PROSPECTIVE EARLY CHILDHOOD TEACHERS' CONCEPTIONS OF SCIENCE INSTRUCTION

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Dissertation Prepared for the Degree of

DOCTOR OF PHILOSOPHY

UNIVERSITY OF NORTH TEXAS

August 2019

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Muimongkol, Supreeya. *Prospective Early Childhood Teachers' Conceptions of Science Instruction*. Doctor of Philosophy (Curriculum and Instruction), August 2019, 148 pp., 24 tables, 25 figures, 4 appendices, references, 183 titles.

The purpose of this study was to investigate prospective teachers' conceptions of science instruction prior to the commencement of their early childhood education methods courses. A sample of 100 prospective teachers' drawings and narratives were analyzed using the STLP3 instrument and inductive analysis respectively. Merging findings from the aforementioned analyses resulted in 10 distinct conceptions and these included: (a) science instruction (1) as a demonstration, (2) as engagement, (3) as doing experiments, (4) as inquiry, and (5) as observation all underscored by active learning and social, implementation and cognitive dimensions; (b) science instruction (6) as implementing safety, and (7) as an interaction both underscored by active learning and a social dimension; and (c) science instruction (8) as a demonstration, and (9) as engagement both underscored by passive learning and an affective dimension; and (d) science instruction (10) as enjoyment underscored by social and affective dimensions. These findings reflected the complexity and multidimensionality of the prospective teachers' conceptions of science instruction. Implications include the need for teacher educators to situate their prospective teachers' prior and new knowledge of early childhood science instruction within theoretical frames rather than simply relying on prospective teachers' knowledge of science instruction from K-12 experiences. Implications for future research include the need to study prospective teachers' conceptions prior to and at the end of early childhood methods courses.

ACKNOWLEDGEMENTS

This dissertation would not have been possible without the guidance and encouragement that supported my work over the last five years at the University of North Texas. I would like to express my sincere gratitude to those who have made it possible for me to travel along the journey of a Doctoral degree in Curriculum & Instruction.

To my exceptional Committee: I give my deepest thanks to Dr. Dina C. Castro, my major professor, for her guidance in helping me achieve success with the dissertation. Special thanks to Dr. Karthigeyan Subramaniam, my committee co-chair for providing endless support, for his patience and time in guiding me through the methodology, and for teaching me how to think and write as a researcher. Special thanks also go to Dr. Carol D. Wickstrom and Dr. Tran Nguyen Templeton for the insights and thoughtful questions, they shared while serving as dissertation committee members.

Thanks to Dr. Carol Hagen, for her guidance regarding my findings and discussion; without her support, my dissertation could not have been completed. To my sister, Dr. Chaowanee Kumlertluk Moore, for her suggestions on how to write a dissertation as a professional.

To my family, especially my father and mother, for being the strongest and most loving persons I know. Without their support, I could not have reached my study goal. Thanks to my husband, Nu, for being patient along the course of my study in the U.S. and to my children, Khai Mook (Pearl) and Khai Tun (Gracie), the greatest loves of my life, for being my motivation, strength, and the embodiment of beauty and joy.

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CHAPTER 1

INTRODUCTION

The field of early childhood education (ECE) has recently increased its emphasis on the learning of specific subjects and science is one of these (Areljung, Ottander & Due, 2017; The Organisation for Economic Co-operation and Development (OECD), 2006). Science is an important subject for children because it is linked to their lives and environment; for instance, children can learn about the organs of the body and their functions. Children become more engaged in science when they can use their senses or engage in hands-on activities because these allow them to be more active in the learning process. Science instruction is becoming increasingly important in preschool through 3rd grade classrooms; therefore, it has become necessary for teacher educators to advocate for conceptualized science instruction for prospective early childhood teachers.

Teachers across the country are working hard to equip children with the skills needed to prepare for science, technology, engineering, and mathematics (STEM) careers to be well equipped as part of the modern workforce, and an educated society knowledgeable about technology is recognized as a need for the 21st century. Improving the quality of today's teachers is a crucial part of the effort to harmonize education with the development of society and technology.

The National Research Council (NRC, 2012) directs teachers toward careers in high-quality science teaching with clear criteria to indicate what teachers can do to support science learners at all age levels. Therefore, the NRC calls for teachers to practice active involvement in scientific investigation; it also introduces them to resources to expand their knowledge and ability, to build their scientific understanding, abilities, and attitudes, and to make use of their collaborative science learning experiences in the classroom.

Early childhood and science education research supports the idea that science should be introduced to young children as early as possible (Pendergast, Lieberman-Betz, & Vall, 2017). The National Association for the Education of Young Children (NAEYC) and the National Association of Early Childhood Specialist in State Departments of Education (NAECS/SDE) have raised critical questions regarding early childhood education, including “What should children be taught in the years from birth through age eight? How would we know if they are developing well and learning what we want them to learn? In addition, how could we decide whether programs for children from infancy through the primary grades are doing a good job?” (NAEYC & NAECS/SDE, 2003).

The aim of early childhood science education is for young children to find out about their everyday surroundings (Brenneman, 2011; NSTA, 2014), especially since young children have intrinsic motivation to engage in science and science learning (French, 2004). The National Science Teachers Association (NSTA) affirms that learning science in their early years can foster children’s curiosity and enjoyment in exploring the world around them and lay the foundation for a progression of science learning in pre-K to 12 settings and throughout their lives (NSTA, 2014). Teaching science early, during preschool, is important (Allen, 2017; Ashbrook, 2018; Clements, 2016; Inan & Inan, 2015; IPST, 2011; Kim & Han, 2015; NGSS Lead States, 2013; NSTA, 2014; Trundle, 2009; Weidong & Bird, 2016). Thus, not only does early childhood science education support children’s better understanding of science concepts, acquisition of scientific thinking skills, and improvement in various developmental domains, but also the whole of children's development is furthered with the help of both indoor and outdoor learning environments (e.g., nature-related activities) (Sackes, Trundle, & Flevares, 2009).

Several policy directives are related to early childhood science education: they include (a) establishing a system of learning networks; (b) providing and promoting the prenatal care, child-rearing practices, and education necessary for child development; (c) preparing every child for entry into primary school; (d) reforming teacher pre- and in-service education; (e) improving curriculum content and teaching-learning processes at all levels and in all types of education; and (f) promoting and supporting the participation of families, local communities, social institutions, and mass media in the educational process (IPST, 2011;The MOE, 2003; UNESCO, 2006).

Early childhood educators play a key role in offering the first formal learning environments to children, in which they can gain science experiences. In addition, preparation and professional development programs to improve teacher quality are needed to promote and improve science literacy in the classroom. The National Science Teachers Association (NSTA, 2017) supports teacher preparation aligned with the goals and guidance provided by *A Framework for K–12 Science Education* (NRC, 2012), *Next Generation Science Standards* (NGSS Lead States, 2013), and *Science Teachers' Learning* (NRC, 2015). The NSTA has adopted and applied the *Standards for Science Teacher Preparation* (NSTA, 2012). It is committed to increasing the number of highly qualified science teachers by ensuring that all those entering the profession demonstrate a deep understanding of pure and applied science and have the knowledge and skills required to teach students science in age-appropriate, meaningful ways (NSTA, 2017).

In the United States, science, technology, engineering and mathematics (STEM) topics have been increasingly recognized as appropriate and relevant for children to explore in early childhood settings (California Department of Education, 2012; Greenfield et al., 2009; McClure et al., 2017; National Science Foundation, 2013). Teaching STEM skills involves developing scenarios that reflect the kinds of science content to which preschool-age children are likely to be introduced in their classroom experiences. Despite the emphasis on reform efforts to improve science teacher preparation and professional development, particularly those who teach at the early childhood level, many teachers report entering the classroom feeling inadequately prepared to teach science (Kelly, 2000; Murphy, Neil, & Beggs, 2007). Teachers are limited in their content knowledge and self- efficacy for science teaching (Sackes, Trundle, Bell, & O'Connell, 2011; Tu, 2006).

Consequently, investigating prospective teachers' conceptions of science education is important because teachers' conceptions in both informal and formal settings can reasonably be expected to affect teaching practices (Subramaniam, 2013). Specifically, preparing teachers to teach science effectively in early childhood classrooms is an area of research that is becoming more important for both prospective teachers and faculty members. Researchers have long been aware of the popularity of prospective teachers' conceptions of teaching and learning. Teacher educators need to realize that the teaching process is becoming an important variable in the development of students' epistemological beliefs and a crucial factor for opening doors to new vistas and stimulating novel alternative solutions and ideas in students. Similarly, teacher educators may benefit by helping teachers to explore their teaching and learning conceptions regarding the students in their classes (Mahasneh, 2018).

Statement of the Problem

In recent years, a growing number of researchers in teacher education have focused on the development and design of efforts to prepare prospective primary education teachers (Brown & Englehardt ,2017; Eckhoff, 2017; Mckinnon & Perara, 2015; Subramaniam, 2013; Subramaniam et al., 2018). However, there is a particular limitation on prospective early childhood teachers. Science methods courses taken by prospective early childhood teachers influence their future instruction in early childhood classrooms (Seung-Yoeun, 2010). There are a number of factors found to influence early childhood teachers' teaching of science in the classroom. Sackes (2014) identifies factors that influence early childhood teachers' decisions to devote less time to teaching science in their classroom as follows: (a) their limited science and pedagogical content knowledge , (b) pressure to teach content areas other than science (Greenfield et al., 2009; Nayfeld et al., 2013), (c) limited availability of science-related materials (Greenfiled et al., 2009), (d) perceptions that young children are incapable of learning science concepts (Fleer, 2009), and (e) low teacher self-efficacy for teaching science (Maier, Greenfield, & Bulotsky-Shearer, 2013; Nayfeld et al., 2013).

In several countries, including Sweden, Belgium, New Zealand, Italy, and Australia, and in some states in the US, science is being taught to students at young ages. According to Andersson and Gullberg (2014), effective teaching of science in early childhood requires a set of competencies needed by early childhood educators to conduct classroom science activities. These competencies include teaching early childhood science following theoretical frameworks and using effective curricular approaches. Based on the current literature, it is important to begin the teaching of science in the early years as a required subject area. Effective research-based teaching strategies must be used so that teachers can help to create a stronger foundation in science learning for pre-K to 3rd grade children. Teaching is a very obscure and complicated process, especially the teaching of science for early childhood. Understanding children is every early childhood teacher's challenge.

Prospective early childhood teachers' conceptions of science teaching are an important determinant of how these teachers carry out instruction in their classrooms. Therefore, it is crucial for prospective teachers to equip themselves with the necessary skills to teach science in an effective way before they graduate. Blevin (2018) emphasizes that the way educators teach science strongly correlates with the way they learned to teach science in their undergraduate teaching preparation courses. In the current literature, there is a strong emphasis on the preparation of prospective early childhood teachers, especially in science instruction.

Frameworks

Theoretical Framework of Sociocultural Theory

The theoretical framework that guides this study is that of sociocultural theory. Sociocultural theory has become increasingly important in discussions associated with early childhood education and curriculum at a theoretical level since the early 1990s (Edwards, 2006). This theory emphasizes the ideas of learning connected to the social and cultural nature of development as advocated by Vygotsky (1987). His work reflects sociocultural influence on the construction of knowledge. Vygotsky's view of how children's mental abilities develop focused on the role of the child's social and cultural world. Vygotsky believed that children depend on others to develop their cognitive skills and abilities. The social organization may be the classroom or culture at large. It is the agent for change for the individual. The social context and the language discourse are paramount to human learning. Learners develop knowledge as a social activity within the context of institutional and cultural frameworks. The language and culture of the social group plays a crucial role in helping students develop ideas and knowledge.

Teachers' Conceptions of Teaching

According to Subramaniam (2013), there are three types of views or conceptions of teaching: (a) conceptions of teaching as beliefs; (b) conceptions of teaching as belief-driven, thereby influencing and interacting with conceptions of teaching by determining whether the conceptions of teaching are to be selected, stored, or discarded; and (c) conceptions of teaching as different models of learning, which are classified as dimensions, orientations, and complex sets of propositions.

In this study, prospective early childhood teachers' conceptions of teaching science are understood as the specific set of instructional ideas that collectively function as an organizing framework by which prospective early childhood teachers develop their knowledge of science teaching in pre-K to 3rd classrooms. These instructional ideas, derived from K-12 teaching experiences, life experiences, and social, cultural, and linguistic backgrounds, and expressed in actions like decision-making, lesson planning, and teaching, are focused on control of science content, directionality of science teaching, understanding of students' existing science conceptions, expected outcomes of science teaching, and students' utilization of science knowledge. Moreover, the actions collectively function to express the complex sets of propositions that in turn indicate the different orientations or dimensions to which the conceptions of teaching science belong in line with this understanding of the optimal conceptions of teaching. In this study, the instrument called the Science Teaching and Learning

Portrayals of Professional Practices (STLP3) (Mckinnon & Perara, 2015), adapted from Project Nexus (2011), was used to analyze prospective early childhood teachers' conceptions of teaching science from their drawings, and a qualitative analysis approach was used to analyze their conceptions of teaching science from their narratives.

Purpose of the Study

The purpose of the current study is to investigate the prospective early childhood teachers' conceptions of science instruction in an early childhood classroom.

Research Questions

The primary research question for the present study is: What are prospective early childhood teachers' conceptions of science instruction in the early childhood classroom?

Significance of the Study

The significance of the study is twofold. First, this study is significant because there is a need to understand prospective early childhood teachers' prior conceptions of science instruction knowledge pedagogies before they enter a teacher preparation program and before they enroll in a science method course. This is important because there is a limited knowledge base on prospective early childhood teachers' conceptions of teaching science and on how their conceptions of teaching science influence how they learn to teach science. Second, the study is unique because the Science Teaching and Learning Portrayals of Professional Practices (STLP3) (Mckinnon & Perara, 2015), adapted from Project Nexus (2011), has not been used in a formal setting to analyze drawings in research on prospective early childhood teachers and their conceptions of science instruction.

Research Method

The present study uses a qualitative approach to conduct a secondary analysis of data. These data, in the form of drawings and narratives, relate to prospective early childhood teachers' conceptions of science instruction. The analysis of data employs the Science Teaching and Learning Portrayals of Professional Practices (STLP3) instrument (Mckinnon & Perara, 2015), adapted from the Project Nexus (2011), with prospective teachers' drawings, as well as qualitative analysis to analyze prospective teachers' narrative writing. Both drawings and narratives of prospective early childhood teachers were analyzed to identify their conceptions of science instruction for children in pre-K to 3rd grade.

Operational Definitions

The following terms are associated with this study. Terms are defined here to clarify the specific meanings of terminology used in this dissertation.

- *Conceptions of science instruction:* The current study views conceptions of science as *affective*—students should experience excitement, interest and motivation to learn about phenomena in the natural and physical world; as *cognitive*—students will become able to generate, understand, remember, and use concepts, explanations, arguments, models, and facts related to science; as *implementation*—students must manipulate, test, explore, predict, question, observe, and make sense of the natural and physical world; and as *social*—students will participate in scientific activities and learning practice with others, using scientific language and scientific tools (Mckinnon & Perara, 2015).
- *Inquiry.* Inquiry is an intricate cycle of scientific exploration involving the use of observations, asking and answering questions, studying existing knowledge using other media,

investigating, applying experimental evidence to existing schema to construct or refine knowledge, gathering and analyzing data using various tools, developing predictions and explanations of phenomena, and communicating results clearly. Inquiry requires the development of skills to assist in identification of assumptions, use of critical thinking and problem-solving, and consideration of unconventional or differing explanations (NRC, 1996, p. 23).

- *Inquiry-based Instruction or Teaching*: This approach involves the use of scientific methods (inquiry) in classroom science instruction (National Research Council, 1996). Inquiry-based instruction is primarily focused on "important practices, such as modeling, developing explanations, and engaging in critique and evaluation…" (NRC, 2012, p. 44).*Prospective Early Childhood Teachers:* These are college undergraduate students enrolled in a teacher preparation program preparing to become pre-K to 3rd grade teachers. Participants in this research study will come from this group.

- *Science Content Standards:* The science content standards outline what students should know, understand, and be able to do in the natural sciences over the course of their K-12 education (NRC, 1996, p. 103).

- *Science Teaching Standards:* The science teaching standards describe what teachers of science at all grade levels should know and be able to do (NRC, 1996, p.27).

- *Teacher preparation (for EC-6 teachers):* This concept is understood as a list of professional teaching competencies to be assessed or a course list to complete, along with development of professional knowledge, skills, and dispositions in a community of learners, applying reading, observation, and field experiences through group projects and interactions with others (NAEYC Professional Preparation Standards, 2012, p. 23).

- *Teachers' conceptions of teaching and learning:* These are “the beliefs held by teachers about their preferred ways of teaching and learning” (Chan & Elliott, 2004, p. 819), including what teaching and learning mean, as well as the relationship between the teacher and students Mahasneh (2018).

Summary

This first chapter has presented an overview of the study including the importance of early childhood science instruction, sociocultural theory, and teachers’ conceptions of teaching, seen as the frameworks of this study. It has clarified the purpose and presented the research questions of the study, which lead to the significance of this study. Next, Chapter 2 is a review of the literature related to science instruction in early childhood classrooms and the theoretical underpinnings that will serve as the framework for the study. Chapter 3 discusses the methodology of the study, including the data collection techniques used to collect the secondary data and the instrument used to analyze the drawings and narratives. Chapter 4 presents the findings from applying the Science Teaching and Learning Portrayals of Professional Practices (STLP3) to analyze prospective early childhood teachers’ drawings. An analysis of data from prospective teachers’ narratives is presented as an investigation of prospective teachers’ conceptions of science instruction. Chapter 5 includes a discussion of the findings in relation to the overall research question and the purpose of the study. Chapter 5 further discusses the implications of examining prospective early childhood teachers’ drawings and narratives as it pertains to their present and future conceptions of science construction for teaching children in pre-K to 3rd grade classrooms, and the resulting insights are also presented in this chapter.

CHAPTER 2

RELATED LITERATURE

This review of literature guides the reader through several topics relevant to the formation of the present study. In order to orient the reader to the theoretical underpinnings of the study, the literature review relates to the theoretical constructs concerning how prospective early childhood teachers conceptualize science instruction. This chapter is divided into six sections as follows.

Section 1 discusses the standards that inform the content and practice of early childhood science education. Section 2 presents the current instructional strategies being utilized in early childhood science education. Section 3 presents the literature on prospective early childhood teachers' conceptions of science education. Section 4 discusses the role of drawings as a method to investigate prospective early childhood teachers' conceptions of teaching science. Section 5 presents the instrument that will be used to analyze the data collected for this study. Section 6 presents the sociocultural perspective that will be used as the theoretical framework to guide and frame the study. The review of literature concludes with a discussion of the scholarly and practical significance of the present study.

Early Childhood Science Education

Most U.S. states have developed and published at least one set of early learning standards or learning expectations that describe what children should learn and be able to do as a result of being in preschool (Brenneman et al., 2009). These standards provide (a) a comprehensive description of the knowledge and skills children should have, (b) a guide for administrators and teachers in designing or choosing curricular experiences for pre-K to 3rd

grade students, and (c) benchmarks for early childhood teachers to assess the quality of their offerings (Buchter et al., 2017; NSTA, 2014). The National Science Teachers Association (NSTA, 2014) also identifies key principles to guide the learning of science among young children; these are the following:

1. Children have the capacity to engage in scientific activity and develop an understanding at a conceptual level.
2. Adults play a central and important role in helping young children learn science.
3. Young children need multiple and varied opportunities to engage in science exploration and discovery.
4. Young children develop science skills and knowledge in both formal and informal settings.
5. Young children develop science skills and knowledge over time.
6. Young children develop science skills and learning by engaging in experiential learning.

These principles emphasize the importance of individual, cultural, and linguistically responsive learning experiences and environments for young children. They also emphasize that parents and other caregivers can nurture children’s natural curiosity about the world around them, creating a positive and safe environment at home for them for exploration and discovery. Additionally, the National Research Council advocates that for formal and Informal learning of science, teachers should use the guideline of the science teaching standard below:

1. The planning of inquiry-based science programs
2. The actions taken to guide and facilitate student learning
3. The assessments made of teaching and student learning
4. The development of environments that enable students to learn science
5. The creation of communities of science learners

6. The planning and development of the school science program(National Research Council (NRC, 2012)

The heart of science education is effective teaching. Good teachers of science create environments in which they and their students work together as active learners. Teachers use assessments of students and of their own teaching continually to plan and conduct their teaching. They build strong relationships with students and include their students as active members of science learning communities. For this to happen, teachers need support from the rest of the educational system.

Science Content Standards for Early Childhood Education

The National Science Education Standards produced by the National Research Council (NRC, 1996) provides guidelines for the science content and process skills that are appropriate for children of different ages; the document has been used by most of the states in the United States to develop their state science education standards. In addition, the National Science Education Standards have been used as a guide for creating the science education framework in each area. However, most efforts to develop science standards have focused on kindergarten through 12th grade. According to the NRC, science content standards statements include *Science as Inquiry Standards, Physical Science Standards, Life Science Standards, Earth and Space Science Standards, Science and Technology Standards, Science in Personal and Social Perspectives and History and Nature of Science Standards*, as shown in Figure 1.

