared to only 30 minutes for science (Interview, 02/08/2011). Ms. Jane experienced similar time constraints when teaching science, even though "I think it is something that we need to do [science] all the time, just like reading and math, you know" (Interview, 05/03/2011). Similarly, Ms. Nora pointed out that science "should have some of the same amount of time [as mathematics and reading]" (Interview, 02/01/2011). Moreover, the teachers had to divide that instructional time in their day between two subject areas, social studies and science, "because of our [their] PTP units[1]" (Ms. Parry, Interview, 04/13/2011). Ms. Nora stated that "I think, [on] a lot of campuses the time is split between social studies and science… so you don't have as much as time [to teach science]" (Interview, 02/01/2011).

The fact that the participant teachers had a limited amount of time to teach science in early childhood education confirms the findings in previous research (Blase, 1986; Dass, 2001; Eshach, 2011; Kelly & Berthelsen, 1995; Mansour, 2007). Mansour (2007) found that 95 percent of participant teachers in the study pointed out that they faced "time constraints" to teach science and technology. In that research, the science teachers felt pressure because they had limited time for what they liked to do in their science lessons (Mansour, 2007). Explanations among participant teachers in this study echo the findings of previous studies that, among kindergarten or elementary teachers, it is common that science is not a priority subject, compared to other subjects in the classroom (Bryan, 2003; Greenfield et al., 2009; Mantzicopoulos, et al., 2008; Milner, Sondergeld, Demir, Johnson, & Czerniak, 2012; Weiss, Banilower, McMahon, & Smith, 2001). For example, Weiss, Banilower, McMahon, and Smith (2001) found that the 5,765 kindergarten to third-grade students taught by the teachers in their study averaged language arts for 115 minutes per day compared to only 23 minutes a day dedicated to science instruction.

The reason why the participant teachers in this study said they had less time to teach science than other subjects was the curriculum schedule that they had to follow.

[1]This is a pseudonym of the curriculum focusing on social studies in Pine Tree Elementary School.

The Texas Accountability System provides a set of the required curricula, Texas Essential Knowledge Skills (TEKS), which are state standards for what students should know and be able to do (Texas Education Agency, 2011). Moreover, their school district developed a mandatory curriculum, including the learning goals and objectives that Aligned Green Wood Curriculum (AGWC) students are expected to achieve at every grade in every course. In addition, the teachers had to follow another standard, called the Pine Tree Program (PTP), focusing on social studies. About the curriculum schedules, Ms. Parry stated:

> We haven't finished the lesson yet, because [we] ran out of time. The schedule is very difficult for us [the teachers] to get everything in and so science… That has been a problem. I miss doing a lot of science, because I think it's important, and I feel like we don't [do] enough of it… (Interview, 02/01/2011)

As she explained, the reason why the participant teachers had time constraints for teaching science was due to the schedule that teachers must follow. Ms. Sandy also noted, "kindergarten teachers tend to focus on mathematics and language arts because of the curriculum that they have to follow" (Interview, 02/08/2011). Ms. Parry stated that she would like to teach more science, but the content areas of math, reading and writing "usually come first**…**yeah right… I don't have the time to spend [to do more science], you know, on that because I have other things that we have to do" (Interview, 02/01/2011). Ms. Parry added,

> Okay, so, you know, since I have taught for so long, we [the teachers] didn't have the TEKS before. And so we did pretty much decide what we wanted to teach in science. Everybody. And so in a way it was easier because if the kids were really interested in something we could, you know, go with it and spend more time on. Whereas now it's hard to do

> because we have, I mean, they even tell you that you have two weeks to teach this or you have three weeks to teach this. So [it] does make it harder. (Interview, 02/01/2011)

As such, in the past, teachers were independent and could choose appropriate curricula and make instructional decisions (Laverick, 2007; Mathison & Freeman, 2003; Rodgers & Long, 2002). However, the teachers' roles have changed for preparing young children for future school education because of the "standard-based education system" that they need to follow (Goldstein, 2008, p. 449).

In science lessons, Ms. Parry wanted to be free to decide what and how she taught the students, based on her own science curriculum. She thought that she could support more science hands-on activities that the students were interested in, if she had more time without the tight schedules in mandatory standards. For instance, in the bubble activity that grew from the children's interest, the teachers could not "do any research." Instead, Ms. Parry told the students, "Well, if you're really interested, get your parents to help you research it," because we "don't have time [at school]" (Interview, 02/01/2011).

Several previous researchers have argued that teachers' negative emotions about teaching science prevent them from teaching science effectively (Seefeldt & Galper, 2002; Tosun, 2000; Yates & Chandler, 2001; Yoon & Onchwari, 2006). However, the data in this study indicate the teachers in this study identified mainly time constraints as preventing them from teaching science, not their own personal preferences to teach other subjects.

A similar conclusion is supported by Levitt's (2001) study regarding hands-on activities in science lessons, in which elementary school teachers' beliefs about hands-on activities in science lessons are similar to those expressed by the participant teachers in this study. In other words, the teachers believed “that it's important that they [the students] do hands-on [activities]” and hands-on activities are the best method for students “to learn more” science (Ms. Parry, Interview, 02/01/2011), because those types of activities “contribute directly to student learning” (Levitt, 2001, p. 11). However, the teachers in this study reported they did not often offer hands-on activities in their science lessons, even though they believed that “science needs to be hands-on” (Ms. Jane, Interview, 01/31/2011) due to limitations of time (Levitt, 2001). Baker, Lang, and Lawson (2002) and Knezek et al. (2000) also found that teachers have difficulty including hands-on activities in science lessons because of limited time.

Classroom management

Successful classroom management is important for effective teaching and for teachers’ belief in their ability to facilitate students’ learning (Henson, 2003). Especially in hands-on science activities, researchers have found that teachers can have difficulty in handling and interacting with students (Lewis & Wagner, 2002; Oliveira, 2009) because those activities involve children becoming more active in the participation (Erden & Sonmez, 2011). According to Martin and Baldwin (1993), classroom management includes teachers’ beliefs about what they can do to help improve individual students’ learning and how the teachers understand individual students. So, while classroom management is a key component to effective teaching, many teachers believe that they are inappropriately prepared to manage their classes, which has been shown to cause stress for the teachers (Silvestri, 2003; Youssef, 2003).

Research has also shown that many teachers encounter classroom management problems in inquiry teaching (Baker et al., 2002). However, hands-on inquiry activities have proven effective in assisting students to understand content and acquire process skills (Baker et al., 2002), so teachers need to know how to organize the classroom, as well as how to handle management problems, in order to capitalize on the affordances that inquiry-based learning activities offer children (Milner, 2005).

During the interviews, the participant teachers mentioned classroom management within science classes when discussing science hands-on activities, especially the two novice teachers, Ms. Sandy and Ms. Nora. Both stated that they had difficulties handling their students in hands-on activities. For instance, Ms. Sandy noted that she had to deal with a number of issues that are student-related in her science classes. At the beginning of the school year, Ms. Sandy thought that she had too many active students for the class to be able to engage in hands-on science activities. She explained, “not as much as I would love to [do science hands-on activities]. I try [hands-on activities] every few weeks [laughs]. With this particular class is hard to do that.” After answering the question as to why it is hard, Ms. Sandy replied, “This particular class gets so excited. They really, they get so excited [for me to handle]” (Interview, 02/08/2011). Then she conceded that the students were “really sweet, but they are very active, [and] energetic…I have some very excited girls” (Interview, 02/08/2011). Ms. Sandy admitted that managing the students' hands-on activities was burdensome.

To help her address this issue, Ms. Sandy believed that having “more hands in the classroom, [such as] parents volunteering, would definitely help” her teach science using hands-on activities (Interview, 02/08/2011). She wanted help from volunteers to teach science through hands-on activities because “all of those things take a long time” for “getting it [hands-on activity] ready, getting it set up, taking it and putting everything away” (Interview,02/08/2011). Echoing Ms. Sandy's comment about hands-on activities and classroom management in science instruction, it has been found that inexperienced teachers struggle with managing hands-on science activities, both in terms of classroom management (Appleton, 2002; Appleton & Kindt, 2002). As a result of the difficulty, some inexperienced teachers were hesitant to use hands-on activities, even though they believed that hands-on is a necessary element of science instruction for young children.

For Ms. Nora, with a year–and-a-half of kindergarten teaching experience, it was difficult to "manage the class of 21 kids” in the hands-on science activities because they “were all excited” (Interview, 02/01/2011). To manage the students in science activities, Ms. Nora also emphasized that she needed parent volunteers as helpers. For example, she described a Play-Doh activity where parent volunteers assisted:

> Yeah, you have to manage a classroom and, if it is science, they [the students] I mean, science is all about exploring, so to do it right when you have 21 kids and they are all excited, you need someone to help you classroom manage or someone to maintain smaller groups to where they can get the hands-on experience. I mean, I could’ve made the Play-Doh with the whole class, where I had maybe five students come in to help measure and stuff. Do you think the 15 kids who didn’t get to help are going to be happy? No! So I think having people who could help manage smaller groups to where I think the children would have more participation in the activities. (Interview, 02/01/2011)

Even though Ms. Nora mentioned that one of the goals in creating the science lessons was to engage in activities that were “basically, hands-on” (Interview, 02/01/2011), she needed the assistance of parents to achieve this goal. In hands-on activities, Ms. Nora felt that forming small groups were better to manage the students, so that they could focus more on the activity. She noted that occasionally she had three to five parents volunteer to assist with the activities; she was better able to manage the activities with the parents’ help.

The beliefs of the experienced teachers, Ms. Parry and Ms. Jane, about classroom management differed from those of the two inexperienced teachers. Ms. Parry, in her 36th year as a kindergarten teacher, did not mind receiving help from parents, but she could also handle the students by herself. “I don’t feel like I need to have parents [volunteers] here [in my science lessons]… I mean there are times when, you know, it would be nice to have a parent come in [in order to help with science activities], but I don’t necessarily have to have a parent” (Interview, 05/10/2011). However, Ms. Parry admitted that she took “the easy way out,” such as “read[ing] a book… rather than doing the hands-on things” (Interview, 02/01/2011). That is, Ms. Parry did not find it necessary to receive volunteer help to manage the students. If it was difficult to teach a lesson by herself, she would replace hands-on activities with a different teaching approach, such as reading books. Ms. Parry commented about hands-on activities - “that’s a weakness [in my science lessons]” (Interview, 02/01/2011).

Ms. Jane, an experienced 13-year kindergarten teacher, was confident about managing her classroom. Therefore, she appreciated the help provided by parents but did not find their assistance necessary to manage the students in science activities. She stated, "it [parents' help] would be great to have help just because more kids would get more attention [in science hands-on activities]… but I just, I haven't [had that level of assistance]" (Interview, 01/31/2011). For both experienced and inexperienced teachers, classroom management was a major issue when the science lessons involved hands-on activities.

Overall, the inexperienced and experienced teachers had different beliefs about teaching science lessons with respect to classroom management and parents' help. During the interviews, the inexperienced participant teachers mentioned several times the difficulty of classroom management in science lessons, especially in hands-on science activities, but the experienced teachers did not think that those activities were too difficult for them to manage. According to Appleton and Kindt (2002), in science instruction, inexperienced teachers often choose ''safe'' teaching methods that they believe are easily managed, and they avoid hands-on activities (p. 49), because they often spend more classroom time managing misbehavior instead of instructing students, as compared to experienced teachers (Yilmaz-Tuzun, 2008). However, experienced teachers who had more confidence in their ability to manage students have more experiments with interactive science lessons (Enochs, Scharmann, & Riggs, 1995; Gee, Boberg, & Gabel, 1996).

BELIEFS ABOUT SCIENCE AS A SUBJECT

Teachers have beliefs about each subject area, for example, what science education is about (Calderhead, 1996). In this category, two sub-categories emerged from the teachers' statements that refer to 1) the meaning of science for students and 2) the meaning of science in relation to the teaching of science. These two themes can be valuable for understanding how teachers' beliefs about the nature of science affect the teachers' teaching methods (Keys & Bryan, 2000). For instance, teachers who believed that "science is discovered" attempted to provide students with discovery labs, suggesting more opportunities "to be discoverers" (Brickhouse, Bonder, & Neie, 1987, p. 44).

The meaning of learning science for students

Teachers' beliefs about the nature of science influence their teaching practices (Brickhouse, 1990; Gallagher, 1991). For instance, teachers with a more contemporary and precise comprehension of the nature of science are inclined to apply a more problem-based approach to science teaching (Brickhouse, 1990). Therefore, it is meaningful to identify the participant teachers' beliefs about how they think about science as a subject for their students.

In this study, Ms. Sandy believed that science for children was an understanding "about their world and environment" (Interview, 02/08/2011). She believed science is "more fun than math or the language arts" and "is easier for children than other subjects, such as the letters and math" (Interview, 02/08/2011), because science is based on the students' familiarity with their world. Additionally, Ms. Sandy believed that science encouraged students to learn to think. She noted:

> It's so that they can learn how to think, too, and think about their world and their environment. Science is a good one for them to question things and to learn to think – not just inside the box but [to] be a future scientist. (Interview, 02/08/2011)

When students are able to process information about their surroundings, they build the ability to construct scientific knowledge through the progression of thinking and asking questions. Ms. Sandy's statement is consistent with research suggested by Seefeldt and Galper (2007), who stated that processing the world enables children to develop what constitutes scientific knowledge. In Ms. Sandy's case, processing information about the world involves thinking and asking questions pertaining to science.

Ms. Nora believed that science is about becoming an "inquiring academic" through investigation, exploration, and observation. She stressed the need for hands-on activities in science classes to support the students' curiosity and interest. Based on her beliefs about the nature of science, Ms. Nora commented:

> It's [science] about asking. I mean it is. It's about being curious and asking questions and finding answers to those questions – how things work, why does it work this way, why does it not work that way? So it's all about asking questions and finding answers to those questions through experiments and collecting data and information. (Interview, 05/10/2011)

Similar to Ms. Sandy, Ms. Nora pointed out the significance of the "curiosity" of the students and "asking questions" in science lessons. Science makes use of children's natural curiosity about the world around them (Greenfield et al., 2009), and that curiosity is important for students who are learning science (Hadzigeorgiou, 2001) because, as Ms.

Nora believed, “science is all about investigation” (Interview, 05/10/2011). For Ms. Nora, science investigations lead to “exploring,” “observing,” and “predictions,” so she wanted students to keep those attitudes without worrying about providing correct or wrong guesses (Interview, 05/10/2011). Ms. Nora’s statements demonstrate her belief in the importance of investigations within science. To offer a correction to a wrong answer is not critical to Ms. Nora; instead, she saw science as more about figuring out the process of thinking. For example, Ms. Nora noted that science “is to make your brain for thinking… through the observations [and] making guesses” (Interview, 02/01/2011). Ms. Nora focused on the students’ thoughts, predictions, and questions in science activities. Prior literature has revealed that when students observe an object or situation before they are able to describe or understand the object or situation, they form their own thinking process through hypotheses, investigations, and testing their ideas (Hadzigeorgiou, 2001). In the process of investigations, students construct meaningful new scientific knowledge (Samarapungavan, Westby, & Bodner, 2006). Moreover, Ms. Nora recognized that scientists conduct investigations to develop or apply theories to new cases or problems so that, for her, during the investigations, a “wrong guess” is not the most important part of learning.

Ms. Jane viewed science as related to experiencing the excitement. She noted that “science is everywhere, and it’s enjoyable” (Interview, 05/03/2011). She added,

> Science is just creation to me. That’s what science is to me. And science is, you know—electricity is science. Chemicals are science, just different interactions between chemicals and just how things interact with each other. You know, cooking is a science, just putting ingredients together to

> make new things. So science is just… There's something about science in almost everything. (Interview, 05/03/2011)
>
> … You know, they can do experiments all the time. They can… Even blowing air into a balloon, that is science. Or doing the soap bubbles, you know, things like that, that is science. And so just making them aware of it and helping them see that science is a very fun thing and they can do so much with it, even at home or at school--all around them. (Interview, 01/31/2011)

Ms. Jane wanted to emphasize that science is very much a part of children's daily life, such as electricity, cooking, blowing balloons, and making soap bubbles. Therefore, learning science can also be associated with routines in children's everyday lives (Eady, 2008), and normal routines within a class can be classified as learning science (Longbottom & Butler 1999). Children's insights into their everyday lives help them to understand the world around them, and "they [students] realize science is fun" (Interview, 01/31/2011), when it is related to their experiences (AAAS, 1993; Duschl, Schweinguber, & Shouse, 2006; Eady, 2008; Seefeldt & Galper, 2007). As a result of that belief (e.g. "Science is just everything in nature; it's everything around us"), Ms. Jane's goal was to create a sense for the students to realize that science is easy to discover in their natural environments (Interview, 01/31/2011).

The meaning of science in relation to teaching science

According to Calderhead (1996), each teacher has his or her beliefs about a subject – "what the subject is about" and "what it means to know the subject" (p. 720). In previous research, teachers develop perspectives on teaching science from their learning experiences (Choi & Ramsey, 2009). Calderhead (1996) noted that teachers' past experiences affect the way they think and approach their work. Experiences employ an important position in shaping teachers' beliefs about teaching and learning processes (Mansour, 2009). Teachers' beliefs are important to understand the teaching practices and decisions in the classrooms (Mansour, 2009). Teachers are inclined to teach in the way that they were educated when they were students (Phelps & Lee, 2003; Stuart & Thurlow, 2000). From this viewpoint, past experiences from learning science as a student contribute to teachers' teaching of science, because past memories affect the present, both consciously and unconsciously (Zembylas, 2004). Bryan and Abell (1999) found that past experiences of a teacher as a science learner were an important factor that affected the beliefs about science teaching and learning. The teachers who were interviewed for this study had both fond memories and negative emotions about learning science as students. Ms. Sandy had forgotten what she had learned from science from her kindergarten to college years. During the interview, when Ms. Sandy responded to questions about her experience in learning science as a student, she said: "I don't remember" several times. For instance, Ms. Sandy answered that "I don't remember any, learning any science at all in preschool or kindergarten. I really don't… I don't remember any science in elementary school… I don't remember a lot in middle school… I don't remember anything else I learned [in my university]" (Interview, 02/08/2011). Then, she admitted that she had "avoided science classes" (Interview, 02/08/2011) on purpose when she enrolled in college. Nonetheless, she linked the association of having an interest in science now with conducting many hands-on activities with her students. This seems to have been affected by previous experiences also: She mentioned, "In high school, I had a really good biology teacher. She was very hands-on, had good lessons" (Interview, 02/08/2011). She also talked about her youngest daughter, who enjoys science because the teacher used a variety of science experiments. Ms. Sandy's positive science teaching experience with "hands-on" activities and "experiments" influenced her beliefs about how she wanted to teach students in her science lessons and how they learn science. That is, through positive learning from science experiences, Ms. Sandy constructed "how she believed children best learn science" (Bryan & Abell, 1999, p. 128).