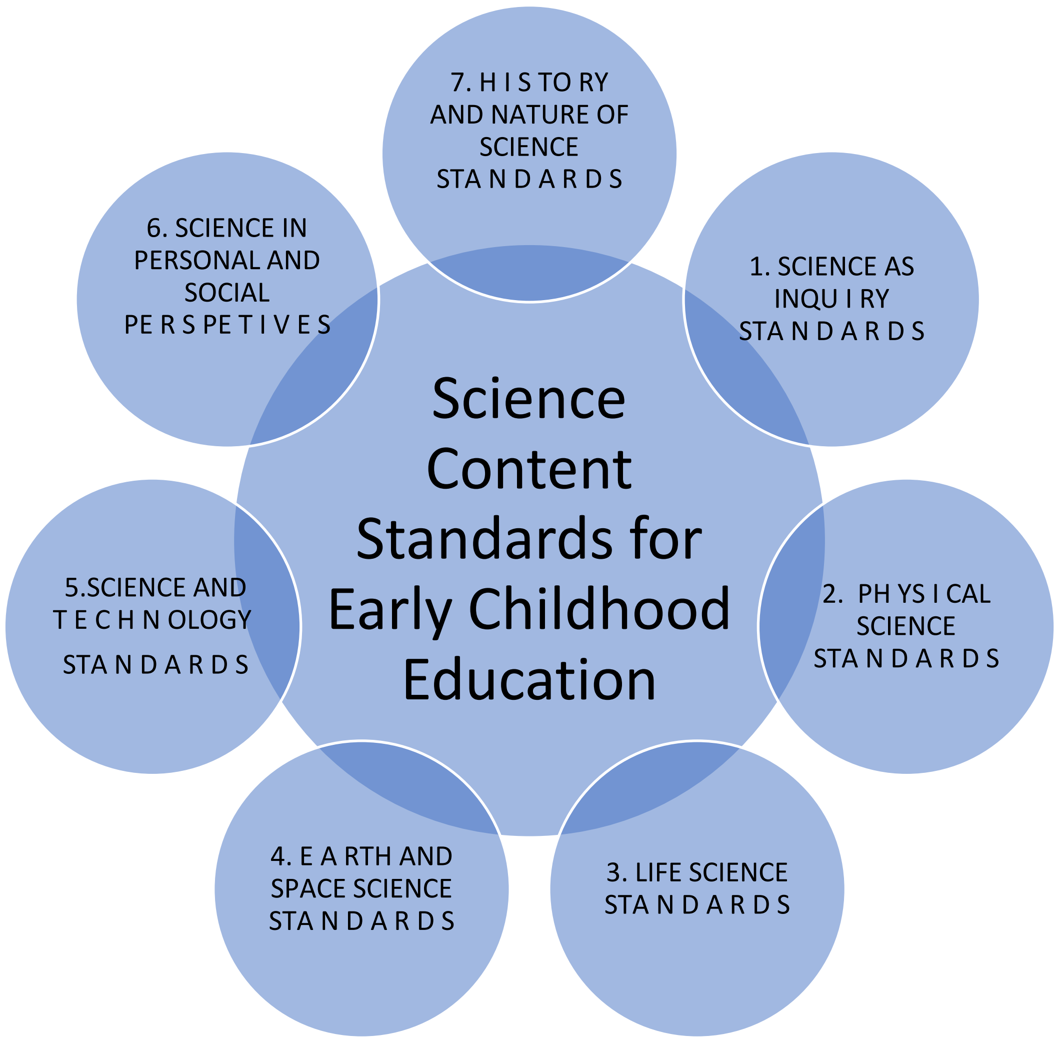


Figure 1. Science content standards for early childhood education (NRC, 1996; Holweg &Hill, 2003).

Unfortunately, according to Trundle & Sackes (2015, pp. 241-242), a survey of the science content standards used by all U.S. states found that only 17 states had science content standards for preschool-kindergarten. Further, only 12 states had separate academic science content standards specifically for preschool (Sackes, Trundle, & Flevares, 2009). A review of the preschool science content standards of those 12 states revealed that the three most common content areas across the states were physical science, earth and space science, and life science. These content areas are derived from the National Science Education Standards for Grades K-

12. Within each common content area, several common themes for preschool were also identified across the states. Seventeen states had science content standards for preschool-kindergarten which identified three science content areas: physical science, earth and space science, and life science.

There were six common themes for physical science:

1. Physical properties of objects and materials (e.g., solid-liquid and hard-soft) was the most common theme (found in the standards used by all twelve states)
2. Classification of objects and materials based on qualities such as weight and shape (nine states)
3. Movement of objects (six states)
4. Sound
5. Light
6. Physical changes

There were four common themes for Earth and Space Science:

1. Weather (eight states)
2. Day and night (four states)
3. Earth materials (three states)
4. Seasons (three states)

There were five common themes for Life Science:

1. Life cycles of plants and animals (nine states)
2. Plant and animal habitats (eight states)
3. Classification of plants and animals (seven states)
4. Common needs of plants and animals (six states)

a. Heredity (five states) (Trundle & Sackes, 2015, pp. 241-242)

In addition to content areas, science process skills were also included in the preschool standards (Sackes, Trundle, & Flevares, 2009). Eleven common science process skills that were most emphasized across the states were identified. These skills included asking questions (ten states; using basic tools (ten states); making observations (nine states); explaining cause and effect (nine states); making predictions (eight states); describing events and observations (seven states); collecting, organizing, and recording data (six states); communicating observations and findings (six states); ordering, sorting, and counting (six states); discussing and drawing conclusion (five states); and making comparison (five states) (Trundle & Sackes ,2015).

Accordingly, science education reform efforts should incorporate the expectations for preschool science education in the National Science Education Standards or the common core standards, and state-level reform efforts also should include standards for preschool science teaching and learning (Trundle & Sackes, 2012).

In spite of the significance of the reforms undertaken based on the Next Generation Science Standards (NGSS) (NGSS Lead States, 2013) or state level for early childhood science standards, there has been limited research in this area. Several interesting studies have been conducted on science education. For instance, Sackes (2014) examined parental priorities regarding science education in Turkey. The participants were 1,456 Turkish parents of pre-K children (36-72 months). The result demonstrated that the number of parents who prioritized science was quite low. The author suggested that parental preferences align well overall with early childhood teachers' tendency to teach less science than other content areas. Parental priorities might be major factor that contributes to the limitations in science learning experiences in students' early years.

Tippett and Milford (2017) incorporated STEM activities into the pre-k classroom. The methodology used observations, semi-structured interviews, focus groups, and a questionnaire to collect data from stakeholders. The purpose of this study was to examine how STEM activities were incorporated in pre-K classes, to explore students' engagement with STEM concepts, and to investigate parents' opinions about STEM. The findings supported the inclusion of STEM-based learning experiences for young children in Canada.

In Belgium, Dejonckheere and his colleagues tested the effects of integrating an inquiry-based didactic method for teaching preschool science in an authentic practical classroom setting. Four preschool classrooms with children 4-6 years old participated in the experiment (N= 57). In order to assess children's attention to causal events and their understanding of concepts related to scientific reasoning skills, the study design involved a simple task in which a need for information was created. Compared to controls, children whose education had involved the so-called control of variables strategy showed significant learning gains in the post-test. Indeed, they carried out more informative and fewer uninformative explorations during their spontaneous play. The importance of such programs was discussed in relation to the field of STEM education (Dejonckheere et al., 2016).

The examples of research on science education in early childhood mentioned above demonstrate that early childhood science education research has been exploring the teaching of STEM subjects to young learners, parental involvement in the classroom setting, and the use of STEM activities in the classroom. Recently, early childhood science education for children in pre-k to 3rd grade classrooms, in particular, has been attractive to researchers who are engaged in investigating science teaching and learning.

Effective Early Childhood Science Instruction

The area of research on teaching science for young children is concerned with questions of what should be taught, how it should be taught, and for what ends or reasons. Young children are capable of developing considerable content knowledge about science, although this varies dramatically by child (Greenfield et al., 2009). Thus, young children can understand science concepts when they are presented with them in developmentally appropriate ways. Further, it is essential to provide accurate science content to young children to expand on their current knowledge of the world and to correct their misunderstandings. The National Association for the Education of Young Children (NAEYC, 2009) indicated that flexible instructional strategies were important for promoting young children's development from the infant/toddler stage to the early grades. According to the literature, the instructional strategies are the following:

- Fostering oral language and communication
- Drawing from a continuum of teaching strategies
- Making the most of the environment, schedule, and routines
- Setting up all aspects of the indoor and outdoor environment
- Focusing on children's individual characteristics, needs, and interests
- Linking children's language and culture to the early childhood program
- Teaching through social interactions
- Providing support for play
- Addressing children's challenging behaviors
- Supporting learning through technology

- Using integrative approaches to curriculum

Besides these instructional strategies advocated by the NAEYC, the literature also suggests that for early childhood science education, inquiry-based instruction is an effective early childhood science teaching approach (Dejonckheere et al., 2016; McLean, Jones, & Schaper, 2015; NRC, 2012; Trundle, 2009; Trundle & Sackes, 2015; Van Uum, Verhoeff, & Peeters, 2016). Inquiry-based instructional approaches offer the most effective way for young children to engage with and learn science concepts. Children are expected to be active agents in the learning activities, such as work in small groups, meaningful science activities, and sense-making. One of the approaches that successfully incorporates inquiry into the teaching of science concepts is an approach based upon idea of "learning by doing." The Project approach, as it is known, involves an investigation of a topic in which children are interested (Curtis, 2002; Katz, 2018; Katz & Chard, 2000). Learning activities focus on child-generated questions guided by teachers. Children use various tools in their investigations, collect and analyze data, and produce artifacts (e.g., drawings, paintings, collages, and dramatic plays) to represent their understandings, and lead children collaborating with their peers (Trundle & Sackes, 2015).

Despite the advantages of the project approach, it involves some challenges. For instance, it is difficult to simultaneously balance children's interests with the required curriculum. Implementing a project approach is a time-consuming task that requires more work from teachers. Designing assessments to measure children's understanding that may develop from a project is also a challenge for many teachers (Curtis, 2002; Drake & Burns, 2004; Marx, Blumenfeld, Krajcik, & Soloway, 1997). In summary, despite the drawbacks, research literature and policy documents advocate for the use of a project approach in the teaching of science in the early years (e.g., AAAS, 2001; Inan, Trundle, & Kantor, 2010; Morris, 2004; Trundle & Sackes, 2015).

Prospective Early Childhood Teachers' Conceptions of Science Education

Teachers' conceptions have been studied for decades. The term conception is used interchangeably with terms such as belief, orientation, idea, attitude, intention, and view (Antoniadou & Skoumios, 2013). Teachers' conceptions within science education literature will be referred to as teachers' conceptions of teaching and learning in science. Mahasneh (2018), defined teachers' conceptions of teaching and learning as "the beliefs held by teachers about their preferred ways of teaching and learning" (p. 819) including what teaching and learning mean, and the relationship between the teacher and students. Mahasneh (2018) mentioned that the conceptions of teaching and learning may be classified as traditional and constructivist. First of all, the traditional conception is based on teacher-centered methods where the teacher is the knowledge source and the student merely the passive recipient. By contrast, the constructivist conception sees knowledge as constructed by the learner, and the positive impact of a child's interaction with peers or adults is stressed (pp 531-532.).

Antoniadou and Skoumios (2013) described three dominant teaching approaches to educating students in science.

1. The transmission approach sees knowledge as transferred from the teacher to the students, the main teaching practice is one in which students affirm scientific principles by carrying out experiments proposed by the teacher, and students work individually.
2. In the discovery teaching approach, knowledge is not transferred from the teacher to the student, but rather knowledge is discovered by the student with the proper guidance of the teacher. Teaching strategies used in the discovery approach are experimentation, questions, investigation, and discussion (Fleer, 2009).

3. In the constructivist approach, knowledge is constructed by the learner. Students work collaboratively, as the process of constructing new knowledge passes between the social and the personal level.

Prior research on prospective elementary teachers’ conceptions of science education has been carried out extensively; however, research on prospective early childhood teachers’ conceptions of science education is limited. The research on prospective teachers’ conceptions of science education has focused on primary teachers' conceptions about science teaching and learning (Ambusaidi & Al-Balushi, 2012; Antoniadou & Skoumios, 2013; Go & Kang, 2015; Subramaniam, 2013; Subramaniam et al., 2018).

Antoniadou and Skoumios (2013) investigated primary teachers’ conceptions about issues related to science teaching and learning (the meaning of learning and teaching, the purpose of teaching, teaching tools, main teaching practices, classroom organization, and teachers’ strategies to deal with students’ errors in science). Teachers’ conceptions are related to the views of the constructivist and discovery approaches. The findings of Antoniadou and Skoumios (2013) are similar to those of Go and Kang (2015), who investigated the self-images of science teaching held by early childhood prospective teachers who had taken constructivism early childhood science education courses. Draw a Science Teacher Test Checklist (DASTT-C), questionnaires, individual interviews, researchers’ field notes, and participants’ documents were collected. The results imply that early childhood science education should provide opportunities for pre-service teachers to reconstruct their own views about science teaching in order to learn and teach based on a constructivist view.

Brown and Englehardt (2017) provide insight into how a sample of early childhood preservice teachers who used iPads and apps in their coursework and high-stakes early learning field placements made sense of using these devices as teachers. Their findings indicate instructional opportunities for teacher educators to consider as they seek to assist their students in making sense about how to implement as well as adopt appropriate and effective instructional strategies into their own classrooms. In-service or preservice work requires teacher educators to recognize that their students, more than likely, have limited experience with such devices as learners and/or as teachers.

Eckhoff (2017) documents a collaborative project involving preservice early childhood education students' development of inquiry-based learning experiences alongside kindergarten students within a science methods course. This study investigated the impact of an inquiry-based teaching and learning experience on preservice teachers' beliefs about science in the early childhood classroom, utilizing a multiple method approach and data including classroom observations, transcripts from lesson planning sessions, PSTs' reflection journals, kindergarten science journals, and pre-and post-measurements for PSTs on the Draw-A-Scientist Test (DAST) and the Science Teaching Efficacy Beliefs Inventory—B (STEBI-B). Analysis of the DAST, the STEBI-B, and qualitative data revealed that the PSTs developed stronger understandings of inquiry-based science and self-efficacy beliefs related to their practice following participation in the collaborative project. Likewise, Lee & Yoon (2008) studied the teaching of prospective early childhood teachers, and how they assess children's inquiry process skills in a science method course. They found that such a course was essential for teachers to be able to help children understand the modes of inquiry and to foster their inquiry-based skills.

In summary, the literature on teachers' conceptions of teaching and learning science indicate the following.

1. Conceptions should be studied using appropriate qualitative research; in particular, the literate suggests using drawings and narrative.
2. Conception can be studied by observing how teachers use iPads to assist their students in making sense about how to implement as well as adopt appropriate and effective instructional strategies into their own classrooms.
3. Conceptions can be studied in relation to prospective early childhood teachers' development of inquiry-based learning experiences and inquiry skills within a science methods course.

The Role of Drawing in Educational Research

Student drawings in science class can be used as a way to document educational phenomena in relation to science education. Activities such as drawing images and doing narrative writing about teaching science can be a means for exploring teachers' beliefs about science education (Thomas et al., 2001). Drawing enables many people to express their inner thoughts, which they often cannot do through written or narrative texts (Markic & Eilks, 2008). Clearly, drawings can contribute to providing evidence in science education as they enable researchers to gain insights into teachers' thinking about science teaching and learning; to gain insights into learners' thinking about science teaching and learning; to study personally-generated drawing as a methodology; to gain insights into teachers' thinking about curriculum, instruction, and assessment; to gain insights into teachers' thinking about science education policy; to gain insights into teachers' thinking about science content; and to gain insights into learners' thinking about science content (Project Nexus, 2011).

The literature on the use of drawing looks at its use in terms of developing both a model for inquiry and a method of assessment for prospective science teachers, for studying prospective teachers of elementary education, for developing a methods course for graduate students specializing in elementary science education, and for designing a science content course for early childhood teachers. Existing research has been conducted on using drawing for undergraduate students in teacher education programs of elementary education, secondary education, or higher education, and for prospective science teachers (Ambusaidi & Al-Balushi, 2012; Katz et al., 2011; Markic & Eilks, 2013; Minogue, 2010; Project Nexus, 2011; Sinclair et al., 2013), but little research has been conducted examining the effects of teacher preparation programs on early childhood teachers (Mckinnon & Perara, 2015).

In a study of elementary and secondary education students enrolled in a required introductory education course, Sinclair and her colleges examined participants' visual images of themselves as teachers, and they modified the Draw-a-Science-Teacher Test (DASTT-C) (Thomas et al., 2001), to create the Draw-a-Teacher Checklist instrument (Sinclair et al., 2013). The results indicated that the graduate participants viewed teachers and teaching in a more teacher-centered way. This suggests that these teachers tend to revert back to more traditional, teacher-centered classroom beliefs, and they often indicate frustration in the classroom. The study further investigated the reasons why some teachers return to teacher-centered classroom practices even when they are aware of the effectiveness of student-centered classroom practices and the need to use a balanced approach in the classroom.

Ambusaidi & Al-Balushi (2012) explored the beliefs of prospective science teachers in the College of Education at Sultan Qaboos University/Sultanate of Oman about science teaching by using the Draw-A-Science-Teacher-Test Checklist (DASTT-C) tool in a Science Methods course. The results revealed that after completing the Science Methods course, prospective science teachers shifted significantly from a teacher-centered approach to an intermediate state between the teacher-centered and student-centered approaches.

Additionally, Minogue (2010) documents the use of the DASTT tool to analyze prospective elementary teachers' beliefs about science teaching and science methods courses. Results indicated statistically significant shifts in participants' mental models of science teaching and learning. The post-course stage showed that more students adopted student-centered practices. The use of the Draw-a-Science-Teacher-Test as a diagnostic tool for both preservice teacher beliefs about science teaching and science methods courses is effective.

Markic and Eilkic (2013) conducted an international cross-level study of German prospective teachers' beliefs about teaching and learning chemistry. The study was based upon drawings of teaching situations, which were analyzed using an evaluation pattern developed using grounded theory. Qualitative scales were used to analyze beliefs about classroom organization, teaching objectives, and epistemological beliefs. Data were collected from university freshmen, student teachers midway through their university teacher education program, and recently graduated teachers who had just finished their university program and were gaining experience as full-time teachers. The initial results revealed that the freshmen in their study professed very traditional beliefs about teaching and learning (characterized by teacher-centeredness and an understanding of learning as receptive consumption).

The Science Teaching and Learning Portrayals of Professional Practices (STLP3)

This current study used the instrument called the Science Teaching and Learning Portrayals of Professional Practices (STLP3). With this instrument, drawings are analyzed using an evaluation pattern based on four strands of the Science Teaching and Learning Portrayals of Professional Practices (STLP3) Scoring Rubric (Katz et al., 2011). Project Nexus blended formal and informal science education (Project Nexus, 2011), and this instrument was adapted by

Project Nexus to be used with prospective teachers to investigate their teaching of science in an early childhood classroom (Mckinnon & Perara, 2015).

The initial STLP3 instrument is based on the six statements of the NRC (2009) document, that "Learners who engage with science in informal environments….

1. Experience excitement, interest and motivation to learn about phenomena in the natural and physical world.
2. Come to generate, understand, remember and use concepts, explanations, arguments, models, and facts related to science.
3. Manipulate, test, explore, predict, question, observe, and make sense of the natural and physical world.
4. Reflect on science as a way of knowing; on processes, concepts, and institutions of science; and on their own process of learning about phenomena.
5. Participate in scientific activities and learning practices with others, using scientific language and tools.
6. Think about themselves as science learners and develop an identity as someone who knows about, uses and sometimes contributes to science." (NRC, 2009, p. 43)

Project Nexus was based on qualitative methodology. Thus, the teachers' drawings provided useful data for examining statements 1, 2, 3, and 5. Statements 4 and 6 are more directly amenable to study through written and verbal data, and they are not easily illustrated or analyzed using drawings (Project Nexus, 2011; Mckinnon & Perara, 2015). For the current study, the Science Teaching and Learning Portrayals of Professional Practices (STLP3) Scoring Rubric (See Appendix B) was used to examine the specific goal that was presented in the drawing. The drawings were subsequently scored from 0 to 16 based on four strands as follow:

1. *Affective*: Students should experience excitement, interest, and motivation to learn about phenomena in the natural and physical world.
2. *Cognitive*: Students will come to generate, understand, remember, and use concepts, explanations, arguments, models, and facts related to science.

3. *Implementation*: Students must manipulate, test, explore, predict, question, observe, and make sense of the natural and physical world.

4. *Social*: Students should participate in scientific activities and learning practices with others, using scientific language.

According to Project Nexus (2011), a methodology using drawings could be beneficial to workers in the education research community. The project reported that the use of drawings as a data collection method was useful for gaining insights into prospective teachers' thinking that had not been clear previously in written or verbal data; engaging in discussion in interviews and emails about insights gathered from the drawings of the prospective teachers; encouraging prospective teachers to reflect on aspects of their developing teacher identities that they had not previously perceived; and giving the teacher candidates a mode of expression that they enjoyed and was novel to them as a data collection strategy (Project Nexus, 2011).

The Sociocultural Perspective

In the present study, the students' drawings and narratives will be analyzed based on four strands of the Science Teaching and Learning Portrayals of Professional Practices (STLP3) Scoring Rubric (Katz et al. 2011). One strand of this instrument examines the "social" aspect by analyzing the drawings in terms of participation in scientific activities and learning practices with others, using the scientific language and tools. The prospective teachers' narrative writing will be used to identify the theme of teaching strategies to reveal students' interaction with others in scientific activities and learning practices. Consequently, sociocultural theory is appropriate in the current study because it aligns with the use of the STLP3 for analysis of drawings. Further, sociocultural theory is appropriate in relation to the use of teachers' narratives to study scientific activities in which students participate to learn along with others and to measure prospective early childhood teachers' conceptions of science instruction in the early childhood classroom.

The sociocultural approach of Vygotsky emphasizes the inextricable link between the individual and the social, where the activities of the individual are always culturally contextualized. Sociocultural theory literature falls into two types. One is that promoted by the Russian psychologist Ley Vygotsky (1896-1934). Another type is the literature produced by interpreters of Vygotsky's sociocultural theory (Neo-Vygotskians). Different from Piagetian constructivism and radical constructivism, sociocultural theory pays serious attention to three crucial aspects: the structural characteristics of schooling; the social organization of instruction; and cultural tools (material and psychological), especially the tools of language and inquiry (John-Steiner & Mahn, 1996; Subramaniam, 2007).

Sociocultural perspective emphasizes the teacher's role within students' construction of meaning. The teacher's role is cited as a mediator of students' learning. The key role of teachers is to motivate students to be active members and contributors within social contexts mediated by cultural tools (material and psychological tools) (Blanck, 1990; Miller,1996; Subramaniam, 2007). Teachers have an important role to play in a child's developing ability to think and to think well. The dialectic connection between cultural tools, interpersonal relations, and students' practical activities transforms students' natural cognitive functions into cultural ones. As can be seen, within this theory, teaching is assisted performance, where assistance is provided at points within the students' zone of proximal development.

Accordingly, knowledge is not generated from within; rather, learning stimulates and leads to development. Culture and social interaction collaboratively guide cognitive development. The zone of proximal development is created by the teacher and student in the context of specific tasks for intersubjective agreement about meaning being made together: it is not simply announced by the teacher but is carried out through mutual participation. This theory captures the idea of teachers as experts in the use of cultural tools leading to cultural amplification and the extending of students' cognitive processes. This study incorporates psychological tools (the semiotic tools of speech, writing, language, and thought) and physical tools (students' drawings and narratives) which mediate thought and activity within the zone of proximal development.

Another key construct of this theory that is particularly relevant to the present study is the relationship between language and thought within the zone of proximal development. In sociocultural theory, thought is expressed through language. To illustrate, the teachers act through metaphors and other figures of speech. They use these as tools to shape and specify their relations to students and their teaching circumstances: a repository of linguistic artifacts for the use in meaning making (Hodson & Hodson, 1998a; 1998b; Howe, 1996; Kozulin, 1990; Miller, 1996; Subramaniam, 2007). In the present study, teachers gave the directions to the students, then the students expressed their thoughts in response to drawings and narratives.

Another essential element of social interaction is scaffolding. In Vygotsky's view of cognitive development, the adults or other partners in a child's world provide scaffolding to help children learn new information and develop more complex thinking abilities. In the classroom, the activity structure manifests as the "interactive opportunities" that enable the teacher to select the relevant and suggested content, organize the content, and relate it to what their audience already knows. As a result, the teachers enable themselves and their students to “publicly display thinking and reasoning for their students to gain access to learning and to demonstrate social and academic competence” (Subramaniam, 2007; Weade, 1987: 17).

Subramaniam (2007) clarified that the zone of proximal development reflects the historical, social, and cultural context in which the cultural templates of society are made intersubjective for students to create meaning. His work also indicates that language, thoughts, and actions within the constructs of paradigmatic and narrative modes of thought reflect multiple ways of viewing reality within this zone of proximal development: that is, they are symbolic devices. Thus, language, thought, and actions, expressed within narratives, are key analytical templates to view the meaning-making processes within the zone of proximal development.

On the other hand, limitations of using the linguistic and psychological aspects of student and teacher interactions within the zone of proximal development are cited by some researchers. Namely, an over-emphasis on linguistic competence may lack conceptual depth (Frawley, 1997; Miller, 1996; Subramaniam, 2007). However, linguistic and psychological aspects must be taken into account with ample consideration of the social context of interaction in which they occur, as shown by Neo-Vygotskians (Confrey, 1995; Tudge & Winterhoff, 1993; Subramaniam, 2007). On the one hand, Subramaniam (2007) recommends that the inhibitory functions of language and its boundaries be captured within the analysis of language in social contexts.

A summary of these major constructs pertaining to teachers and teaching as perceived within sociocultural theory is presented in Figure 2. The figure is adapted from Carter et al. (1999) and captures the key constructs of sociocultural theory and connects these constructs into a composite figure that reflects teaching and learning within the zone of proximal development. It serves as the framework for the current study.

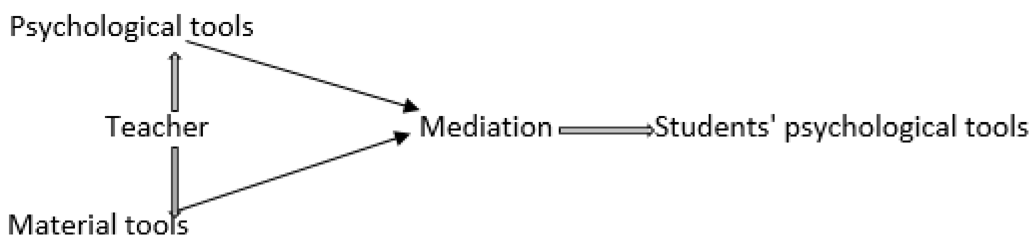


Figure 2. A diagrammatic representation of researcher's articulation of the sociocultural theory

The Sociocultural Perspective on Science Education

Sociocultural learning theory has been advocated and promoted in teaching and learning in many disciplines, and it suggests that science should not be separated from the society and culture in which teaching and learning in science education are situated (Erdogen, 2016). The sociocultural perspective on science education did not take root until after 1970, and it became associated with the “discovery” of Vygotsky's ideas on constructivist learning (Hassard & Dias, 2009). Children construct knowledge through social interactions (Santrock, 2004). Vygotsky suggests that emergent literacy develops through these social interactions in which children develop knowledge, values, and skills. These interactions differ from child to child, which leads to diverse development (Nord, Lennon, Liu, & Chandler, 2010).

Vygotsky questioned how children learned science from the historical and sociological contexts in daily life. He believed that children’s informal daily interactions provided a bank of experiences to draw on to develop more formal, scientific, and conceptual knowledge in later schooling (Hedges et al., 2011). Accordingly, the focus of the sociocultural perspectives on science education includes the role of social interaction in teaching and learning science or in studying the world, whether in classrooms or research laboratories; interpersonal social interaction, whether collaboration in a laboratory or dialogue in a classroom; and sociocultural theory (Lemke, 2001).

The social context for learning science with peers in an early childhood classroom is crucial. Science is a process, and it almost always involves collaboration with others. The Next Generation Science Standards (NGSS) are built on the key assumption that "science is fundamentally a social enterprise, and scientific knowledge advances through collaboration and in the context of a social system with well-developed norms" (NGSS Lead States, 2013, p. 27). Clearly, learning with peers has been identified as a critical component of science learning and science education, with science standards highlighting the importance of providing students opportunities for collaboration, discussion, and reflection around science.

Social interaction and peer collaboration during science learning opportunities may contribute to children's learning of science and inquiry. For instance, children may benefit from jointly planning of an investigation, raising questions through discussion with peers, describing outcomes and patterns in data, and explaining, sharing, discussing and listening as they work with peers on scientific investigations. It has also been argued that working with peers on science problems exposes children to a variety of forms of thinking and interpersonal interactions that likely benefit children both socially and academically (Johnson-Pynn & Nisbet, 2002).

What cultural practices relate to science skills learned in science education in early childhood settings? How can teachers bring these cultural practices of children to science classrooms? According to Bransford and his colleagues, science instruction in early childhood emphasizes learner-centered environments characterized by the ability of the teacher to pay careful attention to the knowledge, skills, attitudes, and beliefs that learners bring to the classroom and use these experiences to structure and organize the learning experiences of children (Bransford, Brown, & Cocking, 2000). Children build knowledge by using both general domain and specific domain learning processes and benefitting from support from older children and adults (Hong, Torquati & Molfese, 2013).

Teachers play the role of understanding what the child is thinking and the child's misconceptions and readjusting the learning environment to enable the child to figure out the solution to the problem at hand, as they pursue a science activity. Culture is integrated in teaching approaches with a learner-centered environment. Teachers will integrate personal and social perspectives on learning and emphasize the role of dialogue in helping students construct science knowledge. Integrating culture into the instruction is challenging for educators in recent years, especially for Early Childhood Science Education.

Therefore, teaching approaches referred to as "culturally responsive," "culturally appropriate," "culturally compatible," and "culturally relevant" are important in classrooms (Bransford, Brown, & Cocking, 2000). Culturally responsive teaching is a method that engages teachers in identifying teaching and learning approaches related to integrating culture into the curriculum (Sleeter, 2010). Strategies of teaching science that emphasize observation, listening to children, questioning, helping children make connections, and learning by making mistakes support the concept of diagnostic teaching or learner-centered teaching.

Materials for teaching science should originate from the natural environment of the children and the families. Cans, plastic cups or bottles can be used in science lessons about the recycling or used for creating telephones. The important calendar days of each country can also be integrated in science lessons for children. For example, teachers can teach about the weather on Song Kran days and ask about the culture in Thailand. Children will gain science knowledge and skills relevant to their family's culture. Relating to a research study of Ng'asike (2010), targeting the teaching of science to match the cultural experiences of children ensures that knowledge and skills of science are meaningful and relevant to the life of the learners.

The sociocultural perspective is part of Development Appropriate Practice (DAP), an important concept relating to the early childhood science curriculum. Kostelnik, Soderman, and Whiren (2011) conclude that teachers must look at children and families within the context of their community and culture before creating meaningful learning for children. Providing young children with opportunities to see science in their everyday activities helps them to build the basic understandings and interest for future science learning (Lind, 1998). Lack of cultural awareness by early childhood professionals can lead to erroneous assumptions and potentially negative outcomes for children.

Although the sociocultural framework has been quite extensively researched and utilized in comprehending students' learning in a variety of disciplines, the idea of prospective early childhood teachers' conceptions in teaching science in a socially constructed way has been minimally investigated. As one example, Eckhoft (2017) investigated the impact of an inquiry-based teaching and learning experience on prospective early childhood teachers' beliefs about science in the early childhood classroom. This study investigated the ways in which prospective early childhood teachers incorporated visual arts media into inquiry experiences to encourage young children to visually represent their scientific thinking. Socio-constructivist philosophy was used as a theoretical framework in addition to the long tradition of inquiry-based science instruction. The findings indicate that prospective teachers of early grades need direct experience with inquiry-based teaching in order to appreciate the strengths and challenges associated with the approach. Prospective early childhood teachers gain experience as both learners and teachers. They serve as a source of support as they seek to appropriate inquiry-driven pedagogical practices within the pedagogically restrictive environments of many contemporary early childhood classrooms.

Providing prospective early childhood teachers with challenging and supportive inquiry-based teaching and learning opportunities during their teacher preparation program can ultimately assist in strengthening their understanding of their role as supportive educators in developing science learning experiences. Based upon current research recommendations for best practices in the classroom, therefore, it is crucial to conduct research based on sociocultural theory in science teaching for prospective early childhood teachers.

Summary

This chapter examined the literature concerning prospective early childhood teachers' conceptions of science instruction, presented the standards that inform the content and practice of early childhood science education, discussed the current instructional strategies, and explained the role of drawings and other instruments that will be used to analyze the data collected for this study. Lastly, the sociocultural perspective that will be used as the theoretical framework to guide and frame the study was discussed. Chapter 3 identifies the methodology, the research design, the population studied, the data sources and data collection, and the data analysis employed for the present study. Chapter 4 presents the findings of prospective early childhood teachers’ conceptions of science instructions from drawings and narratives. Next, Chapter 5 discusses science instruction for an early childhood classroom as it relates to the findings presented in Chapter 4. It then offers implications for future study.

CHAPTER 3

METHODOLOGY

The purpose of this study was to investigate prospective early childhood teachers' conceptions of science instruction in an early childhood education methods class. The primary research question for this study was this: What are prospective early childhood teachers' conceptions of science instruction in an early childhood classroom? This Chapter presents the research design, gives details on the selection of participants, and describes the rationale and processes by which the data were identified, gathered, and managed. Information about the instruments and procedures used for data analysis is included.

Research Design

The current study conducted an analysis of prospective early childhood teachers' drawings and narratives to identify their conceptions of teaching science. The early childhood teachers' drawings and narratives were collected using a qualitative research design. Qualitative research is an approach that encompasses multiple theoretical paradigms, methods, and approaches, such as case study, participatory inquiry, interviewing, participant observation, visual methods, and interpretive analysis (Hesse-Biber, 2017). The qualitative researcher is an "interpreter" using a "naturalistic approach" to construct meaning from individuals' complex lived experiences and realities. The challenge for a qualitative researcher is constructing the research study, in particular choosing the appropriate tools/methods. The methodology for the current study was adapted from Hesse-Biber (2017), as shown as Figure 3.

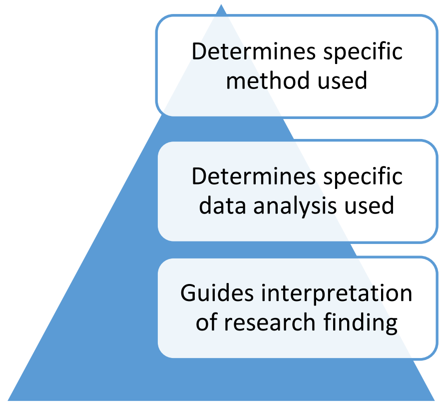


Figure 3. The purpose of methodology.

Participants

Participants for this study were drawn from 415 prospective early childhood teachers who self-enrolled in two of the required early childhood education courses as part of a teacher preparation program. Data were gathered in the fall of 2016, the spring of 2017, the summer of 2017, and the fall of 2017 at a large university in the southwest region of the United States. All participants were sophomores and juniors working toward certification in early childhood through sixth grade with bilingual supplemental, ESL supplemental, and special education EC-12 programming. As shown in Table 1 below, the participants consisted of 392 females (94.5%) and 23 males (5.5%). The racial/ethnic composition was as follows: 220 Caucasians (56%), 44 African Americans (11%), 105 Hispanics (27%), 21 Asian Americans (5 %), and two multi-racial participants (1%). A sample of 100 prospective teachers was selected from among the 392 prospective teachers (See Table 1). Figure 4 presents a diagram showing the number of participants by race and ethnicity.

Table 1

Number of Participants by Race and Ethnicity

Race/Ethnicity	Total Sample	Total Females	Selected Study of Participants
White	234	220	56
Hispanic	112	105	27
Black/African American	46	44	11
Asian	21	21	5
Native American/Pacific Islander	2	2	1
Total	415	392	100

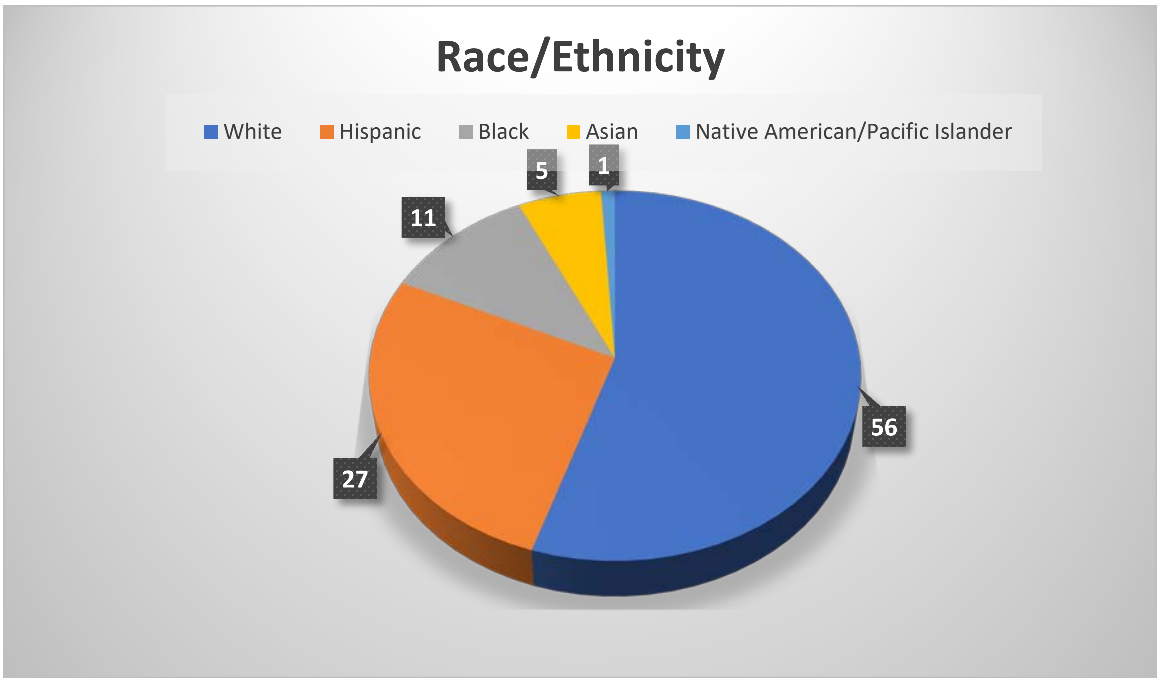


Figure 4. Diagram indicating the number of participants by race and ethnicity.

The selection of 100 participants from the larger sample of 415 participants was based on: (a) participants' self-identification of ethnicity, and/or race, (b) participants' self-identification of their gender as female, (c) each participant having a drawing that was accompanied by a five to ten sentence narrative, and (d) clarity of participants' drawings.

Research Context

The current study was contextualized in a teacher preparation program. All participants were enrolled in two early childhood education courses. The teacher preparation program in which they were enrolled was accredited by the Council for the Accreditation of Educator Preparation (CAEP) and the Texas Education Agency (TEA). The participants' course background for the teacher preparation program in early childhood through grade six (EC–6) included core subjects with the following certification options: teacher certification with no specialization certificate, ESL supplemental certification, bilingual supplemental certification, and special education EC–12 certification, as shown in Figure 5 below. Participants' coursework in the teacher preparation program included a number of required and elective courses in three core areas: the Science and Mathematics core, the Teacher Education core, and the Early Childhood core (See Figure 5).

Data Collection and Data Sources

The current study carried out an analysis of data collected for a larger study. Two items of data, a drawing and a narrative, were collected from each participant on the first day of class in the two courses selected, in the fall of 2016, the spring of 2017, the summer of 2017, and the fall of 2017. The prompt "Draw a teacher teaching science in an early childhood classroom" was given to each participant. The goal of the larger study was to gain insights into prospective early childhood teachers' conceptions of science teaching. In addition to responding to the prompt, each participant was instructed to write a narrative describing her own drawing in five to ten sentences.

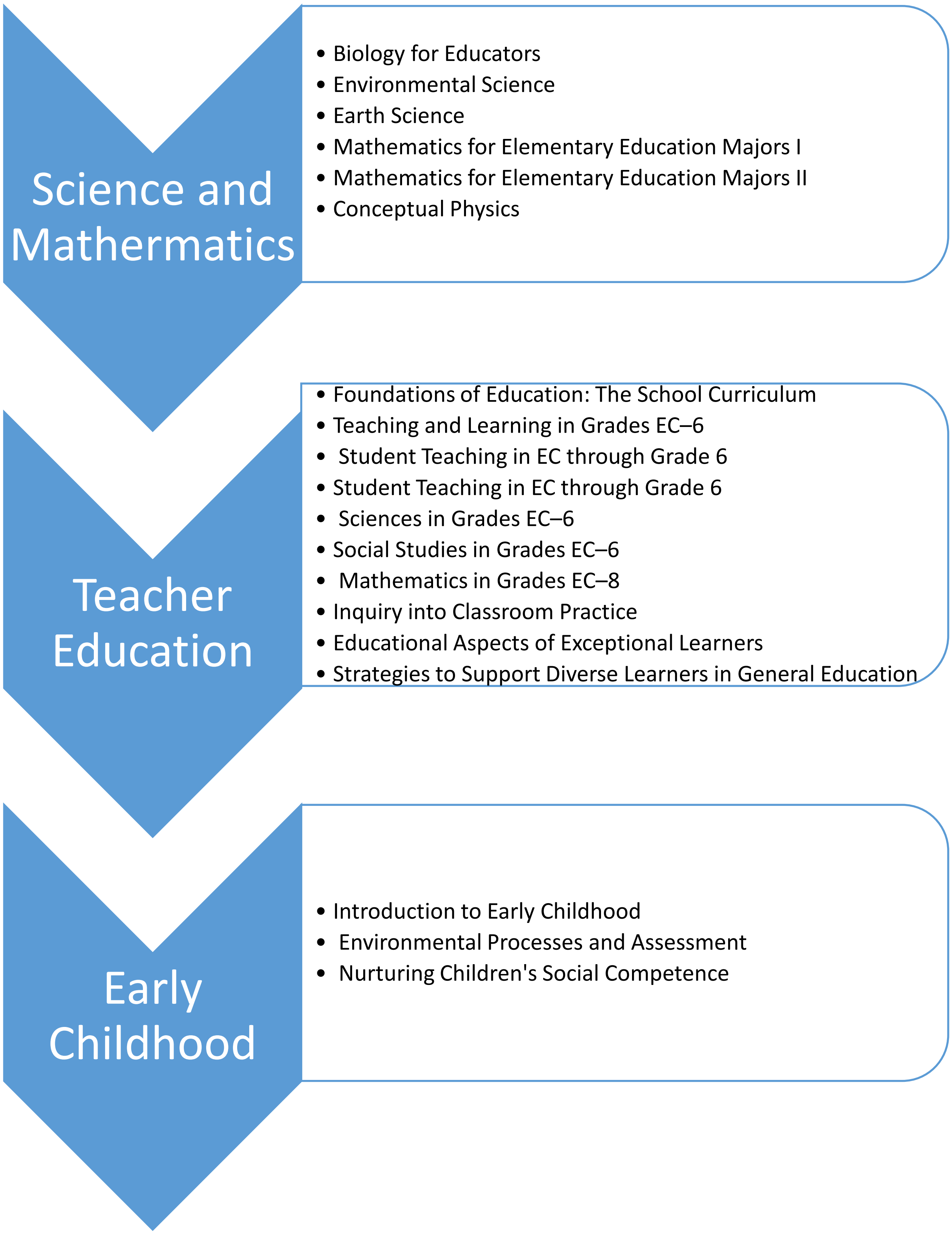


Figure 5. Example of participants' course background in a teacher preparation program.