When Ms. Nora was asked to recall her science learning experience, she did not have fond memories. She remembered filling out science journals, raising chameleons, and dissecting a frog. Overall, she disliked science as a student. In spite of that past experience with science, she would like for her kindergarten students to feel excited about science.

> I guess part of me remembers that science is boring, and I don't want it to be boring [laughs]. I want to make it exciting and fun… [The science lessons] are not that wonderful, so I don't want [my students] to be bored. I have got to keep their attention. They are kindergartners. (Interview, 02/01/2011)

Because Ms. Nora recalled science as a boring subject, she did not want the students to feel that way about science. Her intentions were to make science classes exciting by incorporating science activities. Consistent with arguments by Smith (2003), beliefs carried over from personal experiences can influence science teaching methods and teaching practices (Calderhead, 1996; Eick & Reed, 2002; Eshach, 2003; Mansour, 2008, 2009; Nespor, 1987; Olson & Appleton, 2006; Plevyak, 2007; Smith, 2003; Tsai, 2002). In the case of Ms. Nora, she tended to focus on the process of how she transformed knowledge for her students (Choi & Ramsey, 2009); so, for her, beliefs that science activities should be "exciting and fun" came from her experience as a student (Interview, 02/01/2011).

Ms. Jane also did not enjoy science when she was a student. She did not like science because of the frequent low scores she made on tests and the tedious tasks (e.g., copying the teacher's notes on the board). Her only fond memory was the frog dissection because it was a hands-on activity. Her negative experience with science had motivated her to make the classes more enjoyable. She mentioned that "science is a fun thing to teach" (Interview, 01/31/2011). Ms. Jane added,

> Well, I do have a memory of a college professor who did not teach. All she did was writing on the board, and all we did was copy what she wrote. She barely said anything during class. It is not good. So, I guess I learned from that… What I learned from that was that science needs to be hands-on. Science needs to be fun. Science is doing. And so, because I was not a strong science student, I was kind of determined to make it fun for the kids because I want them to enjoy it. (Interview, 01/31/2011)

Ms. Jane, similar to Ms. Sandy, emphasized that science hands-on activities should be fun and enjoyable for young children. Ms. Jane's preference to create fun science activities and do hands-on science activities was shaped by her past experiences.

Ms. Parry mentioned that she was not very good in science, but she enjoyed teaching the subject matter. Similar to Ms. Nora and Ms. Jane, Ms. Parry wanted the students to enjoy science classes despite her negative experiences. All that she could recall from her science classes as a student was the frog dissection, like Ms. Jane. These experiences encouraged Ms. Parry to hold more exciting science classes.

> I think that's one reason that I would like to try to make it fun for the kids—because I don't want them to feel the same way I did about it, because it is important, and, you know, I just never liked it, because I don't think it was made enjoyable for me … It’s because I didn’t like science [that] I want to make sure that these kids love science. (Interview, 02/01/2011)

As Ms. Parry indicated above, she wanted her students to feel that science is interesting, and this desire stems from her experience as a student. Previous studies have shown conflicting results in terms of whether teachers’ learning experiences as students affected their teaching of science (Calderhead, 1996; Eick & Reed, 2002; Eshach, 2003; Mansour, 2008, 2009; Nespor, 1987; Olson & Appleton, 2006; Plevyak, 2007; Smith, 2003; Tsai, 2002). For instance, Nespor (1987) suggested that teachers’ beliefs with respect to teaching are formed from their experiences as a student. On the other hand, Carely and Stauss (1970) found that a teacher’s science grades and the science courses that teachers took as student were not related to their understanding of the nature of science as teachers. However, Ms. Parry was adamant that her learning experiences in science lessons as a student influenced her teaching science. For example, she said that “because I didn't like science. I want to make sure that these kids love science” (Interview, 02/01/2011).

These findings suggest that the participant teachers carried their beliefs regarding science as a subject into their teaching practices. Most of all, the participant teachers mostly experienced negative feelings when they had to remember their own science learning in school. The teachers used descriptions, such as: “boring,” “I have avoided science classes” (Ms. Sandy), “I didn’t like science” (Ms. Jane), “not my favorite subject" (Ms. Parry), and "too hard" (Ms. Nora). Moreover, they did not remember any scientific content (e.g., "I don't remember a lot [about learning science]," "I didn't really remember [about learning science], honestly"). In order to compensate for their negative experiences with science, the teachers said they intended to keep their science classes exciting by frequently introducing science activities. They did not want students to experience feelings similar to those they felt when they were learning science. According to Bryan and Abell (1999), a teacher's positive or negative experiences affect her beliefs about how students learn science and how she wants to teach science.

In sum, the participant teachers recalled their negative experiences with traditional school science lectures and their desire to teach differently in their science lessons. In this study, due to the participant teachers' science learning experience as a student, they ranked highly the value of students' interest in science, and that value influenced the way they taught science. Their experiences as students encouraged the participant teachers' beliefs that science lessons for young students should be interesting.

BELIEFS ABOUT LEARNING TO TEACH SCIENCE

There is a relationship between teachers' beliefs about learning to teach and professional development. Those beliefs can be a positive or negative attribute for teacher development (Loucks-Horsley, et al., 2003). In that sense, teachers' professional development programs are related to the development of teachers' proficiency in teaching (Loucks-Horsley et al., 2003). The byproduct of teachers' proficiency in teaching is that it improves the student outcomes in learning (Loucks-Horsley et al., 2003). From the professional development programs, teachers are not acquiring the knowledge about teaching, but it also provides the chance to think about their methods of teaching and to reflect on their practices (Loucks-Horsley et al., 2003). In addition, Briscoe and Wells (2001) noted that interactions with other teachers allow teachers to share ideas with other teachers and improve their teaching practices.

In Pine Tree elementary school, there were science workshops once a month at faculty meetings or on early release days, and the kindergarten teachers participated in the workshops. In the workshops, the teachers shared their ideas on what content to teach in science, and what scientific information was available on websites and books. The teachers in this study called themselves "teammates" or "team" (Ms. Sandy, Interview, 05/11/2011). The team met to plan and talk about science lessons several times a week.

In Ms. Sandy's case, she wanted to be a competent teacher by researching what she needed to teach, identify books, and present the material. As a first-year kindergarten teacher, Ms. Sandy received help from her teammates. Ms. Sandy appreciated the help she got from her teammates; “Mostly my team helped me a lot… My team has been . . . they are so wonderful and supportive in helping build [science] lessons” (Interview, 05/11/2011). She echoed that her fellow teachers had created annual planners based on the teachers’ reflections, questions, and thoughts. Then they developed and improved the planner the following year. “We have a planner for each unit, so that kind of guides us about what we’re supposed to be doing” (Interview, 05/11/2011). The team sent her the lesson plans, and they met three times a week to talk about how to teach each topic.

Ms. Sandy also mentioned the important of the Internet to draw lesson plans. Ms. Sandy added, “We are so lucky to have the Internet" (Interview, 05/11/2011), because she can gain access to information, such as what science activities are being held and what science topics are appropriate for young students. Moreover, she uttered the importance of attending professional development program as well. Ms. Sandy believed that she would have to “go to professional development [programs].” to acquire more scientific knowledge and the know-how on teaching science.

In contrast to Ms. Sandy, Ms. Nora frequently took part in science professional development workshops. Ms. Nora believed that the workshops helped her become a better science teacher, primarily through acquiring ideas on how to make science lessons more interesting. “Through the district, you know, [teachers] have professional development that offers two weeks of professional development classes… We get to choose what we want to take” (Interview, 02/08/2011). Ms. Nora mentioned about the science workshops she attended:

> I think [that, at the workshops,] it would be neat to hear from outside of just teachers, just outside professionals who are in the field of science… I think it would just open up the possibilities, you know. We [teachers] are just strictly hearing from other teachers versus from other people who are actually working in the science field. And how do they think about teaching it? Why did they get into their fields? What gets them excited? (Interview, 02/08/2011)

Ms. Nora believed that hearing stories from outside sources provides the sense of what needs to be undertaken to teach science.

Ms. Parry believed that she needed to come up with new ideas to teach science beyond her experience of science teaching. Indeed, the information she obtained from her earlier experiences from the development programs enabled her to teach the students in an improved manner. “Sometimes we [teachers] will get new things and then I will do research on them to find out about them so that I can teach them better” (Interview, 05/03/2011). Since, Ms. Parry did not "want to give those kids wrong [scientific] information" (Interview, 05/03/2011). Ms. Parry added,

> I have taught for so long [that] I have gone to lots of workshops and read a lot, and I have a lot of science books that I look at to, you know, that give me ideas, and I go online sometimes and look for ideas of things… there have been a lot of changes with space and things, you know, so I think I still have to look things up online now. We didn’t have computers back then, you know, so that kind of thing has helped a lot. (Interview, 05/03/2011)

As an experienced kindergarten teacher in her 36th year, Ms. Parry mentioned that there were still some difficulties with obtaining news pieces of scientific information. This is based on the fact her parents had no television and she did not have a computer growing up. For that matter, Ms. Parry attempted her best to keep up with new things (e.g., technology, information) to assist the science lessons. This is a common concern among experienced kindergarten teachers teaching science, and they want to compensate this concern by paying attention to current trends in science and teaching (Kallery, 2004). To address this issue, Ms. Parry learned new scientific information, went to numerous workshops and science-related websites, and frequently read science books. She found the Internet to be most helpful source to obtain science information, which she used it to teach science.

BELIEFS ABOUT THE TEACHING ROLE IN SCIENCE LESSONS

Teachers tend to have fairly reliable beliefs about themselves, principally in relation to the role of teaching (Calderhead, 1996). According to Nespor (1987), "to understand teaching from teachers' perspectives, we have to understand the beliefs with which they define their work" (p. 323). Therefore, how these teachers define the work of teaching science in their classroom may significantly affect the type of activities they choose to engage in with their students when they teach them science (Calderhead, 1996).

All of the participant teachers in this study defined their role in science instruction as a facilitator who guides the students. For example, Ms. Sandy noted:

> I think my role is to help guide them… Steer them towards them exploring and me kind of guiding the way along the process. I like them to come up with ideas and solutions. (Interview, 02/08/2011)

As Ms. Sandy's quote suggests, with her guidance, the students were able to come up with ideas and solutions. For Ms. Sandy, this meant that she was "letting them [the students] explore" in her science lessons (Interview, 02/08/2011).

Ms. Nora also stressed her role as an active participant, in addition to taking on the role of a facilitator in science classes. Ms. Nora stated that "my role to teach science [laughs]? ... just kind of a facilitator for their [the students'] work [in science lessons]" (Interview, 02/01/2011). As a facilitator, Ms. Nora explained what she did in science lessons.

> I want to be an active participant in their [science] learning and making sure that they are understanding the information they are getting, understanding what they are doing and why they are doing what they are doing. (Interview, 02/01/2011)

To be a reliable facilitator, Ms. Nora wanted to participate actively in the students' science learning because she believed that she needed to be a role model for the students. One of her methods was to be excited in science classes, so that her students could follow her. Ms. Nora mentioned, "I think that my enthusiasm catches on and they see, 'Wow, she is excited.' So I think that encourages them to be excited about science and be open to the learning with science" (Interview, 02/01/2011). This approach supports prior evidence who found that it is significant for young children to have positive attitudes toward science, so that, as role models, teachers should not only show curiosity, appreciation, persistence, and creativity but also actively take part in science lessons (Erden & Sonmez, 2011; Harlen & Rivkin, 2004).

Moreover, to facilitate the students' science learning, Ms. Nora emphasized the importance of evoking questions from the students, after which she offers guidance as to what the likely answer might be. She noted that "just letting the students investigate, hands-on, making them be curious and ask[ing] questions and help[ing] them to come up with answers to their questions, guid[ing] their learning through questions and investigations" (Interview, 05/10/2011). The role of facilitator for Ms. Nora meant that she needed to let the students have the opportunity to think deeply. She focused on "encouraging them to think beyond their own thoughts" and "being able to get in there and let them share their thoughts and trust their ideas" (Interview, 02/01/2011).

Ms. Jane also defined her role as a facilitator to support the students' interest. Hence, her role included providing information, but only in cases where an additional explanation is required.

> I think my role is to be a facilitator. I think that may be [to be] present sometimes and see where they take it, to be kind of the guide, but to go where their interests are and where their curiosity takes them. And so my role as a facilitator--my role is not just to give information. I do; I give information, but then it is to expand on what they are already thinking or what they are already doing and to maybe clear up some misconceptions along the way. (Interview, 01/31/2011)

As Ms. Jane's statement suggests, she supported the students' various ideas and thoughts. The question of whether the students responded with the correct answer was not an important issue. Ms. Jane believed that, as a facilitator, she wanted the students to freely share their opinions in the science lessons, instead of her merely transmitting scientific information. In addition, Ms. Jane believed that she had "a huge responsibility to help them [her students] have a positive attitude towards learning [science]... as their first teacher" (Interview, 01/31/2011) since Ms. Jane thought that "they [her students] are only five," so "how they feel about learning science" will influence their future science learning (Interview, 01/31/2011). Therefore, Ms. Jane believed that, in science instruction, she needed to be a facilitator, supporting the children's interest and curiosity about science, instead of just being a transmitter of scientific information.

Ms. Parry also saw her role in science lessons as that of a facilitator. Ms. Parry mentioned that "I would hope that it [my role] is a facilitator [in science lessons]" (Interview, 02/01/2011). Being a facilitator means that Ms. Parry provided materials and, through the materials, her students "discover things on their own and they can ask questions and want to learn more about it" (Interview, 02/01/2011). As a facilitator, she attempted to make the science classes more hands-on oriented, and then let the children explore. Ms. Parry said that she did not want to stand up in front of her students; instead, she asked questions or suggested notions that her students needed to know. Ms. Parry added that she believed teaching science encouraged the students to drive the science instruction, so, as a kindergarten teacher, she needed to be attentive to what they were interested in and listen to what the students said and to be aware of what they did. As an example, Ms. Parry remembered “the bubble activity.” As facilitators, Ms. Parry indicated that the teachers were not “standing up there and modeling for them [the students], instead the students “actually got to go outside and blow the bubbles and make their own bubble makers” (Interview, 02/01/2011). All of the participant teachers believed that their role was to facilitate the students’ science learning. Research has found a close relationship between the teacher’s role in the classroom and students’ motivation for learning science (NRC, 1996). For instance, students’ intrinsic motivation decreases when teachers view their roles in the classroom as transmitting knowledge to the students as an authority figure (Oldfather & Dahl, 1994; Wentzel, 1998). In contrast, in cases where teachers give their students more chances to feel supported, challenged, and autonomous in the classrooms, the students’ motivation increases (Reeve, Jang, Carrell, Jeon, & Barch, 2004).

SUMMARY

In Chapter 4, the findings regarding the four participant kindergarten teachers’ beliefs about science teaching confirm, dispute, and extend the existing literature. Their comments correspond with the four categories about teachers’ beliefs based on

Calderhead's (1996) research. In the first category, teachers' beliefs about students in science lessons, the participant teachers wanted the students to learn "how to think" because science thinking helps students develop their "thinking skills" in general and to learn science effectively. Moreover, the participant teachers said they believed that students learn science better when the teachers supported the students' interest in science. To encourage the students' interest, the teachers attempted to catch the "aha" moments when students expressed their achievements (e.g., "Wow! I got it") in science activities. Also, the teachers liked to include unexpected science activities based on the students' questions or objects that the students brought from home. The teachers said they believed these unplanned activities established a connection between the students' natural curiosity and science lessons and made the students feel that science is fun.

The second category of beliefs, as proposed by Calderhead (1996), concern the participant teachers' teaching in science lessons. The teachers reported that they focused on teaching science through two methods: to teach science through hands-on activities; and to manage the students in order to effectively teach science. The teachers believed that hands-on activities offer one of the most effective ways for the students to learn science. While every teacher in this study preferred to have as many science hands-on activities as possible, they also confessed that the time available to do hands-on activities was limited. The teachers pointed out that the reason why they did not have enough time to teach science was that their schedule was based on the many standards that they had to follow. Additionally, the teachers believed that classroom management is another important factor in science lessons. Regarding this issue, the inexperienced teachers felt classroom management was a serious problem in science classes, while the experienced teachers did not find classroom management to be a problematic issue.

The third category of beliefs addresses teacher beliefs about science as a subject, a topic that is divided into two sub-categories: the meaning for students of learning science and the meaning of science in relation to teaching science. The first sub-category examined what the teachers who were interviewed believed that science means for children, and the second sub-category relates to the interviewees' past experience of learning science as students. The teachers said they believed that science consists of inquiries or experiments, and the topics should be related to children's surroundings, because young children learn science best through science investigations connected with their environments. When the teachers recalled their past learning of science as students, none of the interviewees had fond memories. However, because they recalled science as boring, the teachers said they wanted the students to have positive attitudes toward science.

The fourth category was about the teachers' beliefs about learning to teach science. Even though the participant teachers attend science-related professional development programs in the past, they would like to attend future meetings. In their school, the teachers regularly held science workshops and meetings with their teammates in order to share new scientific information and plan for new science activities. Some of the participants attended science professional development programs beyond their school settings and they believed that those science workshops were useful in teaching science.

In the fifth category, which focused on teachers' beliefs about the teaching role in science lessons, the participant teachers believed their role was to serve as facilitators. As facilitators, the teachers said they wanted to help guide the students explore science topics; the teachers also wanted to be good role models by participating actively in science lessons. Finally, they wanted to support the students' interest in science through numerous hands-on science activities.