Drawing Procedures

Participants were provided with a blank sheet of white paper and drawing supplies (markers, color pencils, and crayons) and were asked to respond to the prompt "Draw a picture of a teacher teaching science in an early childhood classroom." No other instructions were provided, and participants were given approximately 15-20 minutes to complete the drawing. The purpose of using drawing in this study was to collect participants' images and investigate their conceptions of teaching science in an early childhood classroom. Accordingly, the drawing served as a potential instrument—representing projective research techniques, pictorial forms, symbols, forms of text, markers and mirrors, and platforms to elicit discussion—that visually captured participants' interactions with a phenomenon not easily illustrated through text or narratives (Subramaniam et al., 2018). In the field of educational research, drawings have been used to illustrate participants' experiences, tacit knowledge, and practical knowledge about instruction (Brown & Schwartz, 2009; Subramaniam et al., 2018). Therefore, the drawings revealed aspects of the science teaching identities of teachers of early childhood learners.

Narratives

In the present study, narratives were also collected as a data source. Narratives were collected with two objectives: (a) to provide an image and text balanced approach (Radnofsky, 1996; Subramaniam et al., 2018), and (b) to allow participants to describe and interpret their own drawings in their own words (Subramaniam et al., 2018). As qualitative data, narratives can be seen as data reflected in participants' accounts of phenomena, collected in the participants' natural speech (Connelly & Clandinin, 1986; Subramaniam et al., 2018). In this study, the prompt used to collect narrative data was “Briefly describe your drawing in five to ten sentences. Specifically, describe the products and the processes in each drawing.”

Data Analysis

Analysis of Drawings

Participants' drawings of their conceptions of teaching science were analyzed based on four goals of the *Science Teaching and Learning Portrayals of Professional Practices* (STLP3) Scoring Rubric (Katz et al., 2011). The original instrument was based on the goals (or strands) for science learning from the Taking Science to School (NRC, 2007) report. The later Learning Science in Informal Environments (NRC, 2009) report increased the number of goals to six, and it was on these goals that the STLP3 was based (Katz et al., 2011). Goals four and six of the original list were omitted as their analysis relies on verbal and written responses (Project Nexus, 2011).

The goals state that "Learners who engage with science in informal environments. . .

1. Experience excitement, interest and motivation to learn about phenomena in the natural and physical world.
2. Come to generate, understand, remember and use concepts, explanations, arguments, models and facts related to science
3. Manipulate, test, explore, predict, question, observe and make sense of the natural and physical world.
4. Reflect on science as a way of knowing; on processes, concepts, and institutions of science; and on their own process of learning about phenomena.
5. Participate in scientific activities and learning practices with others, using scientific language and tools.
6. Think about themselves as science learners and develop an identity as someone who knows about, uses and sometimes contributes to science. (NRC, 2009, p. 43)

Participants' drawings provided useful data for goals 1, 2, 3, and 5, and the STLP3 (See Appendix C) was adapted to analyze the prospective teachers' teaching of science at early childhood/primary school levels in a formal setting (Mckinnon & Perara, 2015). As the current study included only drawings and written responses, analysis of goals 4 and 6 was not feasible, and thus goals 4 and 6 were excluded. To illustrate the analytic procedure, each goal of the Science Teaching and Learning Portrayals of Professional Practices (STLP3) Scoring Rubric examined a specific goal that was presented in the drawing. The drawings were subsequently scored from 0 to 16 based on the four goals, and each goal was scaled from 0 to 4 (See Appendix B). The goals of the STLP3 are as follows:

1. *Affective:* Students will experience excitement, interest and motivation in learning about phenomena in the natural and physical world (Goal 1).
2. *Cognitive*: Students will come to generate, understand, remember, and use concepts, explanations, arguments, models, and facts related to science (Goal 2).
3. *Implementation*: Students will manipulate, test, explore, predict, question, observe, and make sense of the natural and physical world (Goal 3).
4. *Social*: Students will participate in scientific activities and learning practices with others, using scientific language (Goal 5).

In addition to the STLP3, a Scoring Rubric Supplemental Information Sheet (See Appendix C) was used to clarify specific indicators of each goal. Examples include for *Affective* (goal 1), "…Look at the mouths of the figures present. If anyone is smiling, give credit (that is, if only the teacher is smiling but the students are not, give credit for smiling or the reverse) ..." *Cognitive* (goal 2), "Identify concepts, explanations, arguments, models, and facts using these descriptions—identify concepts and add thought bubbles or comments about bigger science ideas (e.g. energy, evolution)." *Implementation* (goal 3),"Identify manipulating, testing, exploring, predicting, questioning, observing, and sense-making using these descriptions-manipulating - each learner has access to materials in reach or is shown actually touching items (note: manipulating variables for an experiment)” *Social* (goal 5), “Identify participation in scientific activities and learning practices with others, using scientific language, and tools using these descriptions; participate in scientific activities and learning practices with others—students are grouped for interaction.”

Analysis of Narratives

Participants’ narratives were analyzed to reveal conceptions of science instruction in an early childhood classroom. The data analysis procedure used an inductive approach consisting of category development to analyze narratives. The process of data analysis began with transcribing the participants’ narratives. First, the participants’ narratives were labeled through the highlighting of words and/or single phrases in the data and then, through the analytical process of interpretation, the data were assigned codes by the researcher and one member of the dissertation committee. Coding is a means of organizing qualitative data by summarizing, reducing, or condensing it, in order to develop concepts, topic, ideas, categories, and themes (Coffey & Atkinson, 1996). Specifically, coding allows the researcher to identify meaningful data that can be used in the analytical process of inference and interpretation. Hahn (2008) cites three levels of qualitative coding:

1. Initial Coding or Open Coding, where large quantities of research data are focused and labeled;
2. Focused Coding or Category Development, where reexamination of level one codes and data is further focused on;
3. Axial or Thematic Coding, which results in the development of themes.

Second, after coding the data, the authors compared these codes to identify themes and consistent patterns as they emerged through the data collection. These patterns helped to answer the research questions: What are prospective early childhood teachers' conceptions of science instruction in an early childhood classroom? This served as a starting point for manual coding. Manual coding consisted of several readings of participants' narratives. During this procedure, it was found that all coded text appeared to describe teaching strategies, and some categories were revised, removed, and added. Data that could not be coded into one of the predetermined categories were coded with new categories. Then the initial codes were examined and compared for patterns, and similar codes were organized into categories so that meaning could be derived from the data (Saldaña, 2016). The categories were reexamined for major themes (Teaching Strategies) present in the data. Saldaña (2016) states the following, "a theme is an outcome of coding, categorization, and analytic reflection, not something that is, in itself, coded. . ." (p. 13). In this present study, together with one member of the dissertation committee, the researcher reviewed the data and codes with the research study question in mind and identified six major emerging themes of teaching strategies from the analysis of participants' narratives: demonstration, engagement/enjoyment, inquiry/interaction, experiment, safety, and observation.

Next, the number of times each theme was identified in the data was quantified, and a percentage was used to represent the frequency of that theme. Lastly, the findings from the analysis of data (the participants' drawings and narratives) were peer-debriefed with an expert in early childhood teaching. The expert had six years of pre-K teaching experience and 35 years as an instructor in early childhood teacher education and administration. At the time this study was conducted, the expert was the Director of the Child Development Laboratory at the study site. During the peer debriefing, the expert presented and shared her insights about the findings from the analysis of both the participants’ drawings and the narratives. All correspondence with the expert was recorded and was used to re-examine and reanalyze the findings and the data. For example, scores from the STLP3 on cognitive and implementation dimensions were reexamined, and in the subsequent analysis the percentage for the cognitive dimension dropped from 65% to 33%, and for the implementation dimension, the scores dropped from 65% to 37%. Also, the number counts for participants expressing different conceptions of science instruction were reexamined with the narrative data, and in the subsequent analysis the percentage for each conception was recalculated. Figure 6 below presents the analysis of data framework of the present study.

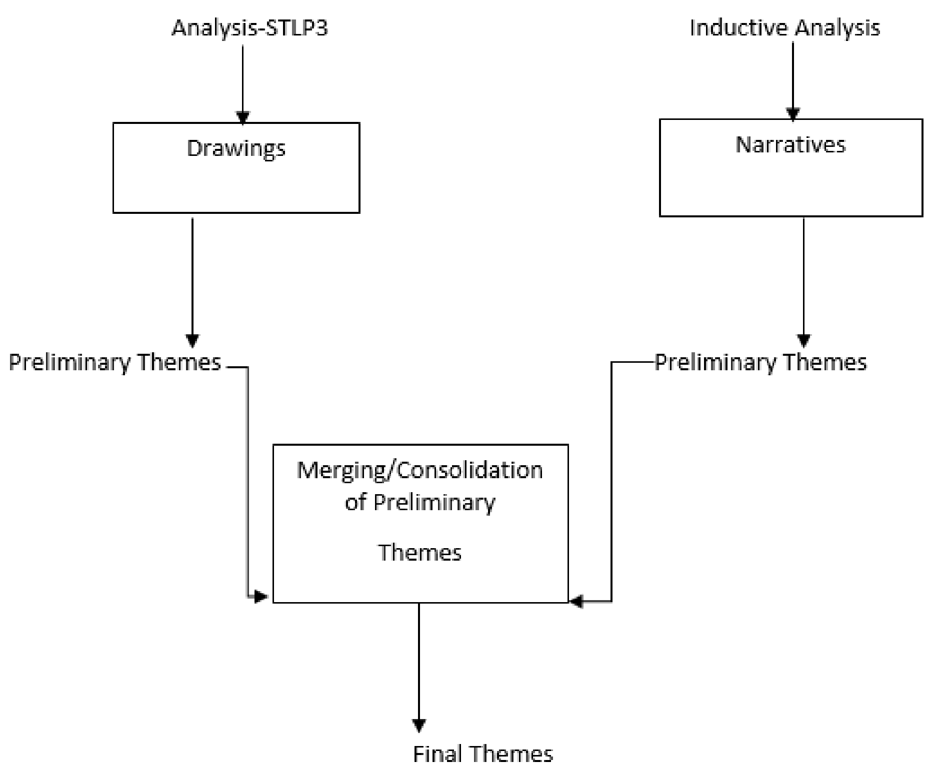


Figure 6. Data analysis framework.

Following this description of the analytic process, the results will be described in sufficient detail so that readers will have a clear understanding of how the analysis was carried out and its strengths and limitations (GAO, 1996; Elo & Kyng's, 2007).

Trustworthiness

Trustworthiness in this study relies on the criteria developed by Lincoln and Guba. Trustworthiness aims at supporting the argument that the study's findings are "worth paying attention to" (Lincoln & Guba, 1985; Elo et al., 2014). The criteria for evaluating trustworthiness in the current study include credibility, transferability, dependability, confirmability, and authenticity measures (Elo et al., 2014). Table 2 presents the qualitative criteria employed for assessing research quality and rigor in the current study.

Table 2

The Qualitative Criteria for Assessing Research Quality and Rigor

Trustworthiness	*Strategy Employed*
Credibility	Use of peer debriefing Co-analysis
Transferability	Providing thick description
Dependability	Code-recode strategy
Authenticity	Researchers, fairly and faithfully

Researchers must ensure that those participating in research are identified and described accurately; this addresses the *credibility* of the study. The term *dependability* refers to the stability of data over time and under different conditions. In this study, dependability was achieved by *confirmability*, which relates to the objectivity, that is, the potential for congruence between two or more independent people about the data's accuracy, relevance, or meaning. The term *transferability* refers to the potential for extrapolation. It relies on reasoning supporting the idea that findings can be generalized or transferred to other settings or groups. Finally, the term *authenticity* refers to the extent to which researchers, fairly and faithfully, show a range of realities (Lincoln & Guba, 1985; Polit & Beck, 2012; Elo et al., 2014).

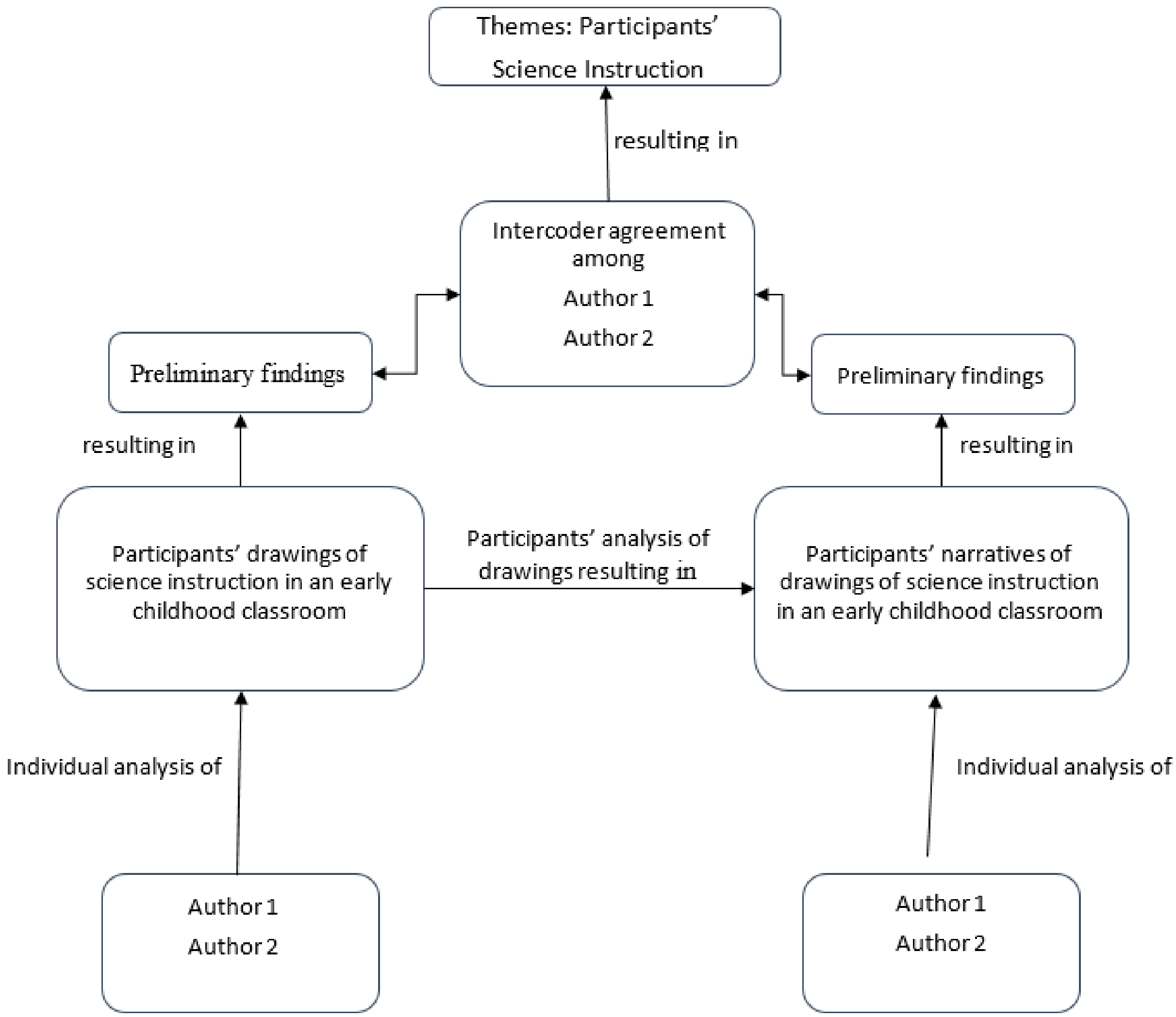


Figure 7. Steps to ensure trustworthiness.

In the present study, several steps were taken to ensure the trustworthiness of the findings. As presented in Figure 7 above, adapted from Subramaniam et al. (2018), all data, including the drawings and narratives, were coded individually by the researcher and one of the dissertation committee members, and an intercoder agreement process (Kurasaki, 2000) was carried out to seek consensus. The drawing data were analyzed by the researcher and by the participants themselves, who wrote the accompanying narratives of the drawings. The use of only drawings has limitations, such as the inability of drawings to capture every detail and nuance of the phenomenon: the phenomena of artistic aptitude/artistic plateau may be relevant. Therefore, the researcher sought to use narratives and intercoder agreement to achieve consensus on the findings.

In addition, demonstrating transferability, findings from this study can be used in future studies comparing prospective early childhood teachers' conceptions of science instruction for young learners in the United States with those of prospective early childhood teachers in other countries.

Summary

The methodology of this study was designed for the investigation of prospective early childhood teachers' conceptions of science instruction. The study utilized participants' drawings and their narratives of their drawings. Four strands of the Science Teaching and Learning Portrayals of Professional Practices (STLP3) Scoring Rubric were used to analyze participants' drawings, and qualitative analysis was applied to analyze narratives. This process served to identify participants' conceptions of their science teaching identities for teaching early childhood learners.

CHAPTER 4

FINDINGS

The purpose of this study was to investigate the prospective early childhood teachers' conceptions of science instruction in an early childhood classroom context. This chapter reports the findings from analysis of participants' drawings and participants' narratives of drawings of science instruction in an early childhood classroom. The findings are presented in two sections: the first section presents participants' conceptions of science instruction based on the analysis of participants' drawings, and the second section presents participants' conceptions of science instruction based on the analysis of participants' narratives of drawings.

Participants' Conceptions of Science Instruction: Drawings

Analysis of participants' drawings using the STLP3 instrument revealed four themes that characterized participants' conceptions of science instruction. These four conceptions were: (a) science instruction in an early childhood classroom is a social activity, (b) science instruction in an early childhood classroom as an affective endeavor, (c) science instruction in an early childhood classroom is the implementation of activities for learning, and (d) science instruction in an early childhood classroom is a cognitive activity. Table 3 presents the findings from the analysis of the 100 participants' drawings conceptualizing science instruction for children in pre-K to 3rd grade. This table details the number of times these four conceptions appeared in the drawing data and it also lists the percentage of the total represented by each conception.

As is evident in Table 3, 85% of the participants' conceptions of science instruction were within the social dimension. That is, participants conceptualized science instruction in a pre-K to 3rd grade early childhood classroom as being a social activity. Participants' conceptions of science instruction was coherent with the STLP3's description of science instruction as students participating "in scientific activities and learning practices with others, using scientific language and tools." Additionally, 73% of participants conceptualized science instruction in a pre-K to 3rd grade early childhood classroom as an affective endeavor. That is, this conception was coherent with the STLP3's description of science instruction as being underscored by "experience excitement, interests, and motivation" (Project Nexus, 2011) of both teacher and learners, revealing the way they learn about phenomena in the natural and physical world.

Table 3

Scores and Percentages of Participants' Conceptions of Science Instruction by Dimensions Present in the STLP3 Rubric (N = 100)

Conceptions	Total of Score of each Goal (400)	Percentage(%)
Affective	293	73
Cognitive	132	33
Implementation	146	37
Social	340	85

On the other hand, 37% of participants had conceptions of science instruction as implementing activities for learning. Participants' conceptions of science instruction were coherent with the STLP3's description of science instruction as implementing activities for learning, that is, students "identify manipulating, testing, exploring, predicting, questioning, observing, and sense-making of the natural and physical world." Likewise, 33% of participants had conceptions of science instruction as a cognitive activity. Participants' conceptions of science instruction were coherent with the STLP3's description of science instruction as cognitive activity, that is, students “come to generate, understand, remember and use concepts, explanations, arguments, models and facts related to science.”

Next, I present examples of each conception using participants’ drawings. For example, Figure 8 details a participant drawing that received a score of four showing evidence of learning with others, using scientific language and using scientific tools. Figure 9 shows an example of a participant’s drawing that portrays no social activity. Figure 10 illustrates a participant drawing that received a score of four showing “smiling figures with specific indicators.” Figure 11 shows an example of a participant’s drawing that portrays no affective endeavor. Figure 12 presents a participant drawing with a score of four showing science instruction as an implementation of activities for learning. Figure 13 shows an example of a participant’s drawing that shows no evidence of an implementation of activities for learning. Figure 14 details a participant drawing that received a score of four showing “evidences or models of concepts, explanations, arguments, models, or facts.” Figure 15 shows an example of a participant’s drawing that shows no evidences of cognitive activities for learning.