Teachers' beliefs are considered to be a good source for understanding how teachers teach in their classrooms (Laplante, 1997; Pajares, 1992). Hence, in the next chapter, the findings relate to how the beliefs are actually carried out in the classroom.

Chapter 5: The Kindergarten Teachers' Practices

This chapter presents findings regarding the second research question: How do the kindergarten teachers demonstrate their beliefs about science teaching in the teaching practices? The data collected to address this question came from the researcher's observations during science lessons of the participant kindergarten teachers, as well as from formal interviews, casual conversations, and educational materials used in the participant teachers' science activities (e.g., lesson plans and children's science notebooks).

Important for discerning how teachers' beliefs about science affected their science lessons came from classroom observations. Observations were conducted in the classroom, on the playground, or in some special learning place (e.g., the atrium and other teachers' classrooms). After each science class, interviews were conducted the teachers and educational materials were collected.

From the observation sessions, attention was geared toward the teachers, while the responses or statements made by the students because of the IRB policy. In addition, under the IRB policy, pseudonyms were used or expressions of "a boy," "a girl," or "a student" were used instead of their real names to mention a particular child.

Analysis is based on what occurred in the observed lessons and the teachers' statements about the beliefs, which is categorized according to Calderhead's (1996) framework: their beliefs about the students as learners, teaching science, science as a subject, and the teacher's roles in teaching science. The fourth category of teachers' beliefs about learning to teach science is not included in Chapter 5 because the school did not want outsiders to observe the teachers' monthly science workshops and weekly meetings. In the first category of teachers' beliefs about learners in science lessons, the participant teachers believed that, through science instruction, the students needed to learn how to think, in order to provide a good basis for their future learning.

Their belief in supporting their students' interest in science was related to their teaching goals in the second category of teachers' beliefs, which are the beliefs about teaching in science. As described, the teachers thought that the best way to teach science was to support the children's interest in the subject. To achieve that goal, the teachers believed that they should provide more hands-on activities in the science classes. However, they also utilized various other methods to stimulate the students' interest toward science. In terms of classroom management, the teachers focused on successfully handling the students in order to effectively teach the content of the science lessons; this was the second pivotal point in their teaching goals in science lessons. In particular, Ms. Sandy and Ms. Nora, who had less teaching experience, experienced difficulty in handling the children during science the activities compared to the experience teachers. At the time of this study, Ms. Sandy and Ms. Nora were in their first and the second years, respectively, as kindergarten teachers in Pine Tree Elementary School. To solve the problems associated with classroom management, the two less-experienced teachers wanted assistance from parents in the hands-on science activities.

In the category of beliefs about science as a subject, the teachers were focused on the children's experiences and the meanings their students gained from science activities, rather than relying on students merely acquiring scientific information. In addition, the teachers believed that their teaching roles included that of being a facilitator to support the students' science learning.

With these beliefs in mind, an examination of what occurred in science classes is discussed. This approach is necessary because prior research has indicated that there is a significant relationship between teachers' beliefs and practices (e.g., Bai & Ertmer, 2004; Mori, 2002), while others have noted that beliefs play a major in shaping the teacher's practices (e.g., Bandura, 1997: Nespor, 1987; Pajares, 1992).

Beliefs about learning and teaching science directly influence various aspects of the teachers' practices, such as lesson planning, assessment, evaluations, and classroom interactions with the students in science instruction (Bandura, 1997; Bryan & Atwater, 2002; Pajares, 1992). As a result, it is meaningful to learn about how and what the participant kindergarten teachers in this study actually did in their science lessons.

DISCUSSIONS IN SCIENCE LESSONS TO TEACH "HOW TO THINK"

As stated previously, the participant teachers believed that students needed to learn how to think during science lessons. In this part, it is investigated if beliefs are in accordance with the teaching practices.

To support students' thinking processes in science activities, the participant teachers provided students with opportunities to suggest and share their ideas and thoughts in discussions. These discussions served the purposes of teaching such thinking skills such as asking questions, communicating ideas, making predictions, and testing a hypothesis.

Ms. Nora induced the students to think about what scientists do, providing a role model to guide them as they learned how to learn about science. On April 29th, when the students learned about trees, Ms. Nora planned to make posters entitled “Two ways trees are helpful to living things,” and there were two suggestions for the students to follow—“1 fact you learned about trees”, and “1 picture of you being a friend to a tree.” The students observed, wrote, drew trees on the playground at the school and then in the classroom; they shared what they thought, as scientists do, such as their observations, investigations, and communications with others.

Ms. Nora wanted the students to think about why trees are important in their observations and then share what they observed. In science activities, children’s thinking process starts with observation (Hadzigeorgiou, 2001). Because she believed that “different kids give information back in different ways” (Interview, 04/29/2011) and that "it’s a large enough process to get them to think and to look at things from a different perspective [through sharing different ideas with other students]" (Interview, 02/01/2011), Ms. Nora believed that such discussions were quite beneficial for the students. Also, through these discussions in science lessons, the participant teachers supported the value of group work and the useful skills that come from learning to work together.

Teachers' strategies to encourage discussions in science lessons

The teachers in this study used various engaging strategies that served both social and cognitive functions because they wanted to support the students' active participation in the science discussions.

Encouraging students' questions

Providing chances for students to ask questions whenever they were curious about a topic was another strategy used by the participant teachers to support the children's learning "how to think." In discussions, the participant teachers attempted to support students by asking questions, thinking carefully and critically, thinking from a different perspective, arranging their ideas, and explaining the problems, thoughts, and possible solutions that they had about science.

As an example of encouraging students' questions, Ms. Nora showed how she accepted children's wrong answers and incorrect predictions. On March 29th, in the magnet activity, for example, Ms. Nora was not distracted by wrong predictions or answers to the question of what the students were supposed to learn from the lesson. Rather, she encouraged the students to keep working and find other answers. In addition, she supported the students to share their ideas because she believed that sharing can motivate students to investigate new possibilities. After the students completed their predictions and explorations of which objects were magnetic, Ms. Nora opened another discussion with the students about what they found in the magnet experiment, encouraging the students to share their ideas and the results of their tests.

> After the students predict and draw the items that stick on a magnet, Ms. Nora makes them share their hypothesis with friends. Ms. Nora sits in front of the students and they are sitting at tables. Each table had two large magnets and many kinds of materials. Ms. Nora tells the students they will have a test – which items that already predicted stick on a magnet. Ms. Nora says, "Test one thing, and then pass it to the next person." The students are experimenting and trying to recognize whether their hypothesis is correct or not. During the experiment, one student shouts out that the penny was not sticking to the magnet. Ms. Nora answers, "I know you are wondering if pennies are not magnetic." She explains that only particular metals can stick to a magnet, not just any metal. After the test, Ms. Nora and the students share their results, determining which items they predicted are magnetic. They find magnetic items, such as the nail, the screw, the hair clip, and the scissors. (Observation, 03/29/2011)

Through the experiment with magnets, the students observed the magnetic force exerted by the magnet. In this activity, Ms. Nora asked the students numerous questions and her questions became a starting point for them to remind them of their last activity and to think of new ideas. For instance, before they started to talk about magnets before the test, instead of talking about her explanations, Ms. Nora asked the students to talk about what they did in the previous class. From this process, she encouraged the students to pay attention to and review what they had done so far. In addition, Ms. Nora believed that encouraging the children to answer questions—even when they were wrong—helped the students not only to share their ideas but offered a way also to understand why they thought a particular way or "why they should believe that to be true" (Interview, 05/10/2011). Ms. Nora and the students were thus able to re-examine something and find other options. In the magnet experiment, for the purpose of testing the students' hypotheses, Ms. Nora's feedback and questions invited the children to say what they thought, not to guess the "right" answer. For Ms. Nora, incorrect answers were fine as long as "they keep investigating" (Interview, 02/01/2011). As a result of her belief, in the discussions, she "didn't want I didn’t want them [her students] to have to worry about being correct" (Interview, 02/01/2011).

In addition, Ms. Nora used various verbal expressions, helping the students become engaged in the predictions. During the magnet activity, she stated that “That was close. That's a good thought, but that's not quite what's happening [with the magnet and the objectives]” when the students’ answers were different from what she had expected (Observation, 03/29/2011). Ms. Nora accepted the student’s idea by saying “good thought” yet noting that it was “not quite what’s happening” as a way to encourage students to develop what they were thinking.

One way Ms. Nora corrected students’ thinking without offering direct solutions was having them engage in discussions that allowed them to share their different ideas. She believed that when the students’ share their thoughts and talk about them, they “gained better insight into some scientific ideas” (Interview, 05/10/2011). These activities involved interactions, such as posing questions and making predictions. In the experiment involving the study of magnetism, the students explored the objects and made predictions about whether they thought certain objects would be magnetic. The students then tested their predictions by putting the magnet next to various objects and if they found an object was magnetic, they affirmed their predictions by saying: “Oh, yeah, this is magnetic.” Because Ms. Nora had prepared two objects - magnetic and not magnetic- the students shouted what they found with exclamations like, “Oh, wow, Ms. Nora, this is magnetic! The knife picks up, but the penny doesn’t” (Observation, 05/10/2011). Through this process, Ms. Nora asked the students to explore reasons for their predictions, to explain why they thought what they thought, and to share what they found.

Asking questions to support children's thinking process

The participant teachers also used questions to encourage the students to think about the concept being taught, in order to elicit reflective responses from students. For instance, in the teachers' science lessons, Ms. Parry asked the students whether caterpillars can eat McDonald's hamburgers to live, and Ms. Sandy asked if non-living things can move. To answer the questions, the students already knew the basic information about characteristics of caterpillars (e.g., what caterpillars eat) and differences between living and non-living things. Thus, the students knew the facts sufficient to understand and apply the facts to different situations. After the students demonstrated their thinking processes, they were able to successfully proceed to analyze, synthesize, and evaluate the scientific material in hand.

As another example of the teachers' posing questions in discussions with the children, Ms. Sandy and the students discussed living and non-living things on April 12th. Prior to the discussion, the students had already learned some of the differences between living things (e.g., real rabbits) and non-living things (e.g., stuffed rabbits). In the discussion, some students were still confused about whether the object was living or non-living. Ms. Sandy then asked some questions reminding the students about the characteristics of living and non-living things. Ms. Sandy asked, "Is it moving?" "Do all living things move?" (Observation, 04/12/2011). In this way, the students learned about the differences and similarities between stuffed and real animals, as she pointed out movement as being one of the differences between living and non-living things.

Ms. Jane also frequently used asking questions in the discussion. On March 3rd, Ms. Jane talked about cold weather as the science topic. She discussed how to use a thermometer. Ms. Jane and the students thought about what made the red line go down. Ms. Jane would often say, "That's a good question," or "That's a great idea," and then ask the student again, "What do you think?" (Observation, 03/03/2011). Her response elicited excitement when helping the students carry out science-learning activities in a supportive classroom culture. When teachers ask students appropriate questions in science lessons, the students' thinking can fit what the teachers are trying to teach (Venville et al., 2003). Also, open-ended questions (e.g., What do you think?) can help students think and construct their answers in science activities (Venville et al., 2003).

In the caterpillar activity, Ms. Parry asked them how they would raise the caterpillars. Through such questions, she made thinking a discernible part of the classroom activity. This discussion approach, which was rooted in asking questions, allowed the students to think of different ideas and provide possible explanations, if necessary. However, when Ms. Parry's questions were too difficult for the students to answer, she would give them hints. Thus, through her questions and hints, she guided the students as they learned how to think for themselves.

In sum, the participant teachers used discussion to support the students to learn "how to think." During the discussions, the teachers had various strategies, such as asking questions, giving positive responses to student's answers, and offering hints to encourage the students’ active participation. These strategies are helpful to make efficient science learning because students have time to think, talk about, and facilitate their debates (Diakidoy & Kendeou, 2001; Vosniadoum, Ioannidesm, Dimitrakopoulou, & Papademetriou, 2001). These discussions guided the students as they learned how to use scientific methods to answer questions and to recognize reality as they were learning thinking skills (Kirch, 2007). Moreover, in discussions, when the teacher asks questions and accepts a wide variety of answers, this allows the teacher to understand the children’s thinking process. Thus, discussions guided by the teacher’s questions can serve a number of purposes.

TEACHING TO SUPPORT STUDENTS’ INTEREST IN SCIENCE

As noted by Siverton (1993), early childhood is “a critical time for capturing children’s interest," so their curiosity and interest about the natural world could be encouraged for future science learning (p. 3). The participant teachers believed that students need to be interested in science activities, and based on that belief, the teachers attempted to support their students' enjoyment of science activities. For example, Ms. Nora believed that student excitement and interest in science lessons are vital for children to learn science. In her science activities, Ms. Nora tried to help the students enjoy and be curious about science activities. She explained, “I think the excitement triggers their [the students’] curiosity. They become more curious. Then they get motivated; they are motivated about science. [That’s why] I want them to be excited about learning”

(Interview, 05/10/2011). Similar to Ms. Nora, the other participant teachers believed in the positive effects of stimulating and maintaining the students’ interest in science.

Paying attention to students' interest in science activities

Ms. Parry believed that the most important factor in a science lesson is to enhance the students’ love of learning science. Students experience their love for science along with the activities. For instance, when Ms. Parry did an activity on making ice cream, some students said that they “feel so awesome!” after dropping ice cubes into a big bowl (Observation, 02/11/2011). Sometimes, Ms. Parry asked the students if they would like to conduct science activities. In the living and non-living things activity, Ms. Parry asked, “Who is interested in science? Are you interested in this science unit?” After her questions, every child raised his or her hand (Observation, 04/12/2011). Ms. Parry believed that the students’ positive responses were evidence of the active engagement with science classes, as well as the level of interest in those activities. Ms. Parry noted, “They [the students] like science. They want to do more science. They will ask me sometimes, ‘Aren’t we doing science today?’ So, I think they have been learning a lot. And I think they have enjoyed it” (Interview, 05/03/2011). Ms. Parry evaluated her science lessons through the students’ responses, and her beliefs were based on the evaluations and judgments of the students’ responses to the science activities.

Science activities supporting students' interest in science

During the interviews, the participant teachers considered the importance of following the children's interest in choosing topics for their science lessons, but they also commented that "there's not a lot of time to do much extra [topics that children are interested in] because we [the teachers] have a certain curriculum that we have to teach" (Interview, Ms. Nora, 01/31/2011). Therefore, when observing the teachers' science lessons, it was found that only Ms. Jane added additional topics – following the students' suggestions - that were different from her original plan.

Ms. Jane thought that she had a responsibility to assist students, such that they become interested in science. When the students demonstrated a real interest, Ms. Jane actively changed her lesson plans to accommodate that interest. For example, on February 1st, after 14 to 15 students talked about the thermometer in the classroom, she decided to talk about the thermometer, noting what a thermometer is and how it can be used. Her original lesson plans were "always being revised" (Interview, 02/01/2011). That is, Ms. Jane tried to do more student-centered activities that could be connected with issues of students' interest. The reason Ms. Jane tried to reflect topics proposed by the students is because she believed that "science is everywhere," such as "gravity," "temperature," and "light comes on when you [the students] turn on a switch," so she wanted the students to feel it (Interview, 01/31/2011). She recognized that science could be everything that the children experience, so they need to focus on the world around them. Specific methods of "observing, thinking, experimenting, and validating conclusions have become a part of the scientific way that people explore the world" (Bryan & Atwater, 2002, p. 826). Therefore, in Ms. Jane's science lessons, she combined the science topics from the required science curriculum and the children's natural surroundings the children.

In Ms. Jane's science class, when she taught “Sharing the Planet” from the PTP program, she and the students discussed plants and animals, and human beings’ responsibility for living things. Ms. Jane attempted to use everything surrounding the students in her science lessons, and, in the moment; she grabbed opportunities for students to connect what they had learned in science activities and the real world. On the topic of “Sharing the Planet,” Ms. Jane and the students talked about plants and animals, and responsibilities to conserve and recycle. That morning, there was a bird up in the eaves right outside the window, and the students all said, “Look at that bird!” Ms. Jane recalled later that “it was just sitting right there, and, of course, their attention is drawn to that. They want to go see what it’s doing” (Interview, 05/03/2011). She commented to the students, “Well, maybe they are looking for a place to build a nest because it’s springtime” (Observation, 05/03/2011). Ms. Jane’s prompt response was from one of her beliefs, “Science is everywhere, and it happen[s] all the time” (Interview, 05/03/2011). She was trying to “help them [the students] be aware of their surroundings and to think beyond just what they are being told or what they are doing at the moment” (Interview, 05/03/2011). To achieve the goal in science lessons of helping the students think about their surroundings, Ms. Jane sometimes mentioned her experience or focused on topics raised by the students, such as the weather and world news. The experiences discussed were familiar to the students, so they were interested in the activities and participated enthusiastically. For example, when Ms. Jane taught about temperature from TEKS, she first told the students about an unexpected weather condition. “Yesterday, at three o’clock in the morning, I heard a loud noise! It was very loud, so I woke up. I thought that it was a tornado!" (Observation, 02/01/2011). Ms. Jane's experience the night before drew the students in. The students reported that they, too, had heard the same noise. Also, she mentioned the large earthquake that occurred off the coast of Japan. Ms. Jane found students to be "very aware of what's happening in the news and what their parents are discussing. So the earthquake landed itself to be a topic of interest, and it fit right in with science" (Interview, 05/03/2011). In those examples, Ms. Jane wanted to understand students' previous experiences and knowledge about scientific topics as important information to plan and develop science activities. Through Ms. Jane's questions or sharing of prior experiences related to a content area to be studied, students' thoughts and ideas about the subject could be activated and developed. For instance, the students shared how they had felt when they heard the loud noise, and they discussed with each other some of the times and places they had similar experiences, in follow-up to Ms. Jane's questions.

Another example of science activities shared with students from Ms. Jane's daily life occurred on April 20th when Ms. Jane brought her goldfish to the classroom for the students to observe. Ms. Jane explained that "because, if we're going to talk about living and non-living, I wouldn't have given them as much of a learning opportunity, if I had just brought in a picture… So I just wanted something living" (Interview, 04/20/2011). Ms. Jane recognized that science is in children's everyday lives, so it needs to be relevant and meaningful to them.