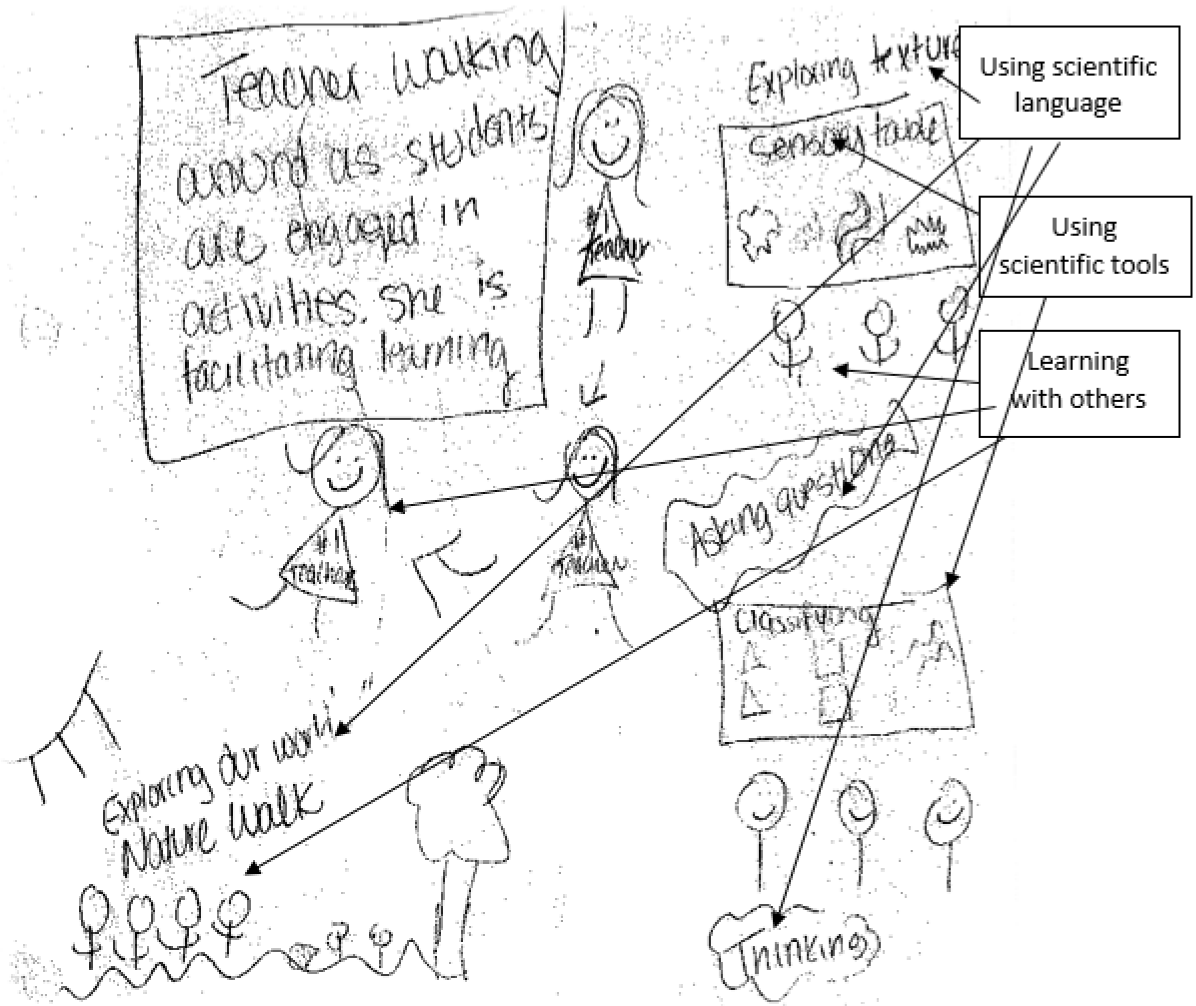


Figure 8. A participant's drawing receiving a score of 4 for science instruction as a social activity.

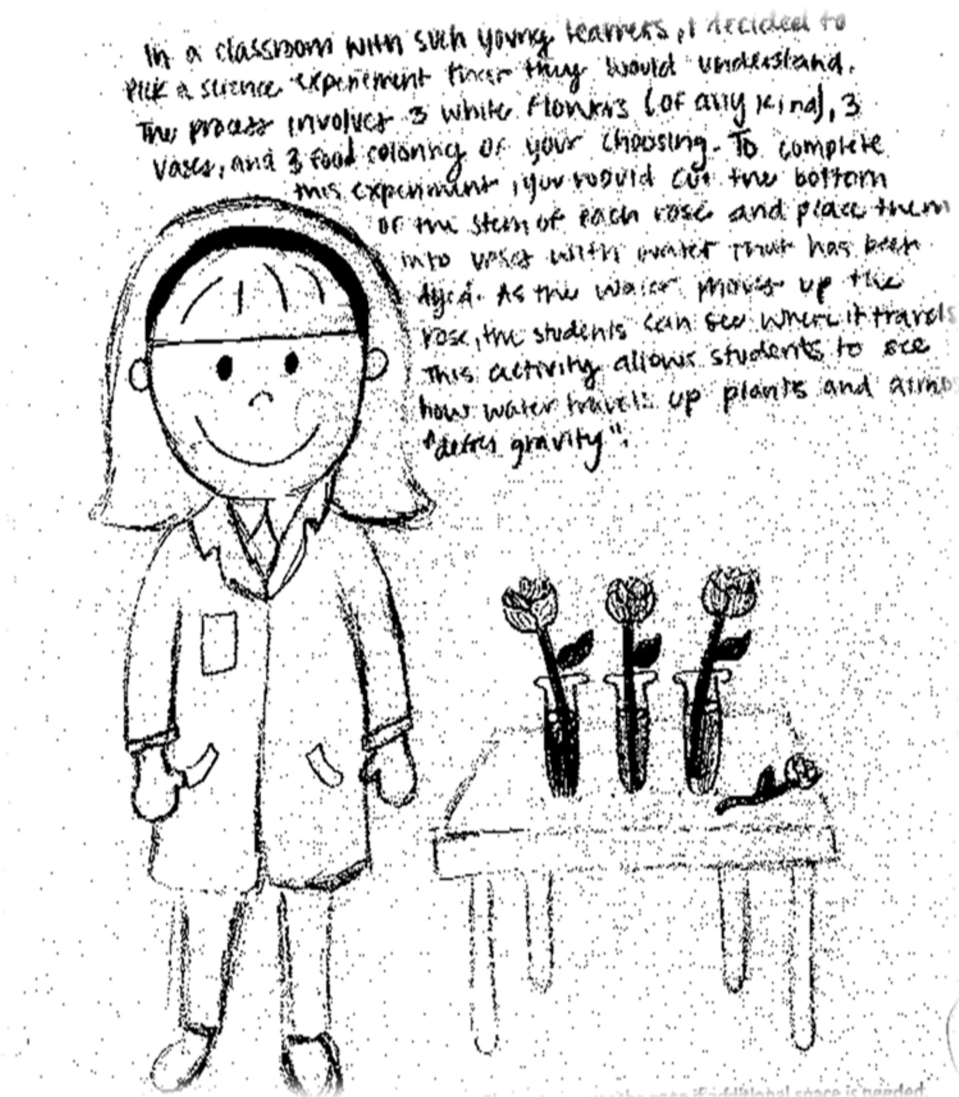


Figure 9. A participant's drawing receiving a score of 0 for science instruction as a social activity.

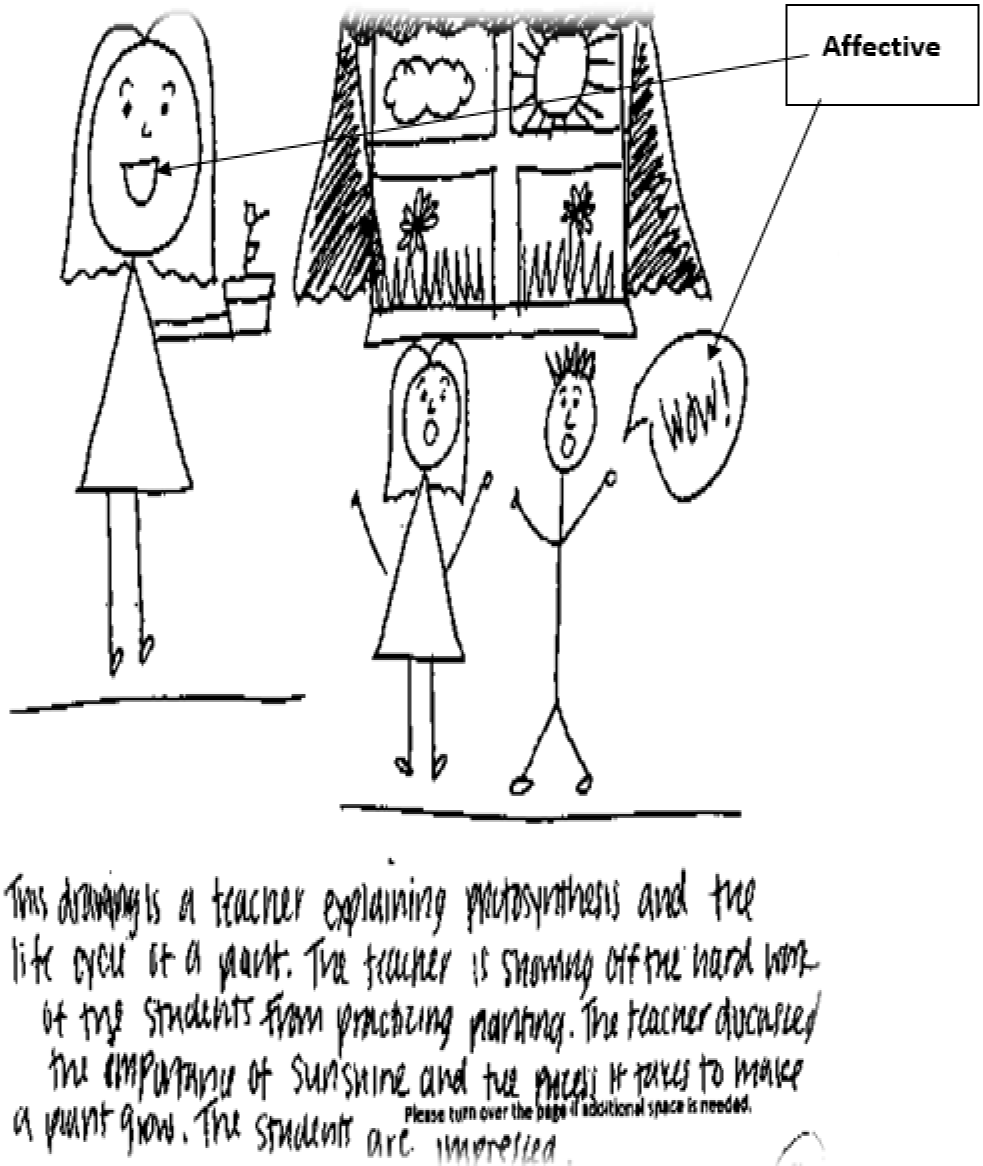


Figure 10. A participant's drawing receiving a score of 4 for science instruction as an affective endeavor.

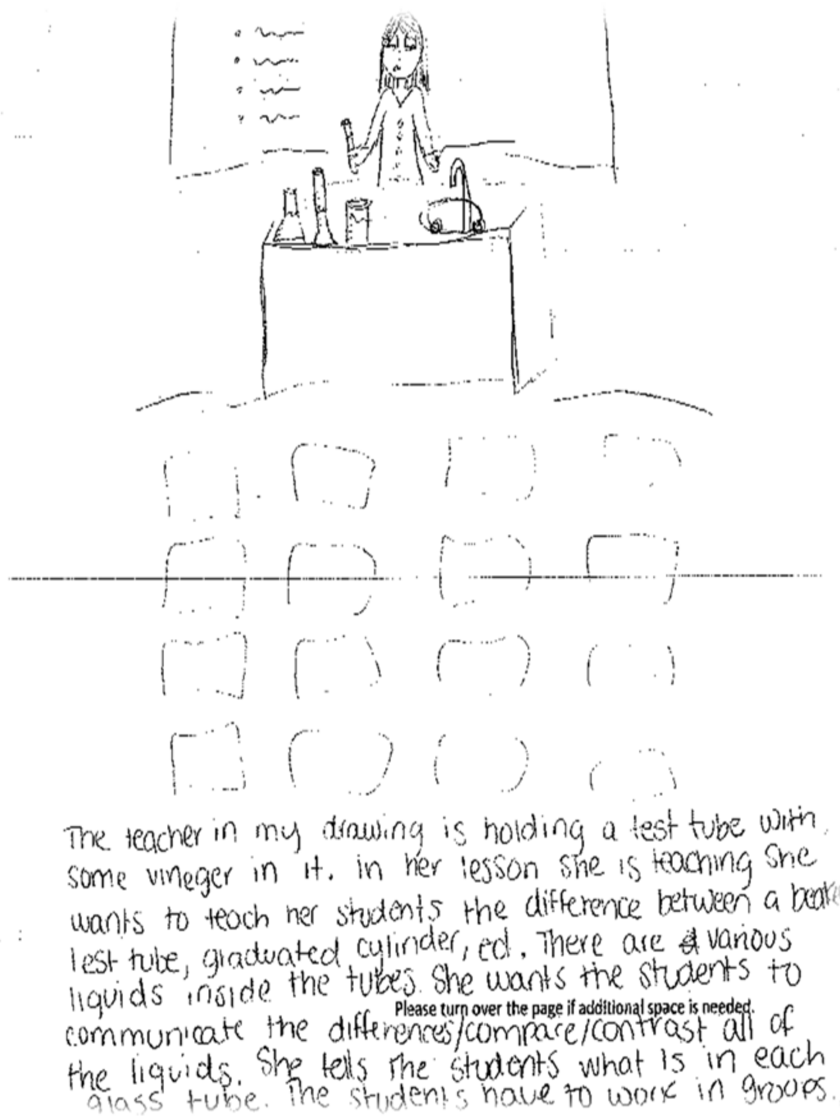


Figure 11. A participant's drawing receiving a score of 0 for science instruction as an affective endeavor.

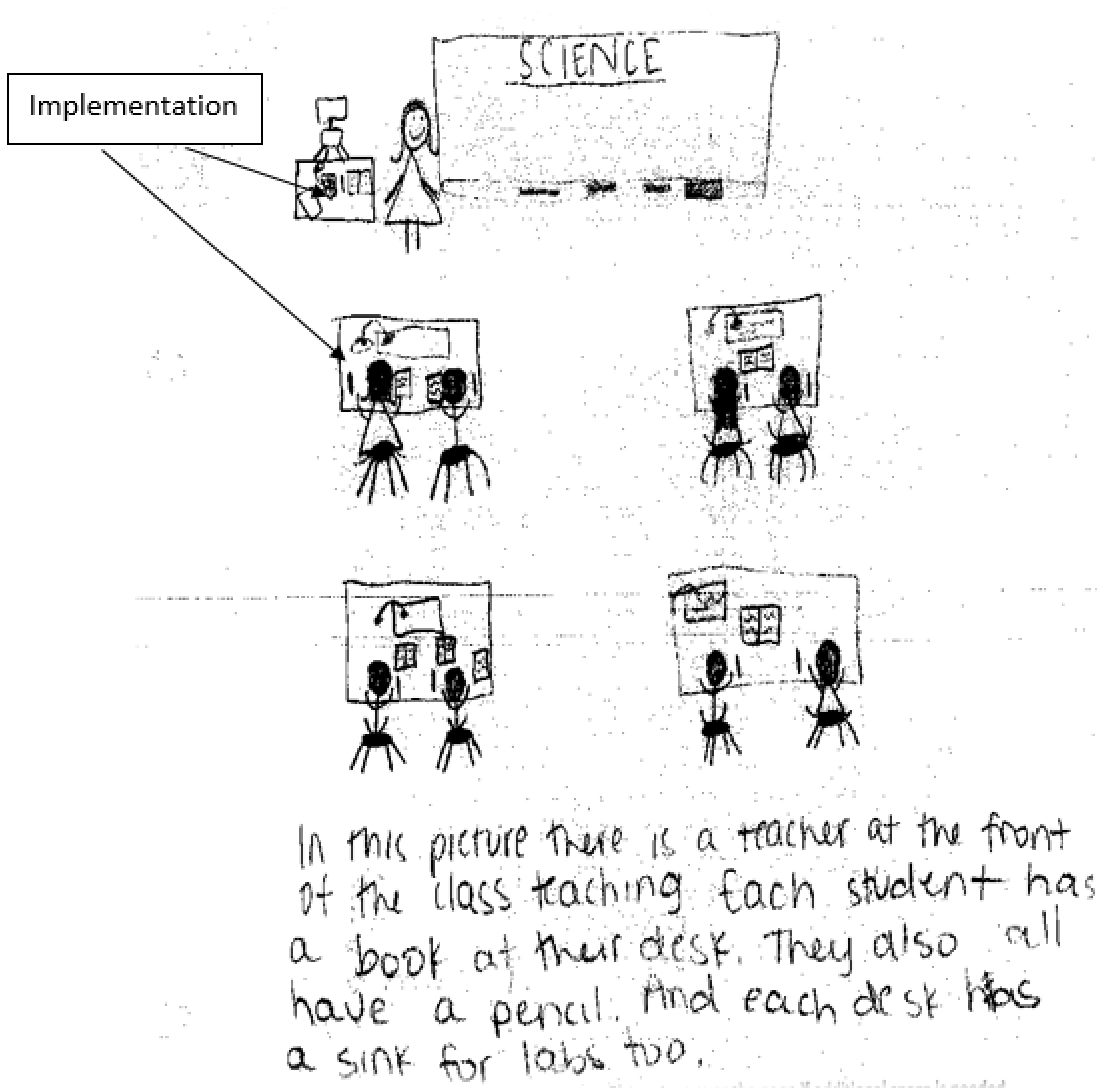


Figure 12. A participant's drawing receiving a score of 4 for science instruction as an implementation of activities for learning.

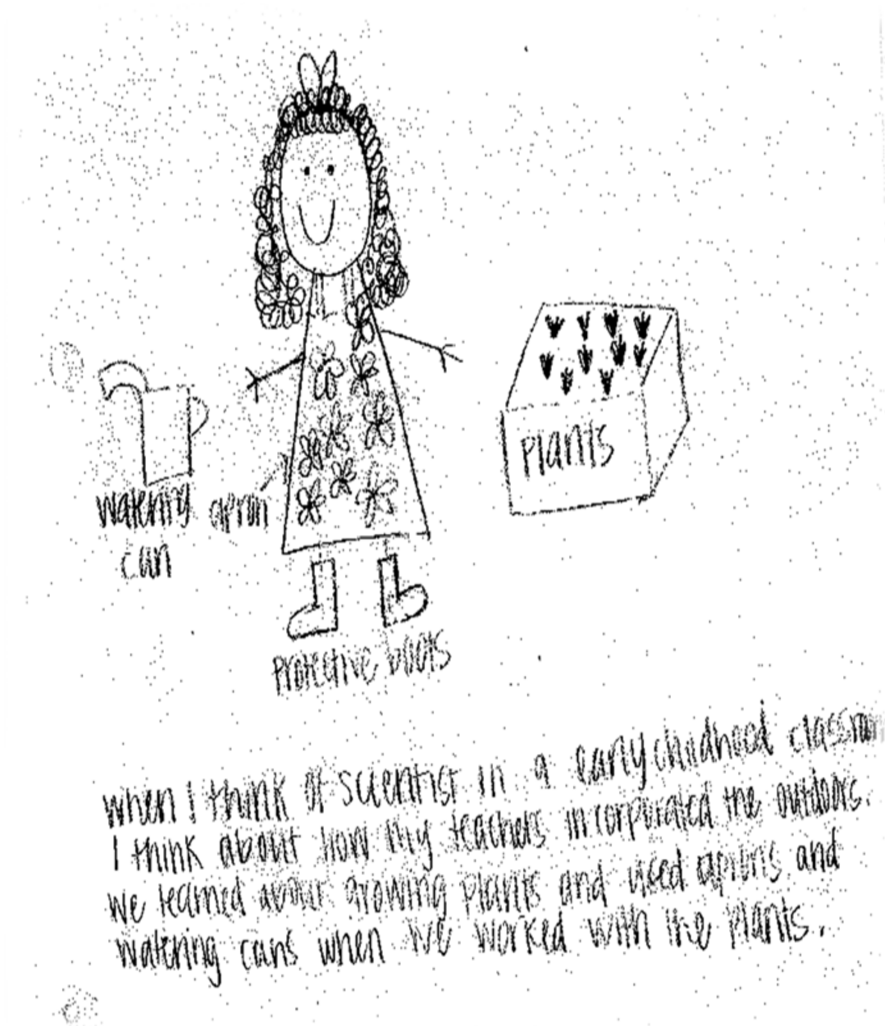


Figure 13. A participant's drawing receiving a score of 0 for science instruction as an implementation of activities for learning.