Sharing students' experiences in science lessons

Ms. Jane frequently shared not only her experiences, but also the students' experiences and opinions about science. In her science lessons, a student brought in a caterpillar that she was raising. Others told stories from their past that were related to the unit. The caterpillar topic began from one student's question, "I have a caterpillar at home and can I bring it?" (Interview, 04/06/2011). This particular student expressed her interest and curiosity in caterpillar, and it was a suitable topic that could be explored in science lessons, because other students were also interested in the caterpillar. Ms. Jane called the student's mother to get her permission. In the middle of "Sharing the Planet," such an activity was not what Ms. Jane had planned. However, she decided to go ahead with the caterpillar activity because she wanted to hold "lessons as they [the topics] come up" and "it is child-driven" (Interview, 04/06/2011). After the activity, Ms. Jane had this to say: "This is not what I had planned to do, but it was the best thing that we could do because Sarah found it; she was excited about it. And it made for a great lesson" (Interview, 04/06/2011). Here, Ms. Jane used a child's interest and experience about caterpillars for developing science activities. She seized a good opportunity to provide the students time to interact around a science phenomenon, i.e., the caterpillar, becoming a lesson based on one child's questions and ideas. Thus, Ms. Jane utilized her student's scientific interest and insights about the caterpillar to support and develop an understanding of science phenomena in activities that she and the students developed and structured together.

The caterpillar activity is described below:

> In the caterpillar activity, Ms. Jane introduces the fact that Sarah brought a caterpillar from home and explains that it will turn into a butterfly. Sarah shows the students the small plastic box that contains the caterpillar and, in answer to Ms. Jane's question, explains that she had found it in her driveway. "Because of the color, the driveway is grey and a leaf is green, [and] the caterpillar is grey! So I can see it!" After Sarah's explanations, Ms. Jane tells the class she will put the caterpillar in the science area and they will need to take care of it. Then she asks the students what the caterpillar will need and what they already knew about it. On a white board, Ms. Jane writes, "Things we know about a caterpillar" and, below that, the students' answers: "Caterpillars have legs." "When it hangs on a tree, it makes a shell." "They eat leaves." "They have bumps on their back." "It looks like it has a moving bubble, when it walks." "They have a lot of legs." Then Ms. Jane read a book, *Beautiful Butterflies.* (Observation, 04/06/2011)

In the first part of the activity, Ms. Jane introduced the topic by explaining that Sarah had found a caterpillar and brought it to share with her friends. When Sarah showed the caterpillar in a box to the other students, they focused on her experience, became curious about the caterpillars, and later found caterpillars at their homes. She spoke to me of what was exciting about the activity, "Well, I think that just because of the nature of being a child they're excited about things and they want to share. And whatever they find important, they want to share with somebody else" (Interview, 05/03/2011). Ms. Jane took part in her students' interest about the caterpillar that Sarah caught by incorporating a serendipitous event into the science lessons. Ms. Jane picked the caterpillar activity from the children's everyday conversations and questions that reflected their interest in the topic. Through this lesson, as suggest in literature, the children were able to process the scientific concepts and theories about their surroundings based on daily observations and conversations (Brewer, Chinn, & Samarapungavan, 2000; Vosniadou, 2002).

In addition, on April 20th, several students brought to class rocks and pieces of wood to share. At that time, Ms. Jane was covering the section on living and non-living things. In her science lesson, Ms. Jane introduced new items, such as pencils, a clock, a goldfish, and plants, rocks and pieces of wood. The students discussed and classified whether the items were living or non-living things. By adding the pieces of wood and rocks to the lesson, Ms. Jane focused on the importance of following what her students were interested in. To know what the students' interests were, Ms. Jane paid attention to "what they are saying and what they're doing and what they're bringing in" (Interview, 05/03/2011). After Ms. Jane recognized such things, she "made it in plans" (Interview, 05/03/2011). She believed that "just picking up on what they are interested in and making them feel valued for bringing stuff in and talking about it is real important" (Interview, 05/03/2011). Through this process, Ms. Jane supported and encouraged the students' interest in learning science. Children have access to numerous scientific phenomena through everyday experiences with plants and animals, as well as nonliving things in their environment (Baldwin et al., 2009; Samarapungavan et al., 2008; Siry & Kremer, 2011). Moreover, Ms. Jane focused on the students' daily experiences that she connected in her science lessons. For instance, the students' experiences in catching a caterpillar and finding rocks could not alone lead to learning; however, Ms. Jane designed meaningful science activities around those experiences.

With regards to the activities, Ms. Jane noted, "I just use whatever knowledge I have and mix it with their interests and their curiosity. And those are the best science lessons" (Interview, 05/03/2011). That is, she thought that the best way to teach science is to learn what the students want to do. In early childhood, children have a natural desire to have answers or interpret what they observe in their surroundings (Kallery & Psillos, 2001), so Ms. Jane sought to catch topics they were interested in and to organize science activities based on those issues related to their questions. Ms. Jane's unexpected science topics gave the students opportunities to know about science issues in their lives and to raise questions and approach answers to questions by themselves. In addition, because the activities came from the children's own interests, their questions were helpful for leading to science investigations that stimulated their thinking process.

Children learn everyday concepts through interactions with the world (Fleer, 2009), while scientific concepts are acquired from schools (Howe, 1996). Everyday concepts are "the foundations for learning scientific concepts" (Fleer, 2009, p. 283), and these two types of concepts are related to each other. In science lessons, Ms. Jane attempted to combine her students' everyday concepts and scientific concepts in ways that encouraged interest in learning science. Hedegaard and Chaiklin (2005) noted that the most effective learning context is finding the appropriate balance between everyday and scientific concepts. Ms. Jane's science classes were improvisational and constructed to an extent by students. The improvisational nature of her lessons was an important aspect of effective teaching.

The second sub-category relates to supporting the students' interest in science. The teachers wanted students to be interested in science activities, so they paid attention to how their students responded to each activity. However, even though the teachers recognized the significance of following students' interest toward topics in science lessons, they "cannot do as much as [they] would like to" because they "have to cover for science curriculum" (Interview, Ms. Sandy, 02/08/2011). Ms. Nora called the curriculum "pretty heavy-duty" (Interview, 01/31/2011). However, Ms. Jane attempted to connect with the curriculum and the students' interest based on their experiences or her experience because she believed that that was very important.

HANDS-ON SCIENTIFIC ACTIVITIES

An examination of the teachers' goals makes it possible to gain a clearer understanding of their behaviors in the classroom (Kang, 2008). In this study, one of the teachers' goals in teaching science was to support the children's curiosity and interest in science. According to Levitt (2001), a teacher's ultimate goal for teaching science is to help the students enjoy science. The teachers in this study believed that science should be enjoyable and full of hands-on activities. During the first interview, all of the participant teachers focused on the importance of hands-on activities. Similarly to the teachers' in Levitt's (2001) study, these four teachers felt that doing such activities contributed to the students' learning science. In fact, the NRC (1996) has noted that hands-on activities that require critical considerations about science include "observation, data collection, reflection, and analysis of firsthand events and phenomena" (p. 33).

Observing science classes for this study revealed that the teachers did, indeed, use hands-on activities, confirming their statements of beliefs. Hands-on activities, as observed during the lessons, ranged from guided discovery in which the teachers led the students through the steps of an activity to more free-wheeling explorations once expectations were established. In the observation session, the students actively participated in the science lessons, and the teachers were eager to support their involvement.

Ms. Parry introduced several hands-on activities, such as making ice cream; playing a tree game in which students observed trees and pretended to be trees, water, and sunlight such that trees can grow; observing a caterpillar; and visiting an atrium in their school. In explaining why she included hands-on activities in science lessons, Ms. Parry noted:

> [I focused on them] probably for [the students] to be able to have hands-on experience of things, so that they could understand it better. So that's why I did the ice cream because they actually got to feel the ice cream, taste it, and see how it melted and that kind of thing. (Interview, 05/03/2011)
>
> And the tree activity, headband, they actually got to pretend to be a tree or one of the elements that the tree needed. And then going to the atrium, they actually got to see the living and nonliving things in the atrium and actually experience them. So, I think that's probably the most important thing. (Interview, 05/03/2011)

In these statements, Ms. Parry stated that she wanted the students to have actual experiences, such as feeling, tasting, and observing through hands-on science activities in order to better understand science.

An example of this occurred on April 14th, when Ms. Parry and the students visited the atrium in their elementary school. During their visit, they observed, found, and felt living and non-living things, as she stated in her interviews. Before going to the atrium, Ms. Parry and the students discussed differences between living and nonliving things. Then, Ms. Parry gave the students their science notebooks and explained what they would do in the atrium. When they reached the atrium, the students observed and sought out living and non-living things, writing down what they looked for. Ms. Parry instructed them to find two living and two non-living things in the atrium. Ms. Parry expected students to have a better understanding of living and non-living things. She commented that:

> Because [in the atrium,] there are a lot of living and non-living things in there and they've got to move around and look for them themselves and explore. I thought that would be really fun for them; plus I can keep them close by rather than going out where some of them might wander off. (Interview, 04/14/2011)

Also, Ms. Parry thought students learned better when they observed real living and non-living things. Ms. Parry said, "It's more important for them [the students] to see the actual living things rather than just pictures of them. I just think that they learn it better that way and it is more real to them" (Interview, 04/15/2011). Ms. Parry wanted the children to construct their scientific knowledge about the world from their observations and explanations.

Ms. Sandy said that she also wanted to have as many hands-on activities as she could. Similar to Ms. Parry, she "love[s] hands-on things," because "they [the students] can do and they can learn by actually doing the things themselves" (Interview, 05/11/2011). On April 12th, Ms. Sandy planned a rabbit activity for the unit on living and non-living things. She wanted the students to observe a rabbit in a different classroom . "The observation, just knowing that we had the bunny, it would be fun to go" (Interview, 04/12/2011). The students waited in groups of four or five for their turns to observe the rabbit. The brown-and-black rabbit was in a cage. Ms. Sandy told the students they could pet the rabbit, later asking, “Did you pet him [the rabbit]?” or “Are you sure you want to touch him?” After all the students had observed the rabbit, they returned to their classroom, where they discussed the differences and similarities between real and toy rabbits. In this activity, the students used observations and prior knowledge to compare living and non-living things. Finding out children’s knowledge is a significant tool for designing activities in a way that focuses on knowledge that students have already acquired through their prior experiences or learning from a class (Siry & Kremer, 2011).

As for Ms. Nora, she believed she met her “goal of science instruction” by noting that: “Basically, hands-on” in science lessons, saying “just providing hands-on activities and going through the scientific process as the best I can and providing the kids opportunities to explore and just really be hands-on instead of teacher direct lessons” (Interview, 05/10/2011). Based on this belief, Ms. Nora designed “making ice cream and magnet activities. There were more interactions with the lessons themselves” (Interview, 05/10/2011), and she considered those her best lessons since hands-on activities stimulate children’s science learning and develop their cooperative skills. Also, inquiry-based instruction gives students more positive beliefs than other kinds of instruction, such as textbooks and worksheet questions (Shepardson & Pizzini, 1994).

Ms. Nora said that hands-on activities were important, because the students “got to explore the objects and see for themselves” (Interview, 05/10/2011). Ms. Nora attempted to give the students enough opportunities to explore, see, and feel objects in the science activities.

> Ms. Nora has planned an observation of trees in the playground and she lets the students have time to freely observe them. Before the observation, Ms. Nora read *Inside the Tree* that explained how important trees are to people's lives. After reading the book, she lets the students know what they are and are not to do while outside. "We are not going to climb the trees." Outside, she tells them to choose a tree and then sketch it. Ms. Nora counts from 1 to 10, while the students choose a tree. Ms. Nora gives them pencils and they observe and sketch their chosen trees. During the sketch time, Ms. Nora shows them how to draw the leaves and bark. Ms. Nora and the students go back to the classroom, and then they share what they observed and sketched. (Observation, 04/28/2011)

In the informal interview that followed the activity, Ms. Nora said, "The fact that they learned about trees and they were looking at the leaves and the barks and, you know, it just brings up close. The trees are different. They have different leaves and different barks and different height, so it is just getting familiar with the topic" (Interview, 04/29/2011). This lesson was effective because, when curricula are connected with experiences outside of classrooms, children learn more effectively (Tenenbaum, Rappolt-Schlichtmann, & Zanger, 2004).

Through various hands-on activities in science lessons, the participant teachers wanted students to be active participants and not passive recipients of information. Particularly, Ms. Nora taught the students to be scientists through hands-on activities (Interview, 05/10/2011). In science education, students need to understand the value scientists put on knowledge along with the rationale that scientists use (Enfield, 2000). Therefore, it is significant that teachers recognize what scientists actually do and how they go about doing it (Annett & Minogue, 2004). The teachers also found that following the scientific processes was helpful for them to teach science effectively.

Constraints for conducting hands-on science activities

Even though the teachers' science activities were in line with their beliefs about having more hands-on activities and their belief that hands-on activities offer the best way for students to learn science, they mentioned that it was not easy to teach science through hands-on activities. For example, in the first formal interview on February 1st, Ms. Parry said that she frequently reads books instead of conducting hands-on activities in her science lessons. Her reasoning was that she thought reading books is an "easy way," and "doing hands-on things… takes more work to get the materials and supplies together" (Interview, 02/01/2011).

During the observations, the teachers added more explanations about differences between their beliefs about hands-on science activities and actual science lessons based on different characteristics of each topic. Ms. Parry and Ms. Jane commented:

> I think, I mean I don't think you can do everything hands-on. You know, you can't teach them about a tiger by going and having a tiger or whatever. You might have to read books or do things like that, like today a computer lab we went to a program where they were able to pick an animal and find out about it and they are doing a research report on it. So I think, you know, that is just another way for them to learn, so I think you have to use a variety of ways. I think the hands-on is important; I wouldn't say that it's them or us important. You need to have a variety. (Interview, Ms. Parry, 05/03/2011)

> You know, like having the fish, no they [the students] can't touch the fish... but when you lift up the paper [that you painted the fish] you've got that outline of the fish and you can see all the scales and the gills and all of that. (Interview, Ms. Jane, 05/03/2011)

Ms. Parry believed in the importance of hands-on science activities for the students to learn science, but whether they did hands-on science activities depended on characteristics of the topics in science instruction. Hence, she taught science in various ways, such as "read[ing] books" and going to "a computer lab" (Interview, 05/03/2011). Ms. Jane shared the same opinion as Ms. Parry. She said there was a gap between her belief about doing hands-on activities in her science lessons and her practices in actual science lessons. Ms. Jane thought that "it just depends on what the topic is as to whether it is hands-on or not" (Interview, 05/03/2011). Both teachers believed that, although hands-on activities are valuable, it was not always possible or appropriate to do that sort of activity.

In sum, the four teachers' beliefs about hands-on science activities, in some cases, had yet to be put into practice. All the teachers believed that hands-on science activities are helpful for young children to understand scientific concepts. However, the teachers did not always use this method of instruction in their teaching. They noted that hands-on activities required time to prepare, and had limited time in their schedules for science lessons, and questions about whether some topics were appropriate for hands-on activities. In cases where teachers thought that hands-on activities in actual teaching practice would be difficult, they believed in the merits of using other methods to stimulate interest and to teach science to the students.

VARIOUS OTHER METHODS TO TEACH SCIENCE AND TO STIMULATE INTEREST IN SCIENCE LESSONS

In the participant teachers' practices, their science activities were frequently related to various other subjects such as language arts and art; those combinations are considered to be common in elementary schools, since the integration of science, mathematics, and language arts can improve elementary school students' achievement in science and foster positive attitudes toward science (Yore, Bisanz, & Hand, 2003). Moreover, Yore, Bisanz, and Hand (2003) found that integration with other subjects such as mathematics, music, literature, and art in science education helps young students develop positive attitudes and make improvements in their science learning (Harlan & Rivkin, 2000). In science lessons, the participant teachers in this study also did various activities in addition to hands-on activities, such as reading books, introducing new vocabulary, drawing, and writing.

Reading books in science lessons

Language is considered to be an important factor for the development of children's scientific concepts. In science activities, researchers have documented how kindergarten teachers often use narratives or stories to introduce appropriate scientific vocabulary (Kallery & Psillos, 2001; Pressley, 2002; Sackes et al., 2009; Smith, 2001). Language art activities in science lessons, such as reading books, writing or drawing in science notebooks and learning vocabulary, are important tools that serve significant roles in the process of learning and participating in the practice of science (Ford, 2006). For instance, different kinds of books, such as fictional narratives and informational texts, have the potential to engage children with the genres of science (Gee, 2004) and specific language patterns in science activities that encourage the development of children's scientific knowledge (Beck & McKeown, 2007; Norris & Phillips, 2003; Yore et al., 2003).

Reading books was the most common strategy used by these teachers in science lessons to convey and share scientific information about topics (Oliveira, 2010). Ms. Jane was accustomed to reading books in science lessons. In fact, that was the most frequent teaching method she used when being observed for this study. Ms. Jane loved “reading stories” and liked trying to incorporate them into whatever the students were doing (Interview, 05/03/2011), because she thought that reading books could give the students useful information. For most science activities, she read from a range of children’s books, such as reference books, nonfiction, fiction, and biography, because she wanted the students to understand that there were many different kinds of books, such as “informational books and nonfiction” (Interview, 05/03/2011). For instance, when it was time for the caterpillar activity, she read a book related to a butterfly’s life cycle, followed by students’ role playing. In the role-playing activity, they pretended to be inside eggs on leaves, and then they became caterpillars who ate the leaves. Everybody made his or her body smaller and then mimicked eating something sitting in the classroom. Finally, the students acted like butterflies that were flying about the classroom (Observation, 04/06/2011). During this activity, Ms. Jane gave the students information about caterpillars and butterflies, and they asked questions and guessed at how they ought to take care of a caterpillar.

Sometimes, Ms. Jane planned to read books in science lessons without other supplemental activities, such as experiments or observations. For instance, as a science activity, Ms. Jane introduced George Washington Carver by reading a biography of the scientist. Also, through reading books like that one and recalling stories, Ms. Jane pointed out some difficult words, such as *inspire*, *inventor*, *ponder*, *compare*, and *contrast* and asked the students for their meanings (Observation, 03/31/2011). Then they talked about the story, about such people as a scientist and an inventor (Observation, 03/03/2011). Thus, according to French (2004), the discussion of the content in the book led to the discussion of the concept underlying the activity of the day, as well as the actual activities.

In the case of Ms. Sandy, she also read books in her science activities. In the living and non-living things activity, at the last moment, Ms. Sandy read the book *My Pony* and asked questions. "Is this one a living thing or a non-living thing?" She wanted the students to organize and recall what they had learned in the activity.

The participant teachers in this study thought that reading books was an appropriate way for children to acquire scientific information. For instance, Ms. Jane wanted a child to know "Oh, if I [a child] want[s] to know more about whales, I can just try and go find a book in the library" (Interview, 05/03/2011). Since children's books encourage their science learning by providing opportunities to observe, ask questions, and reach meaningful conclusions (Castle & Needham, 2007; Monhardt & Monhardt, 2006; Pringle & Lamme, 2005), they can be helpful for children to understand difficult scientific concepts (Morrow, Pressley, Smith, & Smith, 1997; Sackes et al., 2009).

Additionally, in science lessons, the teachers read books to grab the students' attention about the activities. Before engaging in activities, Ms. Nora would read a book to introduce the science topic, so that the students became interested and excited about learning. For the living and non-living things unit, Ms. Nora and the students went out to observe trees on the playground. Before the observation, Ms. Nora read *Inside the Tree*. She spoke of how “trees take care of us [humans]” and “help us to live” (Observation, 04/28/2011). Ms. Sandy would read a long book to the students to raise their expectations about the science activity. For example, on April 29th, she read *The Tiny Seed* prior to observing lima beans. “If they are sitting for a while, they need something right after that, very shortly, to be able to look forward to. So a quiet activity [such as reading books] and then something they can be active and just get their hands-on and have fun with” (Interview, 04/29/2011). That is, Ms. Sandy expected that, in science instruction, integrated inquiry and literacy activities can be an effective teaching strategy to prompt kindergarteners’ motivation to learn science (King et al., 2001; Patrick et al., 2009b)**.**

Ms. Nora also read a book related to science activities before actually talking about the activity. When she taught about magnets on March 29th, she first read a children’s book about magnet families living on a refrigerator. The students were then interested in magnets and understood that they stuck to things, like refrigerators. When Ms. Nora started to conduct the activity on magnets, she asked, “What does magnetic mean?” They answered that a magnet could stick to metal. She also read *What Makes a Magnet* after they finished the activity. She liked to help the students understand science concepts and to remind them of what they learned through experiments and drawings.

In sum, the participant teachers frequently read books to their students because the books included appropriate scientific information that students needed to learn and “it kept their attention" (Ms. Parry, Interview, 05/03/2011). The teachers wanted the students to learn scientific concepts from hearing them read books, such as picture books, fiction, and nonfiction, all books that served as instructional tools that addressed science concepts. Reading books to students also piqued their interest and created positive attitudes toward science topics.

Explaining vocabulary in science lessons

A common activity the participant teachers engaged in during the science lessons was explaining difficult or unfamiliar words as they surfaced in science lessons. Doing so helped the children learn the vocabulary of science contextually by introducing and modeling key terms during the flow of relevant activities, and by explicitly using those terms to describe what children said or did during activities (Samarapungavan et al., 2008).

In the caterpillar activity, Ms. Parry talked about the meaning of "beneficial." Ms. Parry and the students discussed how plants and caterpillars can live, and one student remembered a ladybug as being an insect beneficial to plants. Ms. Parry focused on beneficial bugs and then explained that *beneficial* means "good" (Observation, 04/12/2011). When Ms. Parry taught how water is a resource for living things, the students learned the meaning of two words, *finite* and *infinite*. Ms. Parry first let the students guess the meanings of the words and then asked them: "Water is infinite or is it finite? Thumbs up, if it is infinite" After the students' answered, Ms. Parry explained the meanings of the words and suggested some examples of finite and infinite things

(Observation, 04/15/2011). Children acquire scientific concepts through conscious learning by language (Spycher, 2009). Children show scientific concepts through the use of specialized language, “the lexis and grammar particular to a disciplinary area” (Spycher, 2009, p. 363). Therefore, it can be meaningful for teachers to explain new vocabulary in the science lessons.

Ms. Sandy explained the meaning of the word *survive*. First, Ms. Sandy asked the students the meaning of the word, and they offered their guesses. After the students’ guesses, Ms. Sandy suggested an Internet dictionary site. Ms. Sandy showed the students how to find the website and how to look up the word (Observation, 04/15/2011). Ms. Sandy considered the importance of teaching the meanings of new words during science lessons, so she "explain[s] the words" to "get their [the students'] understanding [about the words]" (Interview, 04/15/2011). When she taught the living and non-living things section, Ms. Nora explained the term *reproduce*. She taught the students that “living things grow and reproduce” (Observation, 04/28/2011).

Prior research (Beck & McKeown, 2007; Bowman, Donovan, & Burns, 2001; Epstein, 2003; Ramaley, Olds, & Earle, 2005; Spycher, 2009) points out the importance of learning vocabulary for children in science lessons. The teachers in this study used the learning of academic terminology in science lessons in order to for the students to understand and display knowledge in expected ways at school (Spycher, 2009). In addition, when discussing the meaning of words, children make judgments about how the words are used in novel contexts, by being required to construct their own examples using the words (Beck & McKeown, 2007).

Science notebooks and drawing in science lessons

The participant teachers used science notebooks in their science lessons in unstructured ways in order to allow flexibility in how the different teachers used them, their appropriateness for various times (e.g., at the middle or the end of the activities), and children's varying levels of literacy skills in the same class. For instance, some children wrote letters in their notebooks, and others only drew pictures in science activities, but the teachers did not focus on those skills; instead, they focused on the students' ideas about the topics or what they learned from the activities. The children used their science notebooks to record key aspects of their inquiry, such as their questions and predictions, their plans for investigation and observation (e.g., what they planned to observe in order to answer their questions and how often), what they observed during their investigations, and their conclusions and questions. Children’s entries included a combination of drawings, photographs taken with digital cameras, and writing though the use of invented spelling, or direct assistance from adult helpers who recorded the children’s oral responses verbatim in their notebooks.

This instructional strategy helps children internalize the scientific knowledge they were taught in their activities (White & Gunstone, 1992). Furthermore, drawing can be helpful for young children who have difficulty expressing their opinions with language (Rennie & Jarvis, 1995). In all, by having the children draw as a part of their scientific activities, the participant teachers not only provided the children with an art activity to express their emotions, but they also supported their students’ science learning by allowing them to illustrate their scientific knowledge and ideas (Samarapungavan et al., 2008; Zoldosova & Prokop, 2006).

All the participant teachers believed that kindergartners learn science better with a science notebook, which all their students used in their activities. The children's drawings in their science notebooks provided useful insights for teachers to understand what their students knew and understood; the drawings were an effective communication tool between the children and teachers. For instance, Ms. Jane commented:

> A lot of it is that way because kindergarten, you know, they can't write a research paper, but they can label their pictures, and they can tell us, and we can make notes. And so that's how we find out. (Interview, 01/31/2011)

For Ms. Parry, the notebooks are "the only evaluation…It's a sample of what they studied… They told what they saw" (Interview, 02/01/2011). Ms. Nora also said, "I do know, if we were doing a lesson on plant life, so you know then for an assessment, 'Okay, make me a story using pictures and words about how a plant begins and take me through its whole life cycle.' So you could use drawing and stories and different things like that, too" (Interview, 02/01/2011). Accordingly, after each science activity, the students expressed their observations and what they were thinking in their notebooks.

For instance, on March 29th, in Ms. Nora's magnet activity, she had students use their notebooks to predict which materials would stick to a magnet:

> Ms. Nora asks and explains what the word *magnetic* meant. She writes that "A magnet can stick to metal" on the white board. Then she show a real magnet and stuck it on the white board. After they talk about magnet and magnetic things, Ms. Nora says, "We are going to explore magnets. Go across the classroom!" The students need to find, in their classroom, things that "might be attracted to a magnet." After the students'

> exploration, Ms. Nora said, “I’ll give you a journal” and then she calls each student’s name. All of the students sit at tables with their own science journals and Ms. Nora gives them papers titled “What can you catch with a magnet?” The students draw or write names of the magnetic things that they found in the classroom. (Observation, 04/29/2011)

In the magnet activity, the students had a time to predict, explore and then to compare what actually happened to the predictions. Moreover, the students shared their explorations and predictions with other students. The students recorded their thoughts, predictions, and findings in drawings in their notebooks, and, by checking these notebook entries. Ms. Nora could recognize whether they had understood the concepts about magnets. Thus, science notebooks have proved to be useful tools for teachers to evaluate their students’ knowledge and understanding.

To support the students' expressions about what they learned, when the students were working in the notebooks, the teachers also interacted with them. The teachers responded to what the students did, and they also answered or asked questions. On April 12th, in the caterpillar activity, the students observed the caterpillar and plants that Ms. Parry had prepared for them. After the observations, and on the paper that Ms. Parry had provided, the students wrote words and drew pictures that showed what they had looked at. While the students were writing and drawing, Ms. Parry went around helping them with their writing. When the students finished writing in their notebooks, they went to Ms. Parry, and she asked them about the caterpillar. “Did you notice the stripe?” “Is the caterpillar white?” “Why do you think they need water?” (Observation, 04/12/2011). Used as a foundation for discussion, the science notebooks offered opportunities for the students to communicate with others and inform others of “their investigations, findings, and conclusions” (Reid-Griffin, Nesbit, & Rogers, 2005, p. 4).

Also, the science notebook served as a kind of portfolio to record what a student had learned. For Ms. Nora, science notebooks were for the students to keep track of their thinking and their learning. “It’s just documentation of their learning, so documentation of their thinking” (Interview, 05/10/2011).

> I think it is a way for them to record their observations and information, and that is one of the things we are supposed to do … I wanted them to be able to record what they had observed. So we used our journals for that, to make observations. And it also lets me know if they understood something… So it is a kind of an assessment in a way. (Interview, 05/10/2011)

That is, for Ms. Parry, the science notebooks serve to record children's learning in science lessons.

In addition, for Ms. Sandy, the science notebook was a kind of portfolio that showed students’ development. Ms. Sandy sent the notebooks home with the students, because she wanted the students to "remember what we [the students] learned," and the notebooks also served the purposes of evaluating the students' development. Through the notebooks, Ms. Sandy could "see so much difference in what they [the students] were thinking early on and what they are doing now [at the end of the semester]" (Interview, 05/11/2011). They were adding a lot more detail in their pictures and making a lot more connections to things that they knew. They drew, and then they wrote what they knew about the world. According to Ms. Sandy, “I just see them adding more and more words and more details and more detail in their drawings and making connections with things that we learned, even earlier in the school year" (Interview, 05/11/2011).

Ms. Jane believed that the science notebooks were for the students to put on paper what they had learned from each science activity. Ms. Jane mentioned the meaning of the children's keeping science notebooks:

> [Keeping a science notebook is] to see that scientists keep records. You know, that's what I want them to see also is that scientists, they don't try to remember everything in their head. They take detailed notes, and they draw pictures, and they date their things, so that they can look back at it for reference. And that's something that I find, that I feel is really important for kids to do is to make observations and to record them. (Interview, 05/03/2011)

Each science notebook served as a kind of "record" similar to what scientists keep, so she wanted the students to use their science notebooks.

On April 14th, Ms. Parry did the atrium activity and she brought out the science notebooks for the students to use as they found two living and non-living things. Every student had a pencil and a notebook, and, when they found living or non-living things, they wrote the names or drew pictures on paper. Recording in the notebooks was helpful for the students to remember what they had observed when they discussed living or non-living things.

In sum, the participant teachers usually found that the use of science notebooks provided an effective way to integrate various subjects, such as drawing and writing, in the science curriculum. Via science notebooks, the teachers encouraged students to engage in inquiry-based experiences by "asking questions, conducting scientific investigations, interpreting data, reporting results, and formulating complete conclusions" (Schmidt, 2003, p. 27). The science notebooks also provided a way for the participant teachers to evaluate and communicate with their students about what the students learned in science lessons.

Using various technology in science lessons

In science lessons, the participant teachers showed visual media by using technology, such as videos, movies, slides, and computer simulations, to extend and expand the students' scientific knowledge. In schools and classrooms, the use of technology, such as computers and the Internet, has grown dramatically in recent decades (Williams, 2000). The participant teachers in this study had their computers in the classrooms, and each computer could be connected with a big screen for students. When the students and teachers wanted to search scientific information or visit websites, the teachers used the computers, and then the students watched the screen.

Ms. Sandy showed a slideshow entitled *What Do We Need? A Tale of Basic Needs*. In the story, there were animals and what they liked to eat; for example, a koala named Katy ate bamboo leaves. Ms. Sandy decided to use the slide show because "the kids [her students] learn in different ways and seeing it in different ways" (Interview, 04/14/2011). Also, Ms. Sandy used educational technology to catch the students' attention about science lessons. She commented that, when the students watched the visual media, "there's a lot more that they notice in the picture versus just me saying something or talking" (Interview, 04/12/2011).

On April 15th, Ms. Parry showed students several websites about water on a slide. Ms. Parry visited a blog entitled, "Where the water is." She showed a circular graph that represented what percent of the earth’s surface is covered with water. For example, oceans cover 97.5 percent and fresh water 2.5 percent, and much of the fresh water consists of the ice caps and glaciers (75%), ground water (20%), and easily accessible surface fresh water (1%). Using these two circular graphs, Ms. Parry pointed out that water is not infinite, and that we need to conserve it (Observation, 04/15/2011).

Ms. Parry used technology, such as visiting blogs on the Internet that are related to science topics, as sources of scientific information. She did so to help her students obtain more information regarding the science lessons. The expression “Google it” had become a mainstay in the classroom (Interview, 05/03/2011). Ms. Parry explained that, “Now, they’ve learned if you need to know more than that, then you Google it” (Interview, 05/03/2011). Also, Ms. Parry used “Google it” not only to gain more information but also to provide the students immediate and accurate answers. For example, “If the kids [students] have a question, they will ask me [Ms. Parry] something and, if I don't know the answer,” then she will respond: “Google it” (Interview, 05/03/2011). Ms. Parry was Googling the information and the students watched the processes and results on the big screen in their classroom. According to Dagdilelis, Satratzemi, and Evangelidis (2004), Googling, effective searching for information, is helpful to construct knowledge and skills. By Googling, Ms. Parry and her students have access to vast databases of scientific information with a few clicks. It is easier and more comfortable than reading books to gain scientific information (Kolikant, 2009; Ramaley et al., 2005).

In summary, the participant teachers used educational technology, such as a computer and slide shows, to give the students a variety of instructional strategies to meet more of their needs. They used these educational materials found in technology because, as Ms. Jane pointed out, "There are so many resources [about science] out there right now [to help the students to learn science]" (Interview, 05/03/2011). For the teachers in this study, using technology in science lessons supports their students to have the latest scientific information and experience more enjoyment from learning.

CLASSROOM MANAGEMENT IN SCIENCE LESSENS

As Yilmaz and Cavas (2008) have pointed out, "classroom management is one of the most important issues in educational settings and it is needed to investigate the teachers' classroom management beliefs and practices" (p. 47). Especially, in inquiry-based lessons, such as science hands-on activities, classroom management is commonly one of the concerns for teachers (Friedrichsen, Munford, & Orgill, 2006). Generally, in science lessons, the teachers in this study employed strategies for classroom management that are positive and interconnected.

In Chapter 4, differences in beliefs about classroom management were noted between the experienced teachers, Ms. Parry and Ms. Jane, who had an average of 29 years of teaching experience, and the inexperienced teachers, Ms. Nora and Ms. Sandy, who had taught for an average of 3.75 years. Typically, inexperienced teachers with five years or less of teaching experience (Peske & Haycock, 2006) have been found to be more focused on classroom management and tend to need additional help in managing their students in science lessons. During observations for this study, the teachers used diverse strategies to handle the students and activities in science lessons.

To support her science lessons, Ms. Sandy thought it was important to maintain classroom management and discipline. Yet, as a first year kindergarten teacher, Ms. Sandy appeared to struggle with handling the students and conducting activities in science lessons, especially hands-on activities. She desired to teach the students who were enthusiastic about science, but the other side of that image reflected frenzied children, which raised concerns. The students in her hands-on activities were, in fact, more active and excited than those in other teachers' science classes.

Ms. Sandy already recognized that she had “a lot of problems with that [managing students] in the first of the year” (Interview, 04/15/2011), an instructional issue that is common for beginning teachers (Yilmaz-Tuzun, 2008). To address this problem, she tried various ways to get a handle on her science lessons. One day, Ms. Jane, an experienced teacher, helped Ms. Sandy encourage students to focus on the activity. During the first interview, Ms. Sandy spoke of the need to recruit assistants to help with science activities. She remembered many adults on "the first day of school – the very first day of school" who offered to help (Interview, 02/08/2011). She commented that "I've had the counselor in; I've had the assistant principal; the principal has been in to observe. I have a mentor teacher; she has been in [my classroom]" (Interview, 02/08/2011). During the observation for this study, Ms. Sandy received help during a science lesson from another experienced teacher, Ms. Jane, who helped the students calm down and pay attention to the activity.

On April 15th, before Ms. Sandy showed slides on a screen, Ms. Jane introduced "a quiet game" that required everybody in the classroom to be silent. During the quiet game, Ms. Sandy had time to set up slides about living and non-living things without being disturbed by the students. After Ms. Jane left, Ms. Sandy's students were quiet and paid attention to the slides about living and non-living things. Even though Ms. Jane assisted for only four minutes, it was helping Ms. Sandy in directing the students to focus on the main activity.

Ms. Sandy was concerned that "I have some very high-energy students that kind of get the rest of the kids going" (Interview, 04/11/2011), so she had several strategies, such as time out and reading books, that would allow the those students who did not focus on the activity to redirect their attention to the science project. For instance, when a boy was not following her directions, she let him "get out of the classroom for a short amount of time" (Interview, 04/15/2011). Ms. Sandy gave him a card about time out, and then he went to the office. In the office, there were some chairs for the children to sit on and think about their misbehavior. However, for children who did not focus on the activity, being sent to the office was the last resort available for Ms. Sandy when she thought that nothing "we [the teachers] have done would have been successful" or "there was no way" (Interview, 04/15/2011). For example, while Ms. Sandy and the students watched PowerPoint slides about living and non-living things (Observation, 04/14/2011), one boy who played with his finger had to sit next to her and focus on watching the slides. Also, Ms. Sandy attempted to "send them to one of the other kindergarten classes" (Interview, 04/15/2011).