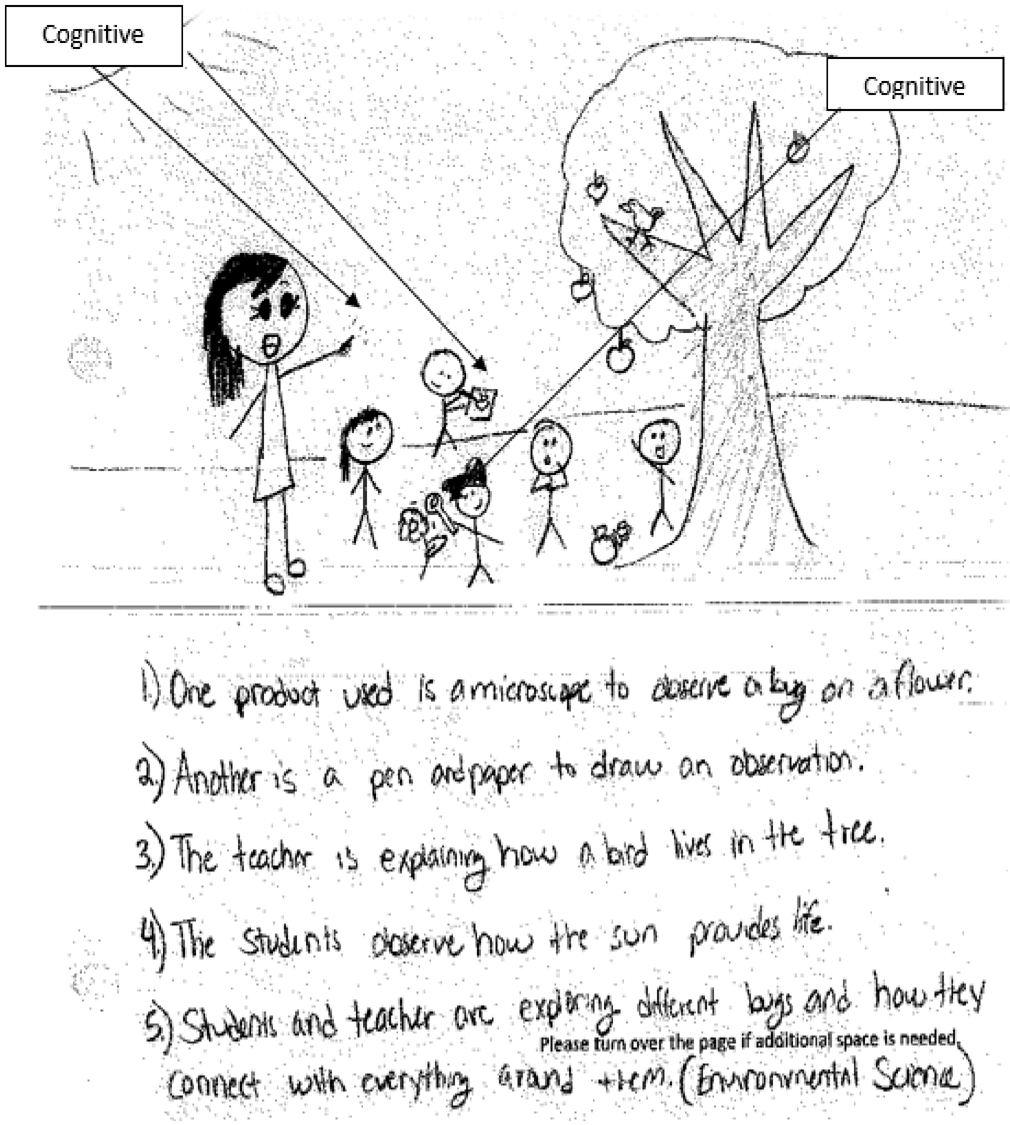


Figure 14. A participant's drawing receiving a score of 4 for science instruction as a cognitive activity.

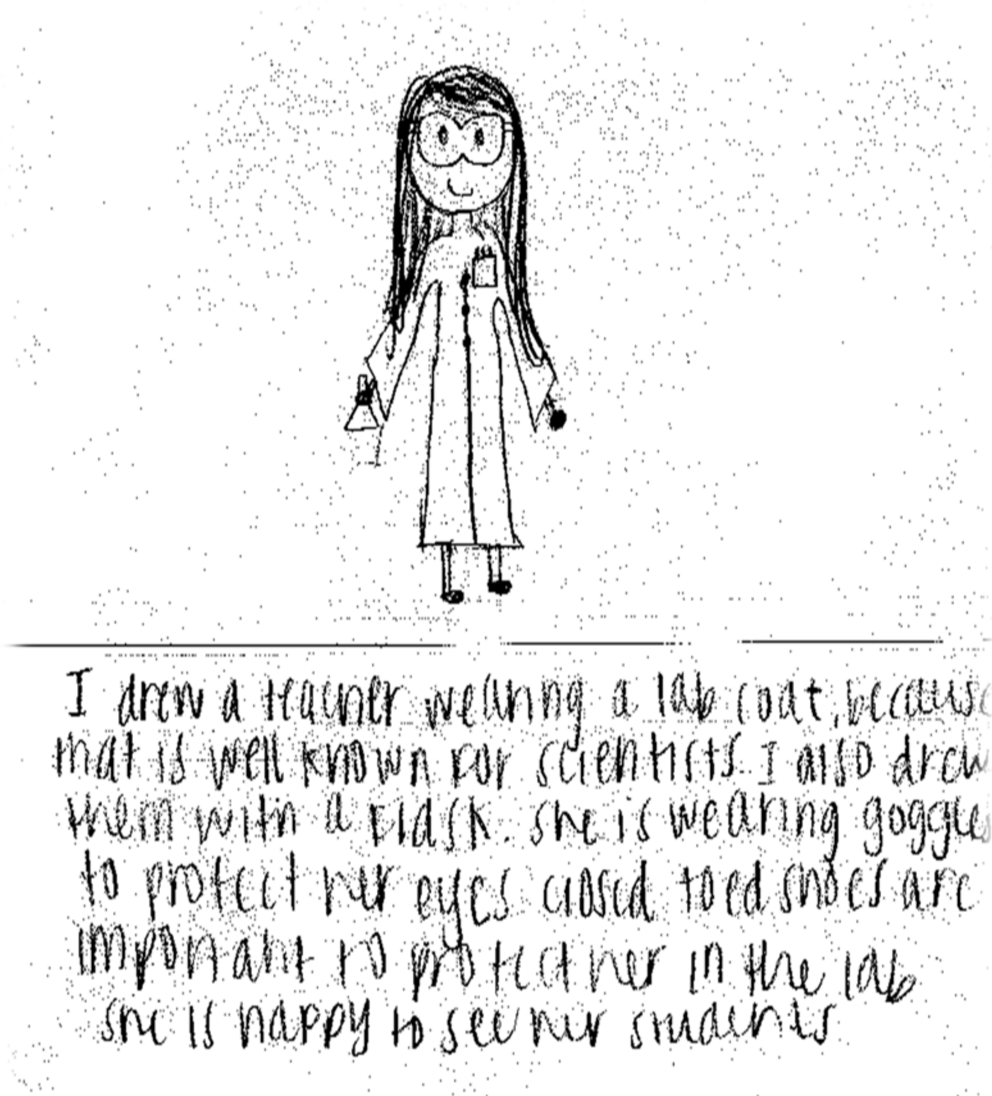


Figure 15. A participant's drawing has a score of 0 for science instruction as a c*ognitive* activity.

Figure 16 shows that the teacher and students are smiling. It includes specific indicators such as the use of the descriptive words "fun" (which is affective). The drawing shows evidence in thought bubbles, containing words such as vocab, hand on, model of concept (physical science, a literacy component) (a cognitive conception). The teacher and students in this drawing are participating in activities of manipulating testing, exploring, observing, or sense-making (implementation and social activities). These teacher and these students are participating in scientific activities and learning practices with others using scientific language and using scientific tools (cognitive, social conceptions).

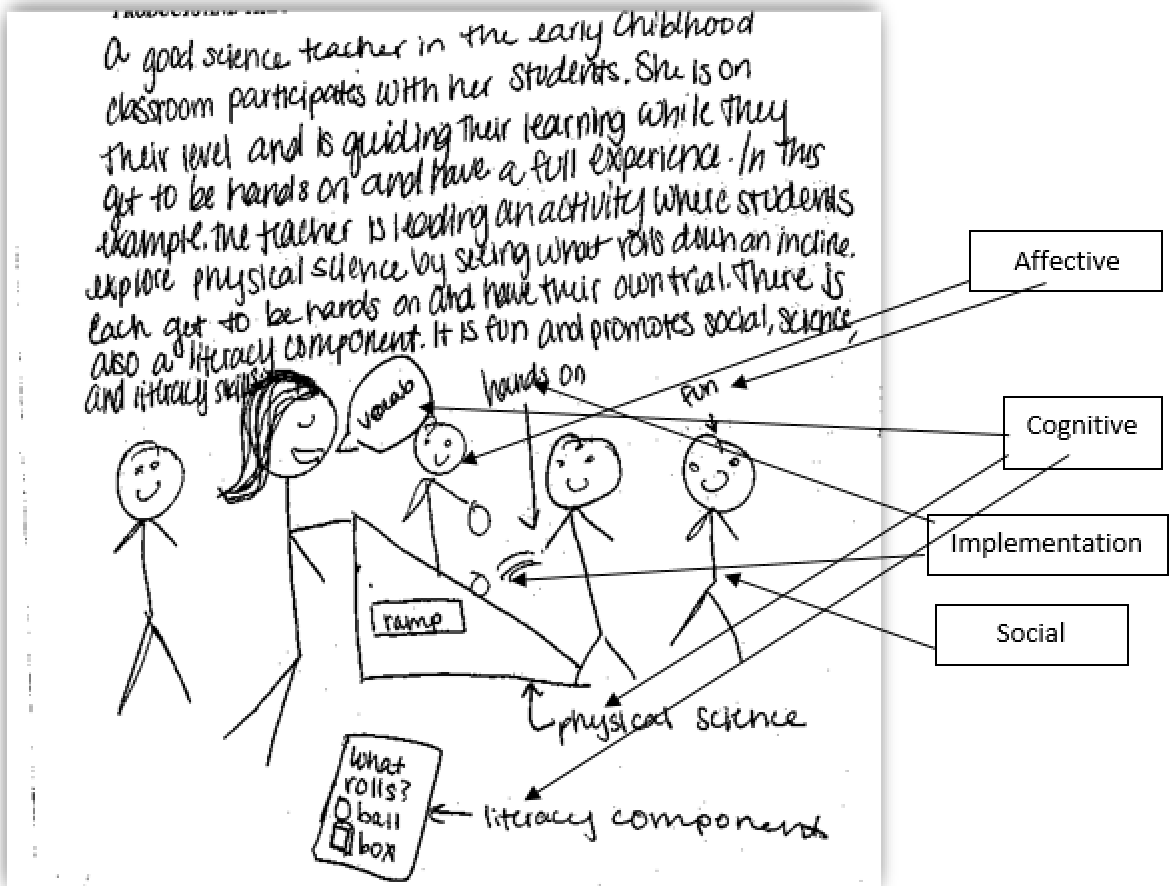


Figure 16. An example of the highest score of a participant's drawing of conceptions of science instruction.

Participants' Conceptions of Science Instruction: Narratives

The analysis of participants' narratives revealed that eight conceptions of science instruction for teaching children in pre-K to 3rd grade classrooms were prevalent among participants in this study. These conceptions included:

1. Science instruction as teachers demonstrating science concepts (*Demonstration 61%*)
   1.1 Science instruction as a demonstration (Passive Learning 40%)
      - Demonstration

- Demonstration + Explaining
- Demonstration + Enjoyment
- Demonstration + Observation
- Demonstration + Safety
- Demonstration + Safety + Enjoyment
- Demonstration + Experiment + Engagement

1.2 Science instruction as a demonstration (Active Learning 21%)

- Demonstrations + Inquiry
- Demonstrations + Engagement
- Demonstrations + Engagement + Interaction
- Demonstrations + Engagement + Inquiry
- Demonstrations + Inquiry + Safety
- Demonstrations + Inquiry + Engagement
- Demonstrations + Inquiry + Observation
- Demonstrations + Inquiry + Experiment + Engagement + Enjoyment
- Demonstrations + Observation + Inquiry
- Demonstrations + Observation + Experiment + Interaction + Safety
- Demonstrations + Experiment + Enjoyment + Inquiry
- Demonstrations + Enjoyment + Experiment

2. Science instruction as making the lesson engaging (Engagement 9%)

2.1 Science instruction as making the lesson engaging (Active Learning 7%)

- Engagement + Inquiry
- Engagement + Inquiry + Interaction
- Engagement + Inquiry + Safety
- Engagement + Inquiry + Experiment
- Engagement + Inquiry + Experiment +Interaction
- Engagement + Inquiry + Enjoyment +Experiment

2.2 Science instruction as making the lesson engaging *(Passive Learning 2%)*

- Engagement
- Engagement + Interaction + Enjoyment

3. Science instruction as teachers and students engaging in science experiments (*Experiment 9%*) (*Active Learning*)
    - Experiment + Demonstration + Safety
    - Experiment + Inquiry
    - Experiment + Inquiry + Interaction + Engagement
    - Experiment + Inquiry + Observation + Interaction + Engagement
    - Experiment + Inquiry + Engagement + Enjoyment
    - Experiment + Inquiry + Interaction + Observations
    - Experiment + Observation
4. Science instruction as implementing science safety guidelines *(Safety 8%) (Active Learning)*
    - Safety
    - Safety + Demonstrations
    - Safety + Demonstration +Enjoyment
    - Safety + Enjoyment + Interaction
    - Safety + Experiment + Interaction + Engagement
    - Safety + Interaction
    - Safety + Interaction + Demonstration + Enjoyment
5. Science instruction as being inquiry-based *(Inquiry 8%) (Active Learning)*
    - Inquiry
    - Inquiry + Engagement
    - Inquiry + Enjoyment
6. Science instruction as students observing scientific phenomena *(Observations 2%) (Active Learning)*
    - Observations
    - Observation + Demonstration + Experiment + Engagement
7. Science instruction as making the lesson joyful (*Enjoyment 2%) (Passive Learning)*
    - Enjoyment + Experiment
    - Enjoyment + Safety + Observation
8. Science instruction as students interacting with one another and/or with the teacher in science activities (*Interaction 1%*) (*Active Learning*)
    - Interaction + Demonstrations

For clarity, I next define the key constructs, *Demonstration*, *Engagement*, *Inquiry*, etc. inherent in each of the eight conceptions of science instruction. *Demonstration*, according to participants, is an activity to passively and/or actively show science concepts/principles to students. *Engagement,* according to participants, is an effective way to show teacher enthusiasm, spark students' interest, and initiate scientific inquiry, and to get students to be involved with science concepts/principles. The term e*ngagement* also refers to the degree of attention, curiosity, interest, optimism, and passion that students show when they are learning or being taught science. *Experiment*, according to participants, involves an experimental set-up where their students, and they themselves are engaged in scientific practices for doing science. *Safety*, according to participants is the notion of modeling and instilling the skills and knowledge of science safety to students. *Inquiry*, according to participants, is a strategy whereby students and participants become engaged in cognitive and procedural activities. Cognitive activities involved students' problem-solving through the construction of questions, hypothesis testing, and formulation of solutions/tentative answers for scientific phenomena. Procedural activities involved students' engaging in experiments, and collecting and analyzing data to provide evidence for or against their hypotheses. *Observation,* according to participants, involved providing their students with scientific practices and tools to closely examine scientific phenomena. *Enjoyment* according to participants, is the notion of using fun, the "wow" factor, and interest to encourage the learning of science content. *Interaction*, according to participants is teachers' getting their students and themselves involved in learning science concepts/principles through teacher-students participation structures and through group work. In the following sections, a detailed account of each conception of science instruction is presented.

Demonstrations

Analysis of participants' narratives indicated that science instruction as demonstrations predominantly involved participants' engaging in a number of actions leading to students' passive learning of science content (40 out of 61 = 66%), and to students' active learning of science content (21 out of 61 = 34%) respectively (see Table 4). Table 4 details the numbers and percentages of participants' conceptions of science instruction as demonstrations for passive learning and for active learning and includes the demonstrations associated with other conceptions such as, *Enjoyment*, *Interaction*, *Inquiry*, *Experiment*, and *Safety*. Figure 17 and Figure 18 are pie-charts that illustrate the percentages of participants' conceptions of science instruction as a demonstration, underscored by students' passive learning and underscored by students' active learning, respectively.

Table 4

Numbers and Percentages of Participants' Conceptions Science Instruction as Demonstrations for Passive Learning and for Active Learning

		N	%
	Science instruction as a demonstration (Passive Learning)		
1.	Demonstration	15	
2.	Demonstration + Explaining	8	
3.	Demonstration + Enjoyment	6	
4.	Demonstration + Observation	4	
5.	(i) Demonstration + Safety	4	
(ii) Demonstration + Safety + Enjoyment		2	
6.	Demonstration + Experiment + Engagement	1	
Total		40	66

	N	%
Science instruction as a demonstration (*Active Learning*)		
1. (i) Demonstrations + Inquiry	6	
(ii)Demonstrations + Inquiry + Safety	2	
(iii)Demonstrations + Inquiry + Engagement	1	
(iv) Demonstrations + Inquiry + Observation	1	
(v)Demonstrations + Inquiry + Experiment + Engagement + Enjoyment	1	
2. (i) Demonstrations + Engagement	3	
(ii) Demonstrations + Engagement + Interaction	1	
(iii) Demonstrations + Engagement + Inquiry	2	
3. (i) Demonstrations + Observation + Inquiry	1	
(ii)Demonstrations + Observation + Experiment + Interaction + Safety	1	
4. Demonstrations + Experiment + Enjoyment + Inquiry	1	
5. Demonstrations + Enjoyment + Experiment	1	
Total	21	34

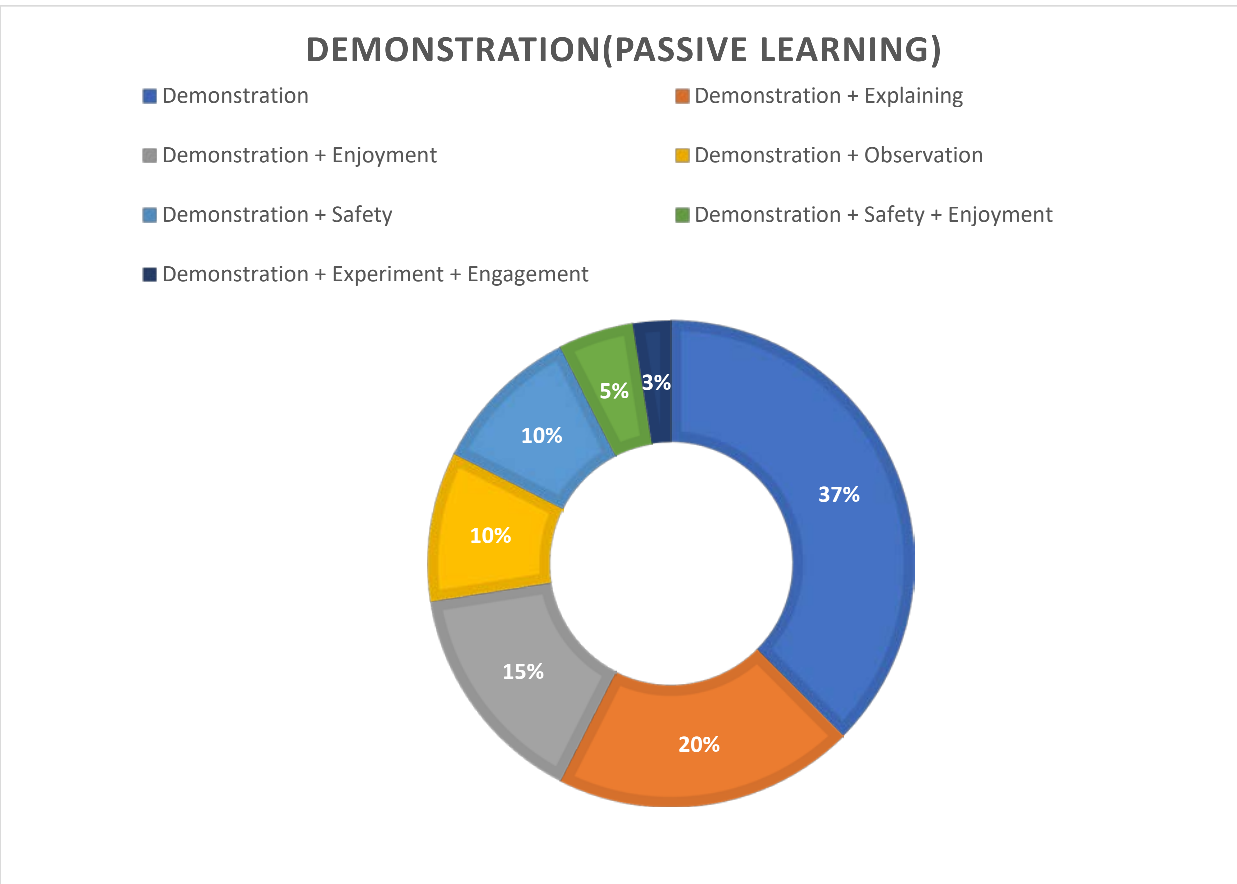


Figure 17. The diagram indicates the percentages of participants' narrative conception of science instruction as a type of demonstration (passive learning).

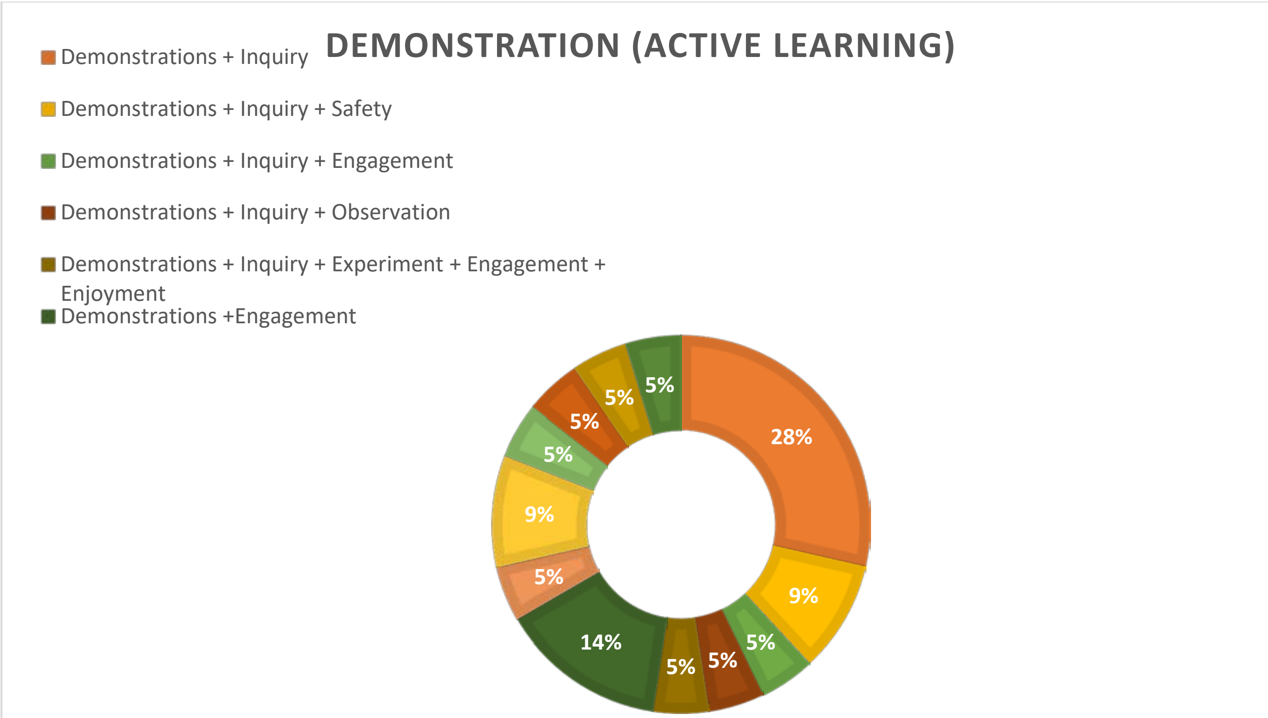


Figure 18. The diagram indicates number of percentages of participants' narrative conception of science instruction as a type of demonstration (active learning).