In addition, Ms. Sandy was used to reading books to calm the students down after an activity and even to focus them on the activities. Ms. Sandy said, "I have some very high-energy students that kind of get the rest of the kids going. Plus, anytime that I change the schedule around; they do get a little excited… So I have some free time to read books" (04/11/2011).

Other participant teachers had their own methods for managing students during science activities and for capturing the students' attention. When visiting Ms. Jane's class, it always seemed to be calm and organized. In science lessons, Ms. Jane employed these methods to manage her students: First, she complimented students who focused on activities. On February 1st, Ms. Jane talked about a storm and read a book about it. During the activity, Ms. Jane pointed to one girl and said, "Sue! You are very patient!" After this compliment, Sue smiled proudly, and other students focused on Ms. Jane again. That is, according to literature, Ms. Jane motivated the students by encouraging pro-social behavior and setting clear expectations (Dolezal, Welsh, Pressley, & Vincent 2003; Ross, Bondy, Gallingane, & Hambacher, 2008).

Second, Ms. Jane set rules for students to follow in her science lessons. For instance, to speak, the students had to raise their hands. If students forgot, Ms. Jane reminded them to raise their hands when they knew an answer (Observation, 03/03/2011). Ms. Jane also told the students what she wanted them to do. For example, she said, "I wish everybody would be quiet and sit still" (Observation, 02/01/2011), "I can't hear Kevin!" (Observation, 03/03/2011). This strategy, used by other teachers of kindergarten in this study[2], tended to include "mostly [of] subjective commands, involving both the commander and the commanded parties explicitly in the speech act" (Oliveira, 2009, p. 807).

Ms. Nora encouraged the students to calm down and focus on her through introducing simple activities before moving on to the main activities. For example, on March 29th, Ms. Nora played the game, *I Spy*, with the students before she taught magnets. Ms. Nora gave some hints for the students to find something or someone in the classroom. "I spy someone wearing pink!" and then the students answered "Betty!" "I spy somebody wearing orange!" The students cried out, "Molly!" (Observation, 03/29/2011). While Ms. Nora continued to play this game, several children went to the restroom, and others sat on a carpet. The students enjoyed this game, so it was easy to gain the students' attention to introduce a book about earthquakes and to talk about magnets. Most students looked at and focused on Ms. Nora and what she said. That is, through a simple game, Ms. Nora made her science activities interesting by teaching thinking skills that helped "to keep their [the students'] attention" (Interview, 02/01/2011). Ms. Nora added "If I don't [make the science activity interesting], they [the students] are going to be running all over the place [laughs]" (Interview, 02/01/2011).

An inexperienced kindergarten teacher, Ms. Nora, believed she needed parent volunteers to carry out hands-on activities in science lessons. She thought that a parent

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2 For instance, Ms. Nora used, "All eyes up here" and "Everybody was on your bottom; I need everybody on your bottom please" (04/05/2011).

volunteer “helps manage smaller groups, keeps them on task” (Interview, 05/01/2011). In the science activities, such as the ice cream-making activity, in each group she placed a parent volunteer, some of whom were students’ mothers. She explained, “If we were making ice cream and I’m the one up there and only three or four kids got to come and mix it, they would not be as enthusiastic; they would not be as excited [about] it. They would not learn as much” (Interview, 05/10/2011). Because of her belief about the positive contribution of parent volunteers, Ms. Nora did a hands-on activity with several mothers in her science lessons. In preparing for the ice cream activity, Ms. Nora assigned students to several groups, and each group had a volunteer mother. In the groups, the mothers and the students took part, following Ms. Nora’s directions. After all the groups had made ice cream successfully, the students, the mothers, and Ms. Nora shared the dessert.

> Ms. Nora, wearing a small microphone, stands in front of the students and mothers. There are three parent helpers, and Ms. Nora introduces the mothers to the students. Each group had five students and one mother, and all are sitting on chairs at tables. On the tables sit milk, plastic bags, vanilla syrup, rock salt, measuring cups, and measuring spoons. Ms. Nora indicates the milk and then asks, “Milk is a type of what?” The students answer, “Liquid!” Ms. Nora asks, “How can we make ice cream with the milk?” and “How are we going to turn this liquid to a solid? Give me some ideas.” She explains, “I’ve got liquid [milk], [plastic] bags, rock salt, vanilla measuring spoons, and I’ve got sugar.” Some students answer, “We have to freeze!” Ms. Nora tells them they need to put milk, vanilla, and sugar into the bag and then says, “It is still liquid. How can we make it solid?” One student suggests they need to put some ice cubes around the bag to freeze it. Another student proposes that they have to put the ice cubes into the bag and then it will turn solid. After some discussion, Ms. Nora gives the mothers and students directions on paper on how to make ice cream. Each student has a partner, and the mother helper assists him or her. In each group, every student tries to put ingredients into the bag, and the mother helper helps the students put in the proper amount. Thanks to

> the mothers' help, not a single student spills any milk or forgets the ingredients. Then Ms. Nora gives the students ice cubes, and they put the ice cubes and rock salt into the plastic bags. They put the first bag that is milk, vanilla, and sugar into the ice cube bag and then shake them together. Ms. Nora takes photos of the students and the mother helpers. While the students and mothers are shaking the bags, Ms. Nora encourages the students: "Let's try again." "Pretty good!" "Get the power!" "Awesome!" Also she asks again and again what is happening to the milk. When most students make ice cream, Ms. Nora gives the mother helpers plastic cups and spoons for them to sample the product. Finally, all of the students and mothers are eating ice cream. Ms. Nora asks, "How is your ice cream?" The students answer "Yummy!" or "Good!" After they eat, Ms. Nora thanks the mothers, and the students go to the restrooms to wash their hands. Ms. Nora and the mothers clean the tables. (Observation, 02/18/2011)

Ms. Nora evaluated the "making the ice cream" as one of "the good [science] lessons" because the activities "were so much more hands-on" (Interview, 05/10/2011). There was more interaction with that activity than with other lessons that that she taught. The parent volunteers helped her "manage the small groups" because she thought that, when they made ice cream, if she "had to have gone up there and make one batch and have the kids sit on the rug and watch, they would've been bored. In addition, [the parents' help] allows for more hands-on" (Interview, 05/10/2011). Therefore, the parents' help made possible a successful hands-on activity that, working alone, would have been a struggle for the teacher to execute successfully.

The participant teachers in this study tried to maintain appropriate moods conducive to learning and to make sure that the students were engaged in science lessons, and that there was flexibility for them to work with other students at the same time. To find a balance between classroom management and flexibility for the children in science learning, the teachers used various strategies, such as time out, reading books, quiet games, and parental help. Through these methods, the teachers encouraged their students to focus on the science activities.

BEING FACILITATORS IN SCIENCE LESSONS

In what are considered the best practices in early childhood science education, teachers play the role of facilitators rather than as transmitters of knowledge (Chaille & Britain, 2003). To do this, teachers probe the students' understanding and help them resolve conflicts between scientific concepts and their prior knowledge (Dietz, 2002). For instance, in Levitt's (2001) study, the teachers described their teaching role as a facilitator or encourager in science lessons. By being facilitators, the teachers in Levitt's (2001) succeeded in their classrooms, as in other studies (Chaille & Britain, 2003; Xiao et al., 2005) where teachers helped students learn through manipulating materials, using their knowledge, and discussing their thoughts.

In this study, the participant teachers regarded their role not as the traditional transmitters but rather as facilitators of science learning by using such instructional strategies as “hands-on” lessons. For instance, Ms. Jane stated, "I think my role is to be a facilitator" (Interview, 01/31/2011). Also, Ms. Nora said that "my role to teach science [laughs]? ... just kind of a facilitator for their [the students'] work [in science lessons]” (Interview, 02/01/2011). As noted in the above, such statements mimic the best practices within early childhood science education.

The teachers encouraged social construction by asking the students to state their thoughts, investigate solutions for the task at hand, work together, listen, and critique ideas, and agree on a common solution. In addition, the teachers supported the students in recognizing the process of the activity by asking questions about the ways they solved the problems or what helped them to think of the things that they did.

One strategy the teachers used to facilitate science learning was to ask the students questions that prodded them to share their ideas and opinions. When Ms. Parry presented the making ice cream activity, she said little to the students about how they would make it. Instead, she showed the ingredients and tools and let the students guess how to do it on their own. For instance, unexpectedly, the ice cream was too thin, prompting Ms. Parry to elicit solutions from the students with "What can we do?" The students suggested answers, such as: "Put in more ice!" "More rock salt," and "More rolling" (Observation, 02/11/2011). Unfazed, the students tried to find solutions. Also, she frequently asked, "What's the next step?" with students answering what they supposed would happen (Observation, 02/11/2011). In this process, Ms. Parry attempted to ensure that every student was interested and took a part in the activity. Her facilitation served to "scaffold children's learning by asking questions, providing hints and remainders to children through the process" of science activities "and modeling skills for children as needed" (Samarapungavan et al., 2008, p. 883). That is, Ms. Parry, as well as the other teachers, used appropriate questions that invited students to say what they thought, rather than to try to guess the right answers.

After the ice cream activity, Ms. Parry commented that it was one of the most difficult activities in that semester, "because it didn't work" (Interview, 05/03/2011). She added that, during the activity, she was thinking that "I don't know why [it] wasn't working... I don't know what I did wrong" (Interview, 05/03/2011). Even though making ice cream was not as easy as Ms. Parry had expected, she helped the students communicate by encouraging discussion and supporting the students to share what they thought in order to firm up the ice cream, such as “Put in more ice!” “More rock salt,” “More rolling.” Therefore, even though she felt that she had failed, she had still provided benefits for her students by supporting them as they explored the process of making ice cream.

The participant teachers also facilitated the students' active participation in science activities. To do that, Ms. Nora listened to the students' responses including incorrect answers.

> On February 18th, Ms. Nora carries out making ice cream to examine how milk, liquid would be changed by cold ice cubes and salt. She asks the students why they need to do the things they are doing. For example, as the students are mixing ice cubes and rock salt in a bowl, Ms. Nora asks, “Why are you putting rock salt to the ice cube?” She walks around and by each table and asks, “What happened.” Whenever the students answer, she exclaims, “Good job!” or “Pretty good.” (Observation, 02/18/2011)

Even when the students gave incorrect answers, Ms. Nora actively supported them and responded warmly to the students. In this activity, she often said, “Wow!” or “Awesome!” After those positive expressions, the students actively raised their hands to have more opportunities to answer her questions. Ms. Nora's encouragement seemed to support the students' participation in the science activities. Thus, the participant teachers' role both stimulated and created opportunities for the students to apply what they learned in science lessons. The teachers positively responded, smiled, paraphrased students' ideas, or wrote them on the white board. As facilitators, the teachers were able to scaffold and guide students' discussions to help them to build cognitive abilities.

Ms. Parry carried out her role as facilitator as a way of keeping her students engaged in the science activities. For the caterpillar activity, Ms. Parry brought in a live caterpillar. The students were learning about the lifecycle, so they were thinking about what caterpillars eat and then observing what were they were supposed to learn. In the caterpillar activity, Ms. Parry focused on learning "some observation skills," part of the state standards. Through this activity, Ms. Parry wanted the students "to think about what plants and animals would need" (Interview, 04/11/2011).

> Every student is sitting on the carpet, and Ms. Parry is in front of them. Ms. Parry asks, "What do you think is the meaning of planet?" One boy answers, "Earth!" Ms. Parry explains the topic. "Today, we will talk about 'sharing.' In this planet, many people, animals, and plants are living and sharing together. In our classroom, there is an animal!" Most children shout, "Caterpillar!" Ms. Parry asks them again, "How many caterpillars do we have?" The students answer again, "Two!" Ms. Parry asks, "What do the caterpillars eat?" The students answer, "Leaves. A caterpillar needs food!" Ms. Parry shows leaves in a plastic bag and explains that they will eat these leaves. Ms. Parry then states that they will watch and observe the caterpillars, draw a picture and write about it. She shows a science notebook that the students need to draw in and write about the caterpillars. The title:"I observed caterpillars on the plants." After the introduction, Ms. Parry lets the students observe the caterpillars. In the middle of the classroom, there are caterpillars on plants on two children's desks. Two baby plants are in two pots with tiny caterpillars on each plant. The caterpillars already ate some leaves. Ms. Parry calls some students' names, and then they observe the caterpillars as others wait their turns. During observations, Ms. Parry asks the students about smells, colors and shapes

> of the caterpillars. After the observations, Ms. Parry checks that all of the students have seen the caterpillars. Ms. Parry gives the students their notebooks and explains that they will draw and write about what they see. While the students draw and write about caterpillars, Ms. Parry directs them on what they should do. "You draw what you saw. You can tell me how you feel, when you touch them." (Observation, 04/12/2011)

In the first part of Ms. Parry's caterpillar activity, she posed questions and then provided a brief introduction about the topic on observing caterpillars. Her questions about the topic appeared to make the students feel interested and led them to take part in the activity. That was one of the goals in that lesson. Ms. Parry stated, "I thought, well, I am trying to get them excited about the [lifecycle] unit, so this was kind of a way to get them excited about it" (Interview, 04/11/2011). To achieve her goal, Ms. Parry prepared for the caterpillar activity, and she brought the caterpillars and plants from her home. She thought that "it would be good to compare them [the caterpillars and the plants] and for them to talk about what they think they [the caterpillars] need and then that way we can go into it deeper" (Interview, 04/11/2011). During the activity, Ms. Parry facilitated and directed their attention (e.g., "Look at the yellow stripe on the caterpillar!"), because the most appropriate hands-on activities are guided by knowledgeable adults (Hadzigeorgiou, 2002). She visited each table where students were drawing and writing, and suggested several times how to observe and what could be observed. In addition, she listened to what they had observed and helped those students who had difficulties writing what they thought. It was hard for some students to draw what they had observed, so Ms. Parry asked and prodded them. "Did you notice the stripe?" "What color was the caterpillar?" "The caterpillar is white?" These questions aided students as they tried to remember what they saw and to express their ideas. Also, waiting until the students answered was part of the facilitation. For instance, Ms. Parry was patient in waiting for the students to figure out how to express their thoughts. Through these strategies, Ms. Parry supported and facilitated her students' involvement during science activities.

In sum, as facilitators in science lessons, the participant teachers in this study attempted to react positively toward the students' answers or actions. The teachers' role involved mainly managing the process of science activities, such as asking questions to maintain student participation by encouraging students to speak out their own ideas, to listen to other students, and to build on others' ideas.

SUMMARY

This chapter focused on the second research question: How do these kindergarten teachers demonstrate their beliefs about science teaching in their practices?" In it, the researcher examined the teachers' practices in their own science lessons. The researchers did so by dividing the chapter into six sections to demonstrate the teachers' teaching practices based on their beliefs about science. These sections included: discussions on teaching children "how to think"; teaching to support students' interest in science; hands-on science activities; other methods to teach science and stimulate interest in science lessons; classroom management in science lessons; and being facilitators in science lessons. Most of the sections demonstrated how the participant teachers' science lessons reflected what they believed about teaching science. However, some of the practices were not in congruence with their beliefs, such as conducting hands-on science activities and supporting children's interest to select topics for science lessons. For instance, in science lessons, the teachers did not have as many hands-on activities as they wanted, and most teachers did not select scientific topics that students were interested in.

The first section, discussions to teach children "how to think," was about teachers' beliefs that students should learn "how to think" through science lessons. To encourage their thinking processes, the teachers introduced discussions in their science lessons. The teachers especially attempted to respond actively and positively to encourage more students to engage in the discussions. For instance, during the discussions, the teachers gave some hints or did not correct the students' inappropriate predictions or responses.

In the second section, teaching to support students' interest in science, the teachers focused on whether the students were excited about the science lessons. The teachers checked the students' reactions during or after science activities. However, for most of the participant teachers, it was not easy to follow unplanned topics that students were interested in. Only Ms. Jane appeared to alter or add new topics to her original schedule when students brought up interesting topics. Based on the children's conversations about their everyday life experiences, Ms. Jane picked up on what the children wanted to know. For example, Ms. Jane had a caterpillar activity based on a real caterpillar that Sarah found and caught at her house. In addition, Ms. Jane shared her own and other children's experiences in her science lessons. The underlying reasons as to why it was difficult to follow the student's interests can be traced to the fact there were time limitations imposed on teaching science, classroom management issues, the need to follow curriculum standards, and characteristics of some of the science topics themselves.

The third section covered the hands-on activities teachers used to encourage science learning. This was a topic that all of the participant teachers emphasized in the first formal interview. In their science lessons, the teachers offered hands-on science activities but not for every topic. Instead of conducting all hands-on activities, the teachers used various teaching methods for various topics, such as reading books, learning new vocabulary, drawing, and using visual media.

The fifth section discussed the issue of classroom management and science instruction. In Chapter 4, the participant teachers, based on their years of teaching experience, expressed different opinions about classroom management. The inexperienced teachers tended to recruit parent volunteers to assist and help manage their science activities. Also, to handle the students, the inexperienced teachers used additional behavior management strategies, such as time out, reading books, and receiving help from other teachers.

The final section in Chapter 5 focused on the teachers being facilitators in science lessons, which reflects the teachers' beliefs that facilitating students' science learning is their responsibility in teaching science lessons. To facilitate the students' learning of science, the teachers asked many questions and used other strategies that supported students' active participation and learning in science activities.

For the most part, the teachers' classroom practices executed what they believed they should be doing to teach science. However, it was not possible to carry out the beliefs in occasions, because of time constraints and classroom management issues.

In Chapter 6, the researcher will examine the significance of the findings in this study, the implications for teachers, teacher educators, and school administrators, as well as recommendations for future research.

Chapter 6: Discussion

In recent years, science education has become an important topic in early childhood education (Eshach, 2011; Hadzigeorgiou, 2001; Kallery, 2004). One of the reasons this topic is gaining greater attention is that researchers are finding that early childhood is a critical time for science learning (Siverton, 1993; Smith, 2001), because what children learn in the early childhood years can better prepare them for science learning in elementary and secondary school. Moreover, the early childhood years are significant in shaping children's attitudes toward science (Erden & Sonmez, 2011; Eshach & Fried, 2005; Harlan & Rivkin, 2004). As a result, Siverton (1993) noted that young children should be supported to follow their natural curiosity about their surroundings during early childhood in order to maintain their interest in science and, consequently, their learning achievement in the subject (Erden & Sonmez, 2011; Harlan & Rivkin, 2004).

Kindergarten teachers' beliefs about science are significant in terms of influencing their teaching practices in the science lessons (Calderhead, 1996). Therefore, in early childhood science education, teachers' beliefs about teaching science influence their students' views about science and their future learning of science. Yet, in the field of early childhood education, there are fewer studies about science education when compared to other grades, such as upper elementary, middle, and secondary schools (Eick & Reed, 2002; Erden & Sonmez, 2011; Eshach, 2011; Fleer & Robbins, 2003; Kallery & Psillos, 2001; Luft, 2001; Pappas et al., 2003; Peterson & French, 2008). Therefore, this research is meaningful in terms of its focus on teaching and learning science in early childhood education, in contrast to the previous studies that have targeted mostly upper grades (Chen & Klahr, 2008; Klahr & Nigam, 2004).

This dissertation examined what kindergarten teachers believe about science education, and how their teaching practices demonstrate their beliefs. Over one semester, this investigation involved obtaining the data from four participant teachers in a public elementary school in Central Texas. The data collection employed formal and informal interviews, observations, and collected copies of their educational materials, such as science lessons plans and children's science notebooks. Data were subsequently transcribed and analyzed, based on Calderhead's (1996) categories about teachers' beliefs.

In this chapter, a summary of the findings are presented based on the two research questions:

1) What do a sample of kindergarten teachers believe about teaching science?

2) How do these kindergarten teachers demonstrate their beliefs about science teaching in their practices?

This chapter also provides implications for early childhood teachers, teacher educators, and administrators and concludes with the limitations of this study, as well as suggestions for future research.

TEACHERS' BELIEFS AND PRACTICES IN SCIENCE LESSONS

The participant teachers in this study were found to hold numerous beliefs about science teaching and learning that influenced their teaching in early childhood science. In this research, the findings are summarized in two major sections. In this review of the findings from Chapters 4 and 5, two chapters are collapsed into the four major categories of teachers' beliefs related to science lessons: 1) teachers' beliefs about learners in science lessons, 2) teachers' beliefs about teaching in science lessons, 3) teachers' beliefs about science as a subject, 4) teachers' beliefs about learning to teach, and 5) teachers' beliefs about their teaching roles in science lessons. Thus, under the categories, a brief summary of the teachers' beliefs is demonstrated, followed by examples of how the teachers' teaching practices accords or discords with their beliefs.

Teachers' beliefs about learners in science lessons

Calderhead (1996) noted that, in the science education context, teachers' beliefs reflect how students are supposed to learn science in the classroom. The participant teachers in this study focused on teaching "how to think" and on maintaining the students' interest in science. To teach "how to think," the participant teachers organized discussions in science classes, because "learning is likely to be most effective when students are actively involved in the dialogic co-construction of meaning about topics that are of significance to them" (Wells & Arauz, 2006, p. 379). In the discussion sessions, the teachers supported students' questions and their participation through various teaching strategies, such as giving hints and asking follow-up questions. The students in this study actively talked about science topics and applied what they learned to their personal experiences (Gallas, 1995). Questioning, especially, is an important inquiry skill for kindergartners to develop, strengthening science learning in later years (Samarapungavan et al., 2008). For example, according to Ms. Jane, she recognized that the students' improved learning science that "mainly came through discussions [in science lessons]" (Interview, 05/10/2011). Consequently, in these discussions, the teachers used strategies for teaching "how to think," such as–in addition to supporting students' questions--, sharing their ideas with others, and asking the students questions to encourage the thinking processes.

Teachers' beliefs about teaching in science lessons

This category relates to teachers' beliefs about the objectives of teaching (Calderhead, 1996). The participant teachers in this study believed that science is a process of inquiry than a body of knowledge. As a result of that belief, the teachers considered that one of the most important things in science lessons is conducting hands-on activities. Numerous studies found that hands-on science activities, such as experiments, constitute an important method for young children to learn science (Bryan & Abell, 1999; Buchanan & Rios, 2004; Chiappetta & Adams, 2004; Dietz, 2002; Hadzigeorgiou, 2002; Lind, 1998; Parker, 2000; Peters & Gega, 2002; Siverton, 1993; Thompson, 2007). Through hands-on science activities, children are physically engaged while also thinking about and applying what they are learning (Siverton, 1993), so they learn skills and concepts better (Lind, 1998; Thompson, 2007), as they explore their curiosities about the real world. Additionally, the teachers believed that hands-on activities in science lessons create positive attitudes toward science, as well as enhancing students' science content knowledge.

Inquiry-based instruction prompts students' motivation to do science activities (Patrick et al., 2009a), and an important objective of the National Science Education Standards is to increase students' motivation to learn science (NRC, 1996, 2000). Inquiry-based science instruction in early grades can be a method to prevent students from developing negative views that science is hard and less interesting than other subjects (Andre, Whigham, Hendrickson, & Chambers, 1999). Therefore, for the participant teachers, doing hands-on science activities offered an effective approach when teaching young children because kindergarten children learn better through hands-on interaction with materials. However, the finding in this study shows that a gap exists between the teachers' beliefs and their teaching practices in science lessons. Mismatches between teachers' beliefs and their practices are commonly mentioned in previous research, and researchers have found several reasons in both the external and internal constraints that teachers oftentimes experience (Ajzen, 2002; Flores et al., 2000; Gahin, 2001; Goelz, 2004; Kelly & Berthelsen, 1995; Mansour, 2009). The reasons for the gap between teachers' talking about and practicing "hands-on activity" arise because of concerns about classroom management, limited time allowed for science, and the curriculum standards. For example, the inexperienced teachers were concerned that, if they could not control the class during science lessons, then the activities would be ineffective. Also, all four teachers mentioned expressed concerns about the limited time devoted to teaching science, and standards prevented them from teaching science. Therefore, the teachers integrated other subjects into the science lessons and utilized other methods in their science activities, such as using science notebooks, reading books, learning vocabulary, and using visual media.

The difficulties enumerated by the teachers in this study are echoed by previous research about science education. For example, in early childhood education, teachers generally face issues such as the limited time allotted for science and receiving pressure to concentrate on language arts (Early et al., 2010; Greenfield et al., 2009; Lumpe et al., 2012; Marx & Harris, 2006; Milner et al., 2012; Weiss, Pasley, Smith, Banilower, & Heck, 2003). Regarding the time issue, Ms. Nora noted that, "the language arts is big, the reading and math is big, but then social studies and science is just kind of split, so you don't have as much time [for science]" (Interview, 02/01/2011). In early childhood education, language and literacy skills, such as “alphabet knowledge and phonological awareness” are considered necessary to prepare students for future learning in school (Greenfield et al., 2009, p. 250). Therefore, science has not been relatively emphasized in early childhood curricula compared to math, language, and literacy (Greenfield et al., 2009).

Teachers' beliefs about science as a subject

The third category, which deals with teachers’ beliefs about science as a subject, is the category that involves Calderhead’s (1996) notion that each content area carries its own meanings from the teachers' perspective. Findings in this category highlighted ways that the teachers' own learning experiences contributed to the formation of their beliefs and influenced their teaching practices as well (Calderhead, 1996; Mansour, 2008, 2009;

Nespor, 1987; Tsai, 2002). According to Dewey (1938), teachers' personal experiences are an important element for education. The teachers in this study recalled that their science education while in school consisted of teachers' transmitting information and answering questions from a textbook. As a consequence, learning science in this manner was ineffective because they spent most of their time as students feeling "bored." Because of those negative experiences, all of the participant teachers said that they wished to carry out hands-on science activities and that they wanted to focus on children's interest in science in meaningful ways, so as not to repeat the pedagogy that they had experienced as students. That is, the teachers wanted to "make sure that these kids [the students] love science," because they--the teachers--”didn't like science" when they were young (Ms. Parry, Interview, 02/01/2011). This finding contradicts previous research which reported that kindergarten or elementary school teachers who had teacher-directed science experiences as students had trouble in their own classes supporting children's interest in science and teaching inquiry-based science lessons (Plevyak, 2007; Spector, Burkett, & Leard, 2007; Watters & Diezmann, 2007; Wee, Shepardson, Fast, & Harbor, 2007).

The teachers' beliefs that science education needs to encourage positive attitudes toward science support previous research that teaching activities directed toward developing children's interest is significant for teachers (Eisenhardt, Shrum, Harding, & Cuthbert, 1988; Levitt, 2001). In the case of the four teachers, their beliefs were influenced by their past experiences as students. This result supports prior research in that teachers are affected by their past and present experiences, including learning science as students (Calderhead, 1996; Calderhead & Robson, 1991; Eick & Reed, 2002; Eshach, 2003; Mansour, 2008, 2009; Nespor, 1987; Olson & Appleton, 2006; Plevyak, 2007; Smith, 2003; Tsai, 2002). More specifically, Gilbert's research (2009) indicated that most K-to-3rd grade pre-service teachers who had spent boring and confusing times in teacher-directed science lectures wished to support inquiry-based teaching, instead of repeating what they had experienced as students.

Findings in this study of kindergarten teachers' beliefs and practices about science suggest the teachers have positive attitudes (e.g., "science is a fun thing to teach," "teaching science to children is a lot of fun") toward teaching science. Those findings are in line with the previous research that early childhood teachers have positive attitudes toward science and science teaching (Erden & Sonmez, 2011; Milner et al., 2012). However, the findings of this study also contradict results of previous research in which kindergarten teachers were found to hold negative emotions about science, as revealed by their descriptions of the subject and their own feelings that science was “boring,” “meaningless,” “scared,” and “impossible” (Tosun, 2000, p. 376). Other studies found that teachers also reported feeling fear about teaching science to children in their classes (Yates & Chandler, 2001). Those negative emotions were found to impact students' learning science (Zembylas, 2004).

Teachers' beliefs about learning to teach science

The fourth category concerns with the teacher's belief about learning to teach science in relation to science professional development. According to Kallery (2004), kindergarten teachers tend to be concerned that they do not have the appropriate scientific knowledge to teach science, so they would seek help from professional developmental resources to improve their science teaching. In the current study, the participant teachers attended monthly science workshops and weekly meetings held by the elementary school to discuss their science lessons. The teachers involved in the workshops called themselves, "teammates" or "team" (Ms. Sandy, Interview, 05/11/2011). Some of the participant teachers took part in science professional development programs beyond the school settings. The teachers commented that attending these science workshops improved their teaching of science. Yet, they would like to attend future science workshops to advance their understanding of how to teach science.

Teachers' beliefs about teaching roles in science lessons

The fifth category concerns teachers' beliefs about their roles in teaching science lessons (Calderhead, 1996). Teachers tend to believe that they can rely on their individual differences, such as personalities and teaching abilities, to ensure that class lessons proceed in an efficient and effective manner (Calderhead, 1996). In this study, the participant teachers used the word "facilitator" to describe the role of the teacher in science lessons. Descriptions of encouraging students to go further in their explorations, to be curious, to ask questions, and to feel interest in science lessons suggest a belief in this role for teachers (Levitt, 2001). The participants' descriptions revealed certain non-traditional beliefs about the teaching of science that contradict previous research regarding the role of the teacher (Levitt, 2001). For instance, prior studies have noted that elementary teachers believed their role in the teaching of science was to transmit a body of knowledge (Bell & Gilbert, 1996; Calderhead, 1996). However, the participant teachers in the current study expressed their belief that the role of teachers is to serve as facilitators who guide children's learning of science, which clearly contrasts with the previous research results (Levitt, 2001).

As facilitators, the teachers in this study attempted to allow children to reconstruct, extend, and replace their existing information. To facilitate children's participation in science lessons, the teachers used a variety of strategies, such as asking questions, providing hints and reminders to children throughout the process of investigation, and modeling skills for children, in order to scaffold their learning. The teachers facilitated children's communication with other students about their investigations through frequent small group and whole class discussions, and by supporting the use of inscriptional tools, such as idea boards, posters, and science notebooks to preserve public, sharable records of ideas developed in each inquiry cycle. The teachers also presented interesting topics and hands-on activities to motivate the children to take part in the science activities and to challenge their existing knowledge.

IMPLICATIONS

Based on the findings in this study, there are several implications that suggest directions for the support of kindergarten teachers' teaching of science and of young children's learning of science. The implications are broadly applicable for early childhood teachers, early childhood teacher educators, and administrators.

For early childhood teachers teaching science

The findings in this study showed that the participant kindergarten teachers' beliefs in the changing roles of the teacher were contrary to traditional views, i.e., dispensing facts and transmitting a body of knowledge (Levitt, 2001). Instead, the participant teachers recognized that they needed to be facilitators and role models who guide and foster their students’ positive attitudes toward science. As facilitators, the teachers believed that they should support their students' interest by providing them with lessons based on their experiences with the surroundings and by having more hands-on activities in science lessons. However, the findings suggest there are implications for teachers who are responsible for providing effective science instruction in kindergarten.

First, teachers need to connect the students' daily experiences and science activities in kindergarten. In this study, the participant teachers believed that they should choose science topics from students' interests based on the daily experiences with their environments, since young children develop an understanding about science concepts from complicated interactions in their daily experiences in the world (Baldwin et al., 2009; Siry & Kremer, 2011). Additionally, children learn more effectively when they are interested in activities (Yoon & Onchwari, 2006). The participant teachers believed that children's interest in science education is important. For instance, according to Ms. Nora, when students "feel fun" or "get much more excited about it [science]... they [the students] really get involved [in it]" (Interview, 05/10/2011) and "that [children's interest in science] is going to keep the hunger for science" (Interview, 02/01/2011).

In this study, Ms. Jane attempted to support unexpected activities based on the children's interest in scientific topics evoked by their daily experiences. For example, Ms. Jane changed her science lesson plans and introduced new activities sometimes, in order to follow her students' interests. For Ms. Jane, "science is everywhere, and it’s enjoyable” (Interview, 05/03/2011), and she wanted her students to share her enthusiasm. In early childhood science education, children's real world experiences are important for them to learn and understand scientific concepts (Baldwin et al., 2009; Eshach, 2003; Eshach & Fried, 2005; Inan, Trundle, & Kantor, 2010; Siry & Kremer, 2011). Ms. Jane's unexpected science activities centered around what the students brought from home and found on the playground, such as a caterpillar, rocks, and branches. Previous studies support that experiences-based science activities, such as collecting and observing objects and phenomena in the students’ environment, are meaningful for students who are learning science; additionally, such activities often lead to engaging students in future explorations (Eliason & Jenkins, 2003). Therefore, to support children's “naturalistic experiences," "initiated spontaneously by children as they go about their daily activities” (Lind, 2000, p. 17), teachers need to grasp meaningful and teachable moments for their students and include unplanned activities based on the students' daily experiences (Eliason & Jenkins, 2003; Lind, 2000).

However, conducting unplanned activities based on following the students’ interests is a strategy that in many instances is not easy for teachers to incorporate in the classroom. Previous researchers also noted that, while it is important for early childhood teachers to use children's understanding or perspectives of science phenomena from their life experiences when the teachers plan and design science activities, this is not often the case (Samuelsson & Pramling, 2009; Siry & Kremer, 2011). To follow children's interest in topics in science lessons, teachers need to focus more on what the children know and what they apply in their daily experiences that is scientifically based (Siry & Kremer, 2011). For instance, discussions or conversations in science activities can reveal children's interests, ideas and questions and emerging science understanding. In addition, Chin (2006) suggests that children's questions are important for meaningful learning and motivation in science lessons. Supporting children's more advanced questions contributes to a deep understanding and motivation about relevant scientific issues. In this study, Ms. Jane used the students' interest in a topic from their dialogues when Sarah found a caterpillar at her house. In another spontaneously chosen lesson, when Ms. Jane observed children's play on the playground, she found that several children were interested in small rocks and branches. After play time on the playground, Ms. Jane and her students had opportunities to show what they found and brought from the playground.

Ms. Jane understood that teachers' immediate and appropriate responses toward children's interest in scientific phenomena are significant. However, kindergarten teachers may avoid children's unexpected questions or provide answers that are from the textbooks for teaching science (Levitt, 2001). Kallery (2004), who examined kindergarten teachers’ teaching science, found that, if the kindergarten teachers could not provide correct and immediate answers when the students asked them scientific questions, the children would lose interest in that topic over time.

In summary, for teaching kindergarten science, teachers need to learn how to plan an inquiry-based learning environment to influence children's cognitive and affective needs. Moreover, in early childhood science education settings, teachers need to be able to design science activities that result from unplanned curiosity or interest regarding natural phenomena observed by the children (Eshach, 2011).

For early childhood teacher educators

Teacher educators have responsibilities to prepare prospective teachers to enter a profession that is complex and constantly changing (Mansour, 2009; Mathison & Freeman, 2003). Therefore, teacher educators should understand teachers' beliefs about science teaching and learning; such understanding will be helpful to decide the types of experiences that are important for inexperienced teachers as they enter the profession (Luft, 1999; Mansour, 2009). According to previous research, in science lessons, teachers' beliefs play a critical role in predicting their thinking, motivation, intentions, and behaviors, and their beliefs also affect children's learning science (Jones & Carter, 2007; Keys & Bryan, 2001). For instance, the participant teachers in this study believed that their roles were to be facilitators in science lessons and to participate in science activities as good role models, and they tried to play both of those roles in their classrooms. For teacher educators to effectively train pre-service or in-service teachers teaching science for young children, it is essential to recognize that teachers' beliefs can influence the way they teach.

Second, teacher educators should think about the constraints that may cause mismatches between teachers' beliefs about science and their teaching practices in science lessons. Even though most of the participant teachers' beliefs about the teaching and learning of science were consistent with their actions in their science lessons, some findings in this study further demonstrate that not all of their beliefs turned into practices. From the teachers' perspectives, there are many elements that act as barriers for teachers to put their beliefs and frameworks for action into practice (Mansour, 2009). For example, in this study, the teachers believed that hands-on science activities are effective for teaching young children, but, in the actual classrooms, the teachers tended to use other ways of teaching science because of the limited time and other constraints imposed by the standards that they are required to follow. Therefore, to enable teachers to try to resolve inconsistencies between their beliefs and practices, early childhood teacher educators need to help teachers find ways to think creatively about these problems and to consider the use of innovative strategies to manage the constraints.