Analysis of data indicated that participants who conceptualized teaching as using demonstrations for passive learning of science content used posters, drawings, diagrams, models, textbooks, pictures, etc., to convey the science content to their students. Table 5 provides excerpts from participants' narratives that provide evidence of participants' conceptions of science instruction as demonstrations for passive learning of science content.

Table 5

Examples of Participants' Conceptions of Science Instruction as Demonstrations for Passive Learning

Participant	Demonstrations	Science Content
Susan	Here you can see the teacher teaching about our solar system. She has put the planets in order from closest to farthest from the sun. Once this is done she explains how the planets orbit the sun and this is due to the suns gravitational pull on the planets. Afterwards she tells the students the differences between the planets' orbit and how different	Solar System

Participant	Demonstrations	Science Content
	they are. In the end the students should understand all of the different components of our solar system.	
	Demonstrations + Explaining	
Olive	This teacher is presenting/introducing the water cycle to her class. She defines the terms “evaporation”, “condensation”, and, “precipitation”, to her students and provides visuals to help explain better. This “water cycle” flow chart is drawn on a white board and has the terms written on the side, using arrows to show the steps and flow of the cycle. At first she draws the cycle and has students describe what they see. Then she goes into details and explains what is actually happening.	Water Cycle
	Demonstrations + Enjoyment	
Vivian	Mr. Wright is teaching second graders about the scientific method. The children are sitting at the science lab tables and listening quietly. Mr. Wright is going over the steps of the scientific method while the children quietly repeat after him. The children are having fun while Mr. Wright is teaching. Mr. Wright is enjoying teaching.	Science Process Skills
Joy	This is a kindergarten science class. The teacher is demonstrating the growth cycle of a bean plant. The teacher has brought in all of the necessary supplies: dirt, water, seeds, and containers. The process is demonstrated step by step. The children observe the results of the processes	Life Cycle (Plants)
	Demonstration + Safety	
Ruth	Children are learning about the life cycle of a plant and how it utilizes the process of photosynthesis. The teacher utilizes flowers and add dirt to the soil to demonstrate how water is absorbed through the roots. She wears safety equipment to teach early on safety guidelines. She engages the children by allowing them to water the plants. She speaks throughout the whole process explaining everything.	Photosynthesis Life Cycle (Plant)
	Demonstration + Safety+ Enjoyment	
Eliza	The science teacher has a demonstration after a full day of teaching about volcanoes to give kids a visual of how volcano’s work. She follows all safety guidelines and her kids stay in seats. She has them stay behind the safety lines and wear safety goggles. She has them wear gloves and lab coat to show safety. All kids love it but some are lost but are intrigued.	Volcanoes
	Demonstration + Experiment + Engagement	
Piper	The teacher I have drawn is instructing the class on how to conduct an experiment with non-newtonian fluid. To create the fluid, she has added one part water to two parts corn start. Once the fluid is made she will pass it around to the students and have them touch it. First they will try punching the fluid with force and it will remain a solid. Then they will gently push their fingers into it and it seems as if it is a liquid. The teacher will then explain why the fluid does this.	States of Matter

As evident from the data, participants' demonstrations for passive learning of science content included:

1. Only demonstrations that were used by participants to show science content to their students. Participants who conceptualized science instruction as only demonstrations just showed the science content to their students using posters, textbooks, chalkboard, scientific models, pictures, etc. to convey the science content to their students. Within these participant narratives, students did not interact with their peers and teachers but were required only to listen and pay attention to the participants and the science content that was showcased through the demonstrations.

2. Demonstrations used by participants to show science content with participants explaining the science content to their students using the demonstrations. Within these narratives, participants specifically used posters, textbooks, chalkboard, scientific models, pictures, etc. but used the aforementioned to explain the science content to their students. Thus, this was different from the conception of science instruction as only demonstrations wherein participants just showed the science content but without a component of teacher explanation.

3. Demonstrations that showed science content for the underlying purpose of student enjoyment. Within these narratives, participants' mentioned how they used a drawing, a poster, and procedural steps but connected these uses with students' enjoyment instead of students' learning of science content. The use of demonstrations created learning environments that were fun.

4. Demonstrations used by participants to show science content that specifically made

provisions for students' observation of scientific phenomena. Within these narratives, participants' mentioned that students had the opportunity to observe scientific activities with a teacher explanation component.

5. Demonstrations used by participants (i) to model science safety to students, and (ii) to model science safety to students for the underlying purpose of students' enjoyment. Within these narratives, participants' mentioned the wearing of googles and lab coats to demonstrate the issue of school science safety. In addition, the goal was also to socialize students in to school science safety. In some cases an added conception of enjoyment was added to make the socialization fun for the students.

6. Demonstrations used by participants that led to students doing an experiment with student engagement. Within these narratives, participants' mentioned how to conduct an experiment and how the experiment would keep students interested and focused on the science content that the experiment was demonstrating.

Analysis of data indicated that participants who conceptualized teaching as using demonstrations for active learning of science content also used posters, drawing, diagrams, models, textbooks, pictures, etc., to convey the science content to their students. This conceptualization was different from that of demonstrations as passive learning of science content because active learning involved students being cognitively engaged with the demonstrations (see Table 6).

Table 6

Examples of Participants' Science Instruction as Demonstrations for Active Learning

Participant	Demonstrations	Science Content
	Demonstrations + Inquiry	
Leah	The teacher is demonstrating a simple baking soda & vinegar & is using parent volunteers to help each group of kids participate hands on. Students would have gloves & cover ups when participating & record information in prepared lab manuals to teach the scientific process.	Chemical Reaction
	Demonstration + Inquiry + Safety	
Ada	Because this is a science class in an early childhood classroom, teacher is teaching the simple daily things in class. Such as leaves or flowers. This class can be outside the classroom, such as in the playground or garden, to show the students actual plants and also can ask the students to find and name the plants themselves. The class should be in school to make sure students are safe.	Plants
	Demonstration + Inquiry + Engagement	
Talia	A teacher showing her students how to melt chocolate naturally. The piece of chocolate is solid at the table. She takes the chocolate outside, and she uses a stopwatch to see how long it takes for the sun to melt it. When the chocolate is fully melted, she takes it inside and the students are able to identify how long it took to melt. She then lets the students have their own chocolate and allows them to eat it.	States of Matter
	Demonstrations + Engagement + Interaction	
Zoe	The teacher in my drawing is holding a test tube with some vinegar in it. In her lesson she is teaching she wants to teach her students the difference between a beakers, test tube graduated cylinder, etc. There are various liquids inside the tubes. She wants the students to communicate the differences/compare/contrast all of the liquids. She tells the students what is in each glass tube. The students have to work in groups.	Science Process Skills
	Demonstrations + Engagement + Inquiry	
Remi	The teacher will let students hold equipment if appropriate for their age. Science should be a hands-on subject especially for grades 1-3. The teacher should explain what each instrument does and let the child hold it themselves. Teacher should allow students to ask questions about the topic they are learning. Teacher should address each question that the students ask.	Science Process Skills
	Demonstration + Inquiry + Observation	
Paris	In this drawing, the teacher is teaching about the rock cycle. She has 3 different types of rocks as well as a diagram of the cycle. She is going to pass around the rocks, so the students can observe the differences of the rocks. She then will describe the rock cycle. The students will also have the rock cycle diagram to look at.	Rock Cycle

Participant	Demonstrations	Science Content
Demonstration + Inquiry + Experiment + Engagement + Enjoyment		
Elena	The teacher is teaching the students about photosynthesis w/a presentation and hands on experiments. By having a presentation and a hands-on activity it allows the students to be involved and have fun while learning	Photosynthesis
Demonstration + Observation + Inquiry		
Josie	One product used is a microscope to observe a bug on a flower. Another is a pen and paper to draw an observation. The teacher is explaining how a bird lives in the tree. The students observe how the sun provides life. Students and teacher are exploring different bugs and how they connect with everything around them.	Environmental Science
Demonstration + Observation + Experiment + Interaction + Safety		
Layla	The teacher is standing at the table as she demonstrates how to use a graduated cylinder, a scale and a test tube as the students are watching. The tube actually has a substance in it and the teacher is demonstrating an experiment. The board has some of the rules that the students should follow and know when participating in an experiment.	Science Process Skills
Demonstration + Experiment + Enjoyment + Inquiry		
Hope	I drew a teacher showing her students a science experiment. The students I drew look happy. I drew one student looking shocked because the experiment is really cool. The teacher is doing an experiment because science should be hands on. The kids love this rather than reading.	No identifiable science content
Demonstrations + Enjoyment + Experiment		
Rose	The teacher is acting as a scientist in a science lesson. As a class everyone is going through and learning the scientific method as they conduct an experiment. In the picture they are finishing the experiment and the children are engaged and excited and amazed at what is happening.	Science Process Skills

Participants' demonstrations for active learning of science content included five variations each centered on demonstrations.

1. In most cases, demonstrations were paired up with inquiry (13/21), and in these cases demonstrations were used by participants to show science content that then led to students being engaged with an inquiry activity using the science content from the demonstration. Variations of this conception included these conceptions also associated with safety, engagement, observation, experiment, and enjoyment.

2. Demonstrations used by participants to actively engage students with science also included demonstrations that were associated with the conception of engagement, interaction, and inquiry. Demonstrations used by participants to actively engage students with science through inquiry involved getting students interested in the science content first; this was then followed by students' being engaged in cognitive and procedural activities.

3. Apart from the demonstration and inquiry there were two variations whereby demonstrations were paired with observations: in one of these demonstrations were paired-with observations leading to an inquiry activity while the other was followed up with an experiment that included interaction and science safety activities.

4. Demonstrations used by participants were followed up by an experiment underscored by the conception of enjoyment, and this finally led to an inquiry activity.

5. Demonstrations used by participants and underscored by the conception of enjoyment included a student led experiment.

Engagement

For participants in this study, the conception of science instruction as engagement also took on an active and a passive learning component. Analysis of data revealed that for one participant the conception of science instruction as engagement as passive learning involved the conception of simply getting their students interested and motivated towards learning the science content using a teacher-centered activity. For this participant, the conception of science instruction as engagement did not include other conceptions like inquiry, interaction, etc. Table 7 details the numbers and percentages of types of participants 'conceptions of science instruction as engagement.

Table 7

Numbers and Percentages of Participants' Conceptions of Science Instruction as Engagement

Science instruction as engagement	N	%
Engagement (Passive learning)	1	
Engagement + Inquiry	2	
Engagement + Inquiry + Interaction	1	
Engagement + Inquiry + Safety	1	
Engagement + Inquiry + Experiment	1	
Engagement + Inquiry + Experiment +Interaction	1	
Engagement + Inquiry + Enjoyment +Experiment	1	
Engagement + Interaction + Enjoyment (Passive learning)	1	
Total	9	9%

Seven out of the nine participants included the conception of inquiry within their conception of science instruction as engagement. That is, engagement was integrated with both cognitive and procedural activities which led to either interaction, science safety, an experiment, an experiment and interaction or activity underscored by enjoyment but including an experiment component. Figure 19 presents a pie-chart that illustrates the variations and percentage of participants' narrative conceptions of science instruction as engagement. Table 8 provides excerpts from participants' narratives that were predominantly associated with the conception of science instruction as engagement.

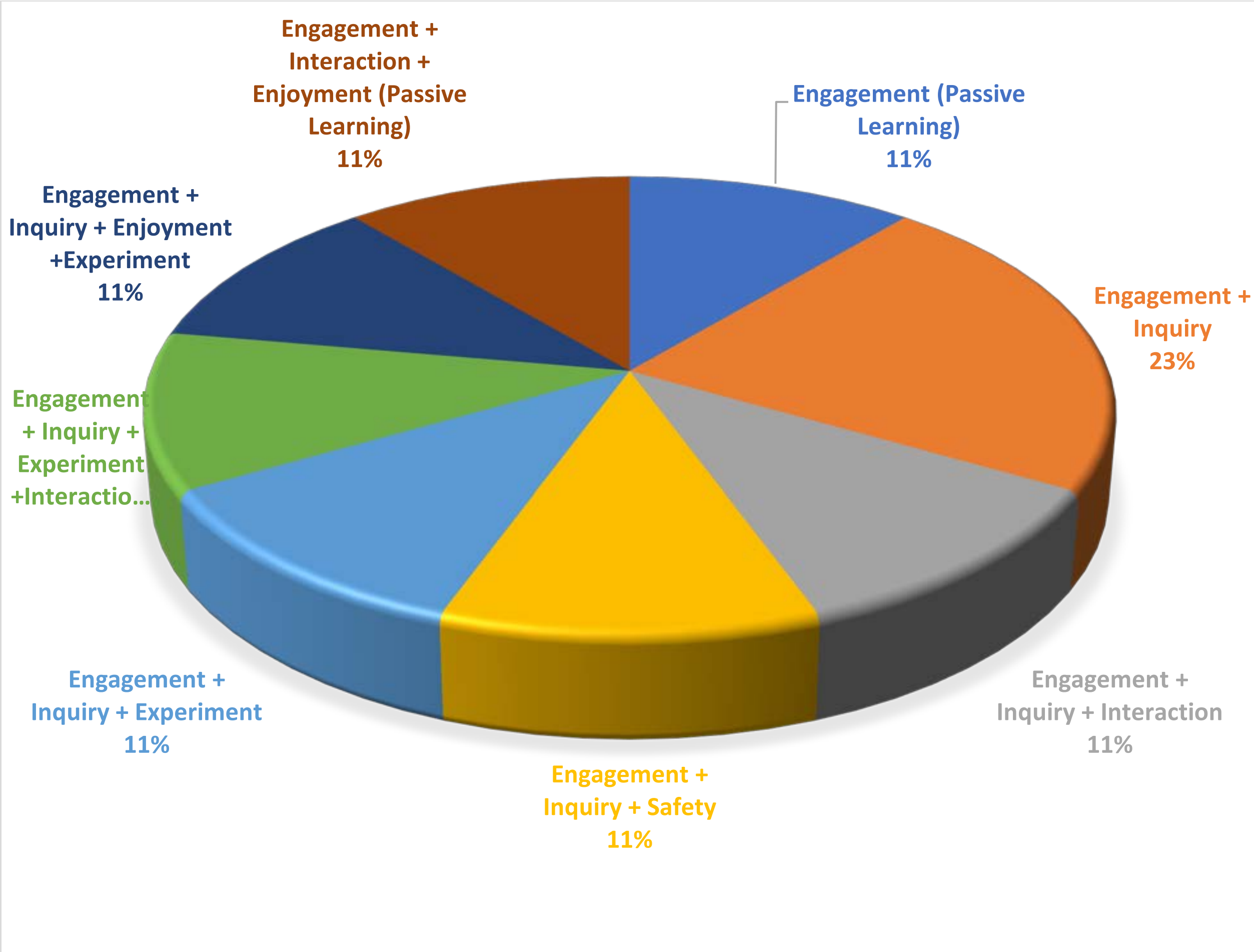


Figure 19. Diagram of the percentages of participants' narrative conceptions science instruction as *engagement* (active learning).

Table 8

Excerpts from Participants' Narratives that were Predominantly Associated with the Conception of Science Instruction as Engagement

Participants		Science Content
	Engagement (Passive Learning)	
Ellie	I would give each child a flower pot, seeds and potting soil. We would plant the seeds ad begin watering them and exposing them to sunlight. I would explain to the students the process of photosynthesis and why the plants are growing in terms that a 3rd grader would understand. I would test their knowledge of the process. I would send the plants home with the students along	Photosynthesis

Participants		Science Content
	with the information on what we have learned about photosynthesis.	
	Engagement + Inquiry	
Ava	The teacher is walking around as students are engaged in activities. She is facilitating learning. In a science classroom, I anticipate it being very hands-on. I want children to touch things, explore, ask questions, think about things, and much more. I envision the science classroom as a place where children can explore our world.	Science Process Skills
	Engagement + Inquiry + Interaction	
Zoey	There is a science sensory/hands on center in the classroom. Teacher lets the children explore/lead. There is more action learning than lecture learning. Teacher is doing hands on science activities with the children. Teacher follows and integrates science TEKS in the Kindergarten classroom.	Science Process Skills
	Engagement + Inquiry + Safety	
Stella	This teacher as scientist is allowing the students to learn in hands on ways outdoors. Getting the children up and moving engages the students. In this picture, the students are learning about life cycles such as that of a butterfly. They see where a caterpillar may live, what it eats and will get to watch it go through its cycle throughout the weeks (the teacher will have a safe place for them to grow). Once is has reached its final stage, the children get to release the now butterflies.	Life Cycle (Animals)
	Engagement + Inquiry + Experiment	
Luna	The teacher is teaching a science lesson and the students have supplies on their desks. Science is very hands on so rather than just showing, the teacher is letting the students do the experiment alongside the teacher.	No identifiable Science Content
	Engagement + Inquiry + Experiment + Interaction	
Alice	A science teacher should facilitate an active learning environment. Allowing hands on learning over a traditional lecture. The teacher should teach thru experimentation and allow students to make assumptions they can test. The classroom should be inviting so all students can get involved. Students should also have the options to work in a group or individually	No identifiable Science Content
	Engagement + Inquiry + Enjoyment + Experiment Content	
Iris	A good science teacher in the early childhood classroom participates with her students. She is on their level and is	Physical Science (Simple Machines)

Participants		Science Content
	guiding their learning while they get to be hands on and have a full experience. In this example, the teacher us leading an activity where students explore physical science by seeing what rolls sown an incline. Each get to be hands on and have their own trial. There is also a literacy component. It is fun and promotes social science, and literacy skills.	
	Engagement + Interaction + Enjoyment (Passive Learning)	
Mila	This is a teacher teaching her students environmental science. Her kids are sitting on the rug while learning about recycling. The teacher is normally dressed. She will give them an interactive assignment. The kids will find it fun.	Environmental Science

For these four participants, teacher-centered activities involved and connected students with the science content through inquiry activities such as, “touching things, exploring, asking questions, thinking about things,” “exploring/leading,” “learning,” and making “assumptions they can test.” Apart from the conceptions of engagement and inquiry, some participants connected the aforementioned conceptions with conceptions like interaction, safety, experiment, and experiment and interaction. For example, Zoey’s narrative indicated that she connected the conceptions of engagement and inquiry with the conception of interaction - “The teacher is doing hands on science activities with the children” while Stella connected conceptions of engagement and inquiry with the conception of safety – “…the teacher will have a safe place for them to grow.” For Luna, the conception of science instruction as engagement and inquiry was connected with the conception of experiment – “the teacher is letting the students do the experiment alongside the teacher.” For Alice, conceptions of engagement and inquiry were connected the with conception of experiment “ … the teacher should teach through experimentation” - and with the conception of interaction – “ Students should also have the options to work in a group or individually.” Lastly, among the nine participants, only

Mila, who also centered her conception of science instruction as engagement, made a connection with the conceptions of interaction and enjoyment. For Mila interaction was her use of an “interactive assignment” which together with engagement let the students in her class have “fun.”

Experiment

Analysis of narrative data indicated that for those participants who conceptualized science instruction as doing experiments, the conception of doing an experiment was associated predominantly with the conception of inquiry and to a lesser extent with the conceptions of demonstration and observation (see Table 9).

Table 9

Number of Participants’ Narrative Conceptions of Science Instruction as Experiment (involving Active Learning)

Science instruction as experiment	N	%
Experiment + Demonstration + Safety	1	
Experiment + Inquiry	1	
Experiment + Inquiry + Interaction + Engagement	1	
Experiment + Inquiry + Observation + Interaction + Engagement	1	
Experiment + Inquiry + Engagement + Enjoyment	1	
Experiment + Inquiry + Interaction + Observations	1	
Experiment + Observation	3	
Total	9	9

As is evident from Table 9, one variation of science instruction as doing experiments was associated with the conception of demonstration and safety. Science instruction as doing experiments was also associated with the conception of inquiry, and included the conceptions of experiments and inquiry with (a) the conceptions of interaction and engagement, (b) the conceptions of observation, interaction, and engagement, (c) the conceptions of observation, engagement, and enjoyment, and (d) the conceptions of interaction and observations. Lastly, science instruction as doing experiments was associated with the conception of demonstration.

Figure 20 presents a pie-chart that illustrates the variations and percentages of participants' narrative conception of science instruction as Experiment. Table 10 provides excerpts from participants' narratives that were predominantly associated with the conception of science instruction as experiment.