For instance, in this study, the participant teachers revealed their beliefs about how they think about science as a subject. During the interviews, they commented that they did not remember much about their learning of science in college; also, they mostly did not have positive memories about science. It is very common that many teachers tend to have negative attitudes toward science (Conezio & French, 2002; Seefeldt & Galper, 2002; Tosun, 2000; Yates & Chandler, 2001; Yoon & Onchwari, 2006). Moreover, when the researcher in this study asked the teachers about science courses in college for teaching kindergartners, they answered:

> I don't really remember, honestly. I only remember one or two [courses], maybe, I can't remember. General science, I know, and I can't even remember, if there was another science class that I had to take [in my university]. (Ms. Parry, Interview, 02/01/2011)

> I have avoided science classes [laughs]. I took, I had to take, like plants, I don't remember. I don't remember anything else I learned [in my university]. (Ms. Sandy, Interview, 02/08/2011)

Annetta and Minogue (2004) contend that current pre-service programs for students who will be elementary school teachers do not adequately prepare them for teaching science to the students, which makes professional development programs especially important for elementary school teachers. Moreover, this situation influences the teachers’ teaching, because teachers teach what they have learned (Eshach, 2011; Kubota, 1997). Therefore, prospective teachers need to have learning experiences that fill in the gaps in their science knowledge and allow them to experience science not only as a body of knowledge but also as a process of inquiry used to produce and validate knowledge (Chaille & Britain, 2003).

To summarize, for teacher educators to help their trainees improve their science instruction: 1) they need to recognize not only what teachers believe about science education in kindergarten, but also how they demonstrate their beliefs in teaching science. 2) teacher educators should think about the constraints that cause mismatches between teachers' beliefs about science and the teaching practices in science lessons. 3) teacher educators should provide appropriate teacher education programs that address the inadequacies in the teachers' preparation to teach science.

For administrators

By understanding teachers' beliefs about teaching and learning science, school administrators are better equipped to support science lessons that teachers do in early childhood settings. Administrators can also advocate for students by encouraging teachers to address beliefs and emotions that may present as barriers to student science learning achievement. This study suggests implications for administrators about how to support early childhood teachers' learning and teaching science. Teachers' beliefs can play an important role in the actual implementation of reform recommendations since beliefs often lead to specific actions in the classrooms (Czerniak, Lumpe, Haney, & Beck, 1999) and the educational administration has a great deal of influence on teachers' beliefs (Milner et al., 2012). In this study, the participant kindergarten teachers requested help to teach science. School administrators should take into account these teachers' remarks and consider whether it might be the case that teachers in their schools indeed require help.

Second, school administrators should provide more instructional autonomy to teachers to make instructional decisions, so that the teachers can adjust their teaching practices to agree with their beliefs. For instance, in this study, the participant teachers indicated they had limited time and had to follow curriculum standards, which prevented them from teaching science at times. The following is from an interview with Ms. Sandy about teaching science and the standards.

> In my opinion, I think we [the teachers] should be doing more in science. But we are covering what we need to cover on the TEKS for Texas, so… Well, I don't know. Just fitting in more science at different parts of the day, some hands-on things that they can do. (Interview, 04/11/2011)

The participant teachers indicated that they were restricted by the different requirements, such as meeting the curriculum dictated by the school district, the state standards, and the school policy. Nonetheless, according to Goldstein (2007), teachers' instructional autonomy "contributes to [teachers'] ability to use developmentally appropriate practices to teach the standards" (p. 47).

The issues related to limited time for teaching science or doing hands-on activities in science lessons were complicated for the participant teachers in this study. That is, the teachers focused on not only making science interesting and relevant for the students but needed to cover science material in standards. As Ms. Sandy mentioned, the participant teachers indicated they had limited time to teach science, and the curriculum standards they had to cover in science lessons were impediments to teaching science. Milner et al. (2012) found that elementary school teachers' beliefs about teaching science were influenced by their administration. As noted by Kubli (2005), teaching science is a complex process. Teachers have to present a given subject, produce interest in the topic, and inspire students to strive for an appropriate understanding. That is, teachers must offer help and finally confirm that the subject has been understood by the students in accordance with the official standards (Kubli, 2005). The participant teachers in this study indicated that they were advocates of “hands-on,” inquiry-based science teaching. However, science classes involved a few hands-on activities, but at the same time, other teaching methods were used largely because they lacked sufficient time to cover all the scientific material For instance, Ms. Parry missed "doing a lot of science" because she thinks "it's important" (Interview, 02/01/2011). The teachers pointed that "the schedule is very difficult for us to get everything in and so science… That has been a problem" (Ms. Parry, Interview, 02/01/2011). As a result of the situation, she read books instead of conducting hands-on activities that take more time and work "to get the materials and supplies together" (Interview, 02/01/2011).

In addition, the teachers recognized other problems that prevented them from conducting science activities. Besides the need for additional time to cover science, especially, "hands-on" investigations, the teachers expressed the need for personnel help in the science lessons to manage the behavioral problems with students. Based on findings from this study, help should be provided to the teachers who have a few years of teaching experience to manage the classrooms.

Third, school administrators need to provide appropriate and effective professional development programs for early childhood teachers teaching science. The teachers in this study indicated the need for more professional development opportunities in order to teach the students more effectively about science. Prior research has shown that increased professional development can influence teachers' beliefs, attitudes, confidence, self-efficacy, and practices in teaching and learning science (Eshach, 2003; Furtado, 2010; Levitt, 2001; Louck-Horsley et al., 2003; Luft, 1999; Lumpe et al., 2012;

Mansour, 2009). According to Eshach (2011), kindergarten teachers need to be shown that science topics are everywhere in the students' surroundings; teachers do not need to look only to the textbooks for potential science topics. Otherwise, the teachers will rely primarily on their lessons from the training programs, which often do not teach teachers that they can find science topics and materials in the nearby environment. In the participant teachers' science activities, they applied what they had learned from science workshops or from meetings with other teachers. For instance, to support the students' understanding of a unit, Ms. Parry chose a game that she had come across at a science workshop. Moreover, for maximum effect, the finding indicates that professional development opportunities need to be long-term, sustained efforts rather than one-shot workshops (Czerniak et al., 1999).

This study reveals that professional development programs should address teachers' needs. For instance, in this study the inexperienced teachers reported concerns about classroom management in science lessons. Classroom management strongly influences the effectiveness of teaching-learning environments and students' learning achievement (Yilmaz & Cavas, 2008). However, it is difficult to find obvious solutions about classroom management (Bryan, 2003), and this is recognized as being a serious concern for inexperienced teachers (Everston & Weinstein, 2013; Appleton & Kindt, 2002; Yilmaz-Tuzun, 2008). For instance, in this study, Ms. Sandy, an inexperienced kindergarten teacher, explained that "[I don't do hands-on science activities often] Not as much as I would love to. I try [hands-on activities] every few weeks [laughs]. With this particular class is hard to do that" After the answer, Ms. Sandy added that "this particular class" meant "they [the students] get so excited. They really, they get so excited [for me to handle]" (Interview, 02/08/2011). Along this same line, Appleton and Kindt (2002) noted that beginning teachers frequently choose "safe" teaching methods that are manageable, while avoiding more interactive labs or hands–on activities. In addition, teachers with a few years of teaching experience often spend more classroom time managing misbehavior instead of instructing students, as compared to experienced teachers (Yilmaz-Tuzun, 2008). While it is true that more experienced teachers tend to be more confident about their ability to handle classroom management, professional development programs could facilitate building confidence by providing less experienced teachers the necessary guidance in dealing with classroom management issues. Such assistance would be beneficial because it has been shown that teachers who have more confidence in their ability to manage students use more interactive lessons, cooperative learning, and problem-solving activities that lead to improvements in students' understanding (Gee et al., 1996). More confident science teachers tend to have more experiments with interactive student-centered lessons (Enochs et al., 1995). The fact that appropriate professional development programs could help inexperienced teachers is supported by the findings in Richardson's research (1996).

Additionally, in professional development programs, school administrators should pay attention to not only teachers' pedagogical content knowledge but also their beliefs about science education. Appropriate professional development programs influence teachers' beliefs about teaching science in ways that can be employed in improving the quality of teaching and ultimately students' learning of science (Goddard et al., 2004;

Lumpe et al., 2012). However, according to Gess-Newsome (2003), many professional development programs have not emphasized "fundamental and complex beliefs about what it means to teach science" (p. 10) but focused on specific knowledge, skills, and strategies to teach children. Through science professional development programs, teachers can gain opportunities to develop their views and beliefs about their science teaching efficacy in ways that are positively connected to their students' science learning achievement (Lumpe et al., 2012; Mansour, 2009). As evidence, the time that teachers spend in professional development programs positively impacts students' science achievement (Lumpe et al., 2012; Wayne et al., 2008).

In sum, administrators should give teachers more support and more freedom to be able to create teaching environments conducive to ideal science teaching. In addition, to support teachers' teaching science in early childhood settings, school administrators should provide appropriate professional development programs focusing on teachers' beliefs, which are often related to their teaching practices.

LIMITATIONS AND SUGGESTIONS FOR FURTHER INQUIRY

Even though this study contributes to the field of science teaching for early childhood educators by examining an issue that has gone largely unaddressed in research, namely, early childhood teachers' beliefs and teaching practices, and the possible connections between them, the study itself contains limitations. The qualitative case study design and scope of this research limit these findings.

First, the sample of the teachers in this study does not represent all kindergarten teachers. To involve a slightly broader sample, the study included two types of participants, based on their teaching experience: two participants were experienced and two were inexperienced public kindergarten teachers. Nonetheless, the data presented in this study is not broad enough to suggest a general insight of the phenomena. For instance, all the teachers taught in one public elementary school in Central Texas, and all were Caucasian females. Therefore, more diverse populations, including those with differences in gender, ethnicity, and urban or rural settings may be considered as a study in future research. By investigating a range of similar and contrasting cases, the data from various other future cases would be "considered more compelling" (Yin, 2009, p. 53). Such data would be able to improve the external validity or generalizability of the findings in this case study to other situations.

Second, this study covered an extended period of time for interviews with participant teachers and field observation of their practices. To collect rich and descriptive data from the participants, this study was conducted from January to May 2011. However, the study period was limited to a single school semester and did not continue into the following school year. Therefore, it can be unclear how the participant teachers might have interacted with a different group of students and, likewise, how they developed and changed their beliefs or practices based on interactions with different teachers or students in their communities. Research which follows these or other teachers into different contexts and through multiple years would provide meaningful insights into how their experience and beliefs are sustained or expanded.

Third, this research focused on the topics of how the teachers acted and what they mentioned in their science lessons, instead of emphasizing what the children talked about and their reactions to the teachers and other students. Since the study is about kindergarten teachers' beliefs and teaching in their science lessons, for the most part, the data collection and analysis paid attention to the teachers’ perspectives on classroom practices. However, during the observation sessions, the students' reactions or responses offered interesting insights for gaining a better understanding of the teachers' teaching practices. For instance, the teachers' strategies to encourage children's participation in science activities, such as questioning, sharing their ideas, and answering questions, depended on the children's responses. In addition, how students participated and contributed to the activities, as well as how they were influenced by their teachers' practices, were significant influences on the teachers’ actions. That is, students and teachers influence each other in classes; they respond to each other’s statements or actions. Hence, a future study might incorporate the students’ perspectives in addition to those of the teachers, to gain additional insights.

Fourth, this study does not reflect additional factors that can make a difference in the results and findings. Horwitz (1999) suggests that beliefs may vary based on “age, stage of learning, and professional status” (p. 557). Previous research demonstrates that teachers’ beliefs are significantly different, depending on various factors, such as membership in professional organizations, gender, the highest educational degree earned, and private versus public school (Allen, 2002; Gwimbi & Monk, 2003; Hallam & Ireson, 2003). In the area of early childhood science education, according to Erden and Sonmez

(2011), teachers' attitudes toward science teaching and practices in preschools are related to factors such as their educational level, years of teaching experience, and the type of school that they work in. For instance, teachers having less than one year of teaching experience and working in private schools have more positive attitudes toward science (Erden & Sonmez, 2011; Gwimbi & Monk, 2003; Hallam & Ireson, 2003). Therefore, to derive a more refined picture of kindergarten teachers' beliefs and perceptions, future research needs to take into consideration other factors with regard to teacher participants, such as age, teaching experience, and gender.

Finally, future research might take the form of a longitudinal study about kindergarten teachers' beliefs about science. The period of this research lasted for only one semester, but, during the interviews, the participant teachers said they planned to develop and change their science activities, based on reflections on their science lessons. For instance, Ms. Parry commented that she "would probably change the ice cream [activity]" (Interview, 05/03/2011). She planned to "use bags" instead of "cans" the next time. That is, the beliefs and practices about teaching and learning science that the participant teachers held during the period of this study may be revised over time in the face of actual experiences in science lessons. Thus, it would be informative to investigate whether teachers' beliefs and practices change, and, if they do, what contributes to the change.

CONCLUSION

Early childhood teachers are one of the most important assets in supporting young children’s science learning because they spend so much time with the children in their classrooms, and those interactions around science influence children’s attitudes and achievement in science. Therefore, the findings from this study about kindergarten teachers’ beliefs about and practices in science provide meaningful insight into how their beliefs influence the teaching of science to young children. This study also contributes to a growing body of research characterizing the importance of kindergarten teachers' beliefs about teaching science, in order to understand not only their beliefs, but also the relationship between teachers’ beliefs and their practices.

The findings in this study suggest a strong relationship between teachers' beliefs about teaching and how they teach science. In particular, the data indicate that the participant teachers preferred science hands-on activities and focused on children's interest in science, and, further, their practices were rooted in their own learning history. Basically, the teachers said they did not want to teach as they had learned as students in schools. The teachers' personal learning history and past schooling experiences appeared to inform their beliefs and practices of teaching and learning science. The participant teachers also wanted their students to have fun in science lessons, contrary to the teachers' learning experiences.

Similar to findings in prior research, this current study demonstrates that teachers' beliefs are related to their science teaching (Bryan, 2003; Bryan & Abell, 1999; Gess-Newsome, 1999; Luft, 2001; Simmons et al., 1999). However, this research also shows that some of the teachers' beliefs did not match with their actual teaching practices in science lessons. The inconsistency between the teachers' belief and their teaching practices in science lessons was derived from the complexities of actual classroom life. For instance, all of the teachers believed that, in early childhood education, hands-on science activities are appropriate for young children’s science learning because kindergarten children learn better through hands-on interaction with materials. Yet, in the actual science lessons, some of the teacher participants did not include as many hands-on activities as they wanted. Reasons mentioned by the teachers for fewer such activities included limited time for conducting science, standards that place greater emphasis on language art and mathematics, and characteristics of topics in science lessons.

Appendix A: Initial Interview Protocol

During the initial interview, I did the following with each participant:

- Discuss the study and the participant's role in the data collection process
- Gather demographic information (teaching experiences, SES of class, schools taught in, grade levels taught, etc.)
- Ask the following questions:

- Why did you want to be a kindergarten teacher at this school?
- How long have you been teaching kindergarten children?
- How long have you been a teacher?
- What do you think is the most important thing for kindergarten students to learn? Why?

I am interested in the teachers' beliefs about and their practices in science education. Please tell me how you think about your teaching during your science class.

- What are the goals of your science instruction?
- Why do children need to learn science?
- What do you think is your role when you teach science?
- What are your strengths when you teach science?
- What are your weaknesses, if any, when you teach science?
- How do you know children's interests, capabilities, and their prior knowledge in your science class?
- How do you evaluate their scientific knowledge or understanding about science?

- What, in your opinion, does good science education consist of?
- What are your concerns about science education?
- Do you think that you need help for your science instruction? If you want help, why? From whom?
- Are you satisfied with your science curriculum for your students? Why? Or why not?
- What are the good things about your science curriculum?
- What are the bad things?
- If you want to change your curriculum, which part? Why do you think that?
- Is there anything that you would like to add that I may have forgotten to ask?

I am also interested in your own past experiences with science.

-What do you remember about learning science in preschool or elementary school?

-What about the high school level? What do you remember about learning science in high school?

-How do your past experiences with math influence your current science instruction?

Appendix B: Second Formal Interview Protocol

This interview was at the end of data collection. I asked each participant teacher the following questions to check my interpretations of the teacher's beliefs and perceptions on science lessons. Also, I wanted to know what the participant teachers thought about their science lessons, during my data collection.

- What were you trying to achieve through your science activities while I was observing you?
- Have my observations and interviews influenced your science activities? If yes, why? And how?
- In the first interview, you told me that your goal for science activities is ------ Do you still have the same opinion? And how are you meeting that goal? Which information or what else helped you?
- What did you focus on when you taught your students in your science activities?
- What did you do in order to support the factor which you focused on?
- What is the most difficult thing in your science activities? And what is the best solution for that difficult thing? (How did you solve that difficult thing?)
- Did you feel or know whether your students have improved their science learning through your science activities? What is the best thing that your students improved on in their science learning? (How did the students improve their scientific knowledge?) And how did you know about their improvement?
- Is there anything that you want to add that I have not asked?

Appendix C: Follow-up Interview Protocol

Usually, the follow-up interview was after I observed or interviewed the participant teachers. I talked about the science activities with the teacher and asked her about her reflections or her personal thoughts about the instruction. The informal interviews with the teacher were recorded and transcribed.

The follow-up interviews with each teacher occurred during planning time or after school when the teacher and I had casual conversations. I explained before starting the research project that our conversations would be part of my data. During the conversations with the teachers, I listened to their perspectives on their science instruction. Also, through conversations with the teachers, I had the teachers' responses to my tentative interpretations of their practices during the science instruction.

In the previous interview, I asked you general questions about your experiences teaching and, specifically, teaching science. Today, I would like to go into more specific questions about your science lesson.

- Please let me know the process for developing this topic.
- What is the purpose of this activity?
- How did you decide on this activity? What did you want your students to learn from this activity?
- How did your students learn about this topic each week?

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