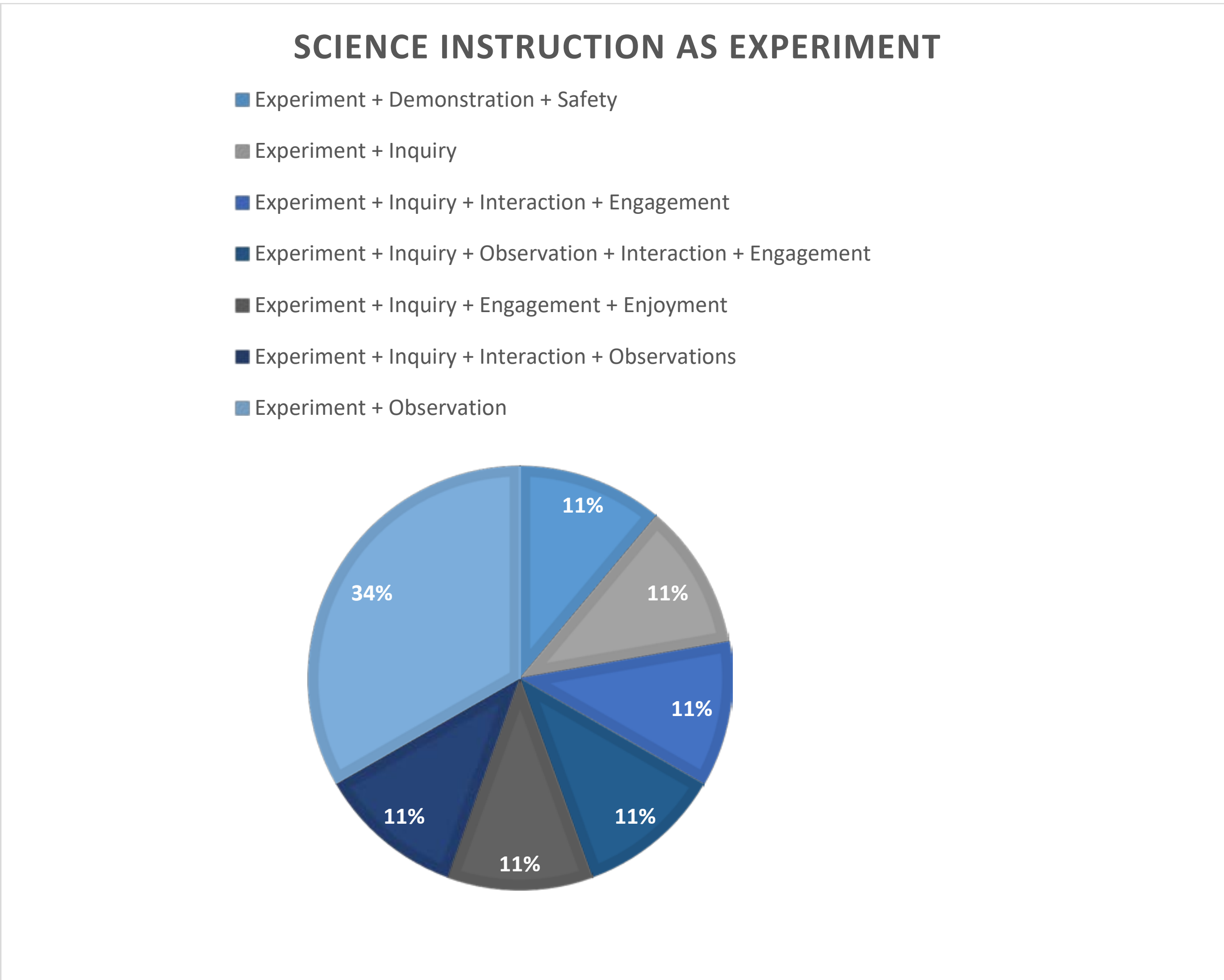


Figure 20. Diagram of the percentages of participants' narrative conceptions of science instruction as experiment (in active learning).

Table 10

Participants' Narratives Indicating Conceptions of Science Instruction as Experiment (in Active Learning)

Participants		Science Content
Experiment + Demonstration + Safety		
Ember	Mrs. Sunshine is teaching the kids a new scientist experiment on science Monday. Last week the students learned about the reaction between Baking soda and vinegar. Mrs. Sunshine wanted to keep the same theme going. Mrs. Sunshine decided to show these kids the reaction between dry ice and water. Following all safety rules she was able to successfully complete the experiment.	Chemical Reaction
Experiment + Inquiry		
Tessa	The teacher is going to allow the students to experiment in the classroom. Students will share a variety of different objects. They will test to see which sink and which float.	Sink and Float
Experiment + Inquiry + Interaction + Engagement + Enjoyment		
Melody	The scientist is professionally dressed. They are doing an experiment for the classroom It is exciting experiment to entice the kids. They are happy because they are having fun. It is a student-centered activity.	No Identifiable Science Content
Experiment + Inquiry + Observation + Interaction + Engagement		
Ruby	In both pictures, students are learning about and exploring measurements of liquids. They are given the opportunity to observe the teacher, discuss and ask questions. They are also given the opportunity to explore hands-on by measuring on their own while the teacher observes/assists as needed. They are measuring using beakers and graduated cylinders. This is a more interactive, hands-on science lesson.	Science Process Skills
Experiment + Inquiry + Engagement + Enjoyment		
Ariel	In the drawing, a student is pouring a liquid into a petri dish. The other students are then creating a hypothesis based on the experiment. The teacher is observing the children conducting the experiment and guiding them. The teacher is there to help the kids have a fun and safe time.	Science Process Skills
Experiment + Inquiry + Interaction + Observations		
Freya	In this classroom, the students are conducting a hands-on lab where each day they get to observe the life cycle of a butterfly. They work in groups of 2-3 to decrease the number of insects needed as well as establish teamwork. Needed for the laboratory is a certain number of butterflies, plants, and insect cages and food for the animal to survive. Objects for learning, release them, and observe in their natural habitat. During the study, students will write down their observations and thoughts.	Life Cycle (Animals)

Participants		Science Content
Experiment + Observation		
Nicole	In a classroom with such young learners, I decided to pick a science experiment that they would understand. The process involves 3 white flowers (of any kind), 3 vases, and 3 food coloring of your choosing. To complete this experiment, you would cut the bottom of the stem of each rose and place them into vases with water that has been dyed. As the water moves up the rose, the students can see where it travels. This activity allows students to see how water travels up plants and almost “defies gravity”.	Transpiration

In most of these five narratives, the experiment was underscored by a science content and the inquiry activity involved students engaged in a minds-on activity - “doing”, “discussing and asking questions, “ “measuring”, “creating a hypothesis,” “conducting a hands-on lab” and writing down “observations and thoughts.” Apart from this, participants like Melody mentioned that her students would interact and engage with the content through a student-centered activity, while Ruby included the conceptions of observation, interaction, and engagement whereby her students observed their teacher modeling the science content and then interacted and engaged with the science content and herself as the teacher – “They are also given the opportunity to explore hands-on by measuring on their own while the teacher observes/assists as needed. They are measuring using beakers and graduated cylinders. This is a more interactive, hands-on science lesson.” For Ariel, the conceptions of experiment and inquiry were connected more with the conceptions of engagement – “…a student is pouring a liquid into a petri dish … students are then creating a hypothesis based on the experiment” – and enjoyment – “kids have a fun and safe time.” For Freya, the conceptions of experiment and inquiry were connected more with the conceptions of interaction – “They work in groups of 2-3 to decrease the number of insects needed as well as establish teamwork” – and observation “ …

observe in their natural habitat. During the study, students will write down their observations and thoughts."

Among the participants who showed conceptions of science instruction as doing experiments, there was one participant, Ember, for whom the conception of experiment was more clearly one of her doing the experiment to show the idea of a chemical reaction and keeping students aware of the safety rules for that particular experiment. Lastly, three participants, Hazel, Diana, and Nicole conceptualized science instruction as themselves doing experiments – "science experiment," "For the experiment, the teacher puts the plant near the window" and "I decided to pick a science experiment … "…with their students observing the experiments and learning the science content from noticing, "watching", and seeing the experiment.

Safety

Analysis of narrative data indicated that for those participants who conceptualized science instruction as implementing science safety guidelines, the conception of implementing science safety was predominantly associated with the conception of demonstrations, and the conception of demonstration led to students' enjoyment in science safety activities. The conceptions of implementing science safety was associated with the conception of enjoyment, experiment, and interaction (See Table 11). Figure 21 presents a pie-chart that illustrates the variations and percentage of participants' narrative conception of science instruction as Implementing Science Safety Guidelines. Table 12 provides excerpts from participants' narratives that were predominantly associated with the conception of science instruction as Implementing Science Safety Guidelines (active learning).

Table 11

Number of Participants' Narrative Conceptions of Science Instruction as Implementing Science Safety Guidelines (Active Learning)

Science instruction as implementing science safety guidelines (*Safety*)	N	%
Safety	2	
Safety + Demonstrations	1	
Safety + Demonstration +Enjoyment	1	
Safety + Enjoyment + Interaction	1	
Safety + Experiment + Interaction + Engagement	1	
Safety + Interaction	1	
Safety + Interaction + Demonstration + Enjoyment	1	
Total	8	8

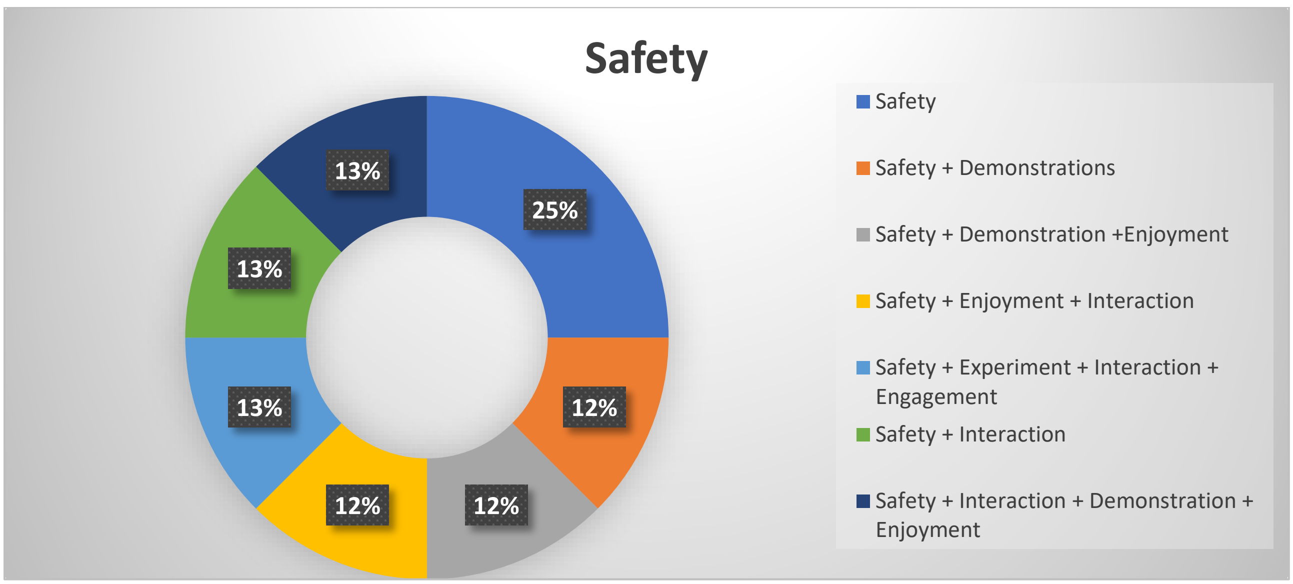


Figure 21. Diagram of the percentages of participants' narrative demonstrating conceptions of science instruction as implementing science safety guidelines (in active learning).

Table 12

Participants' Narratives Indicating Conceptions of Science Instruction as Implementing Science Safety Guidelines (in Active Learning)

Participants		**Science Content**
	Safety	
Sadie	The teacher is teaching the life cycle in a 1st grade classroom. She is wearing goggles because it is important to be safe during labs. I	Life Cycles

Participants		Science Content
	interned in a 1st grade class one year and I remember them learning about life cycles.	
	Safety + Demonstration	
Lucia	Drew the scientist with a lab coat and play glasses for the kids. Put a warning sign for the younger children to be able to see. He is in the middle of the classroom when he introduces the class to him. There are photos behind him to show the class what they will be doing today.	No identifiable Science Content
	Safety + Demonstration +Enjoyment	
Thea	A teacher is wearing goggles and a lab coat. She is holding up a beaker, showing a chemical reaction. In the other hand, she is displaying pictures of leaves. She is very happy. The children are excited too.	Chemical reaction
	Safety + Enjoyment + Interaction	
Violet	The teacher is making sure that the students are learning in a safe environment, and making their learning fun and enjoyable. Having hands on activities and lessons allow for the student to retain the information that the teacher is wanting the students to know. A good science teacher makes it very fun and informative!	No identifiable Science Content
	Safety + Experiment + Interaction + Engagement	
Sophia	The teacher and students are in lab coats and safety goggles to follow safety procedures during the experiment. The teacher is allowing the students to interact with the baking soda volcano. She has allowed one students to put the baking soda in the volcano, then she allowed the other student to put in the vinegar. By allowing the students to interact with the experiment, she is encouraging them to actively learn in class. She also had the girls put their hair up to promote proper safety practices.	Chemical reaction
	Safety + Interaction	
Cali	The teacher and students wear googles and lab coat. The students are sitting at tables big enough to work safely. On the tables are work stations for the students.	No identifiable Science Content
	Safety + Interaction + Demonstration + Enjoyment	
Aria	The teacher is wear a short sleeve lab coat. The kids are playing with lab equipment. The teacher is describing to the class how to use a graduated cylinder. The kids have to wear closed toe shoes. She is keeping the kids interested in the lesson.	No identifiable Science Content

For participants in this study, the conception of science instruction as implementing safety in the pre-K to-3rd grade classroom was centered on both the participants and their students following safety rules/procedures. These safety rules predominantly included both participants and students wearing lab coats and googles, and to a lesser extent having "girls put their hair up to promote proper safety practices," or having kids "wear closed toe shoes" or having a "safe environment."

Inquiry

Analysis of narrative data indicated that for those participants who conceptualized of science instruction as being inquiry-based, participants' narratives conceptualizations of science instruction as being inquiry were predominantly associated with the conception of *engagement and enjoyment* (see Table 13). Table 13 indicates that participants' narratives conceptions of science instruction as being inquiry-based were predominantly associated with the conception of engagement, and the conception of enjoyment. Figure 22 presents a pie-chart that illustrates the variations and percentages of participants' narrative conceptions of science instruction as being inquiry-based. Table 14 provides excerpts from participants' narratives that predominantly indicated conceptualizations of science instruction as being inquiry based.

Table 13

Number of Participants' Narrative Conceptions of Science Instruction as Being Inquiry-Based (Inquiry) (in Active Learning)

Science instruction as being inquiry-based (Inquiry)	N	%
Inquiry	5	
Inquiry + Engagement	2	
Inquiry + Enjoyment	1	
Total	8	8

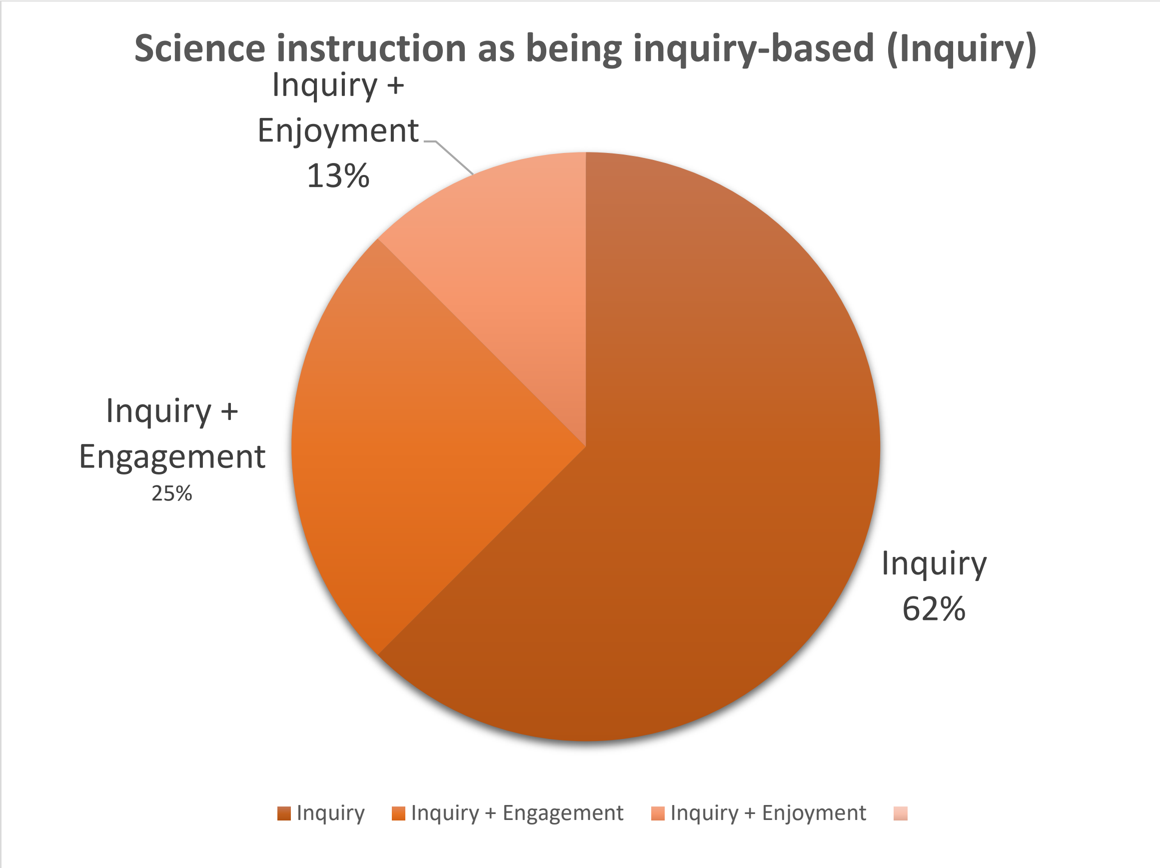


Figure 22. Diagram of the percentages of participants' narrative conceptions of science instruction as being inquiry-based (*Inquiry*) (in active learning).

Table 14

Excerpts from Participants' Narratives Conceptions of Science Instruction as Being Inquiry Based (Inquiry)

Participant		Science Content
	Inquiry	
Grace	When I think of scientist in an early childhood classroom, I think about how my teachers incorporated the outdoors. We learned about growing plants and used aprons and watering cans when we worked with the plants.	Growth (Plants)
Kate	The drawing show 3 different soils, one is just dirt, the other has a little flower, and the third one has a couple of flowers grew in there. They are all in one table so the students can move around and take a look at them. The activity is hand-on because early-childhood students tend to learn better this way. The teacher is asking question to activate their critical thinking. They are in	Life Cycle (Plants)

Participant		Science Content
	groups because if someone does doesn't understand, or the teacher instruction are not clear to them, they can always turn to a classmate who can help.	
Vera	The teacher is teaching the class the life cycle of plants. A student is raising his/her hand to ask a question. The class size is small, an ideal concept to follow.	Life Cycle (Plants)
Claire	The teacher has passed around planet models in the form of a ball so that they can hold them and participate in kinesthetic learning.	Solar System
Lucy	I put flasks and beakers on the table because children learn best when working with tangible products. I put the teacher in front of the class that way he able to be heard by all the students. There is writing on the board that way students are able to refer back to the board if they forget something. If a student has a question, they are expected to raise their hand.	Science Process Skills
	Inquiry + Engagement	
Maria	Science in an early childhood classroom is about curiosity. In this picture you see the teacher leading the students in a "sink or float" activity lesson. Children are allowed to touch the objects and place in the bucket of water on the table. The teacher then asks and writes the outcomes on the chart, to provide literacy.	Sinking and Floating
	Inquiry + Enjoyment	
River	Science should be full of hands-on activities so that it's fun for kids. If it's fun for the kids, there's a good chance that they will remember the information. Science tends to be dreaded by some students, so we should make it as painless as possible.	No Identifiable Science Content

The conception of science instruction as being inquiry-based, i.e. of science activities as having both hands-on components and minds-on (cognitive activities) components, was mentioned by only eight participants. Among these eight participants, science instruction as being inquiry-based was associated with a specific science content. River was the only participant who did not mention any science content, but she mentioned that the hands-on activities she planned to use would help her future students to remember "the information." Participants who associated their conception of science instruction as inquiry-based with science content mentioned a hands-on activity that was then connected to a minds-on activity. Kate's narrative was exemplary of the association between inquiry and science content (see Table 14). In most cases, the minds-on activity was focused on students "asking questions," participating in "kinesthetic learning," "making note to refer back," writing outcomes, "taking notes," creating a "flip book," etc. Additionally, the conception of science instruction as being inquiry-based showed associations with other conceptions. For example, Maria connected her conception of science instruction as being inquiry-based with the conception of engagement – "Children are allowed to touch the objects and place them in the bucket of water on the table" -while River connected her conception of science instruction as being inquiry-based with the conception of enjoyment.

Observations

Analysis of narrative data indicated that for those participants who conceptualized science instruction as observation, the conception of observation was predominantly associated with the conception of demonstrations leading to students' experimentation and engagement in observation activities. (See Table 15). Figure 23 presents a pie-chart that illustrates the variations and percentages of participants' narrative conceptions of science instruction as *Observation.* Table 16 provides excerpts from participants' narratives that were predominantly associated with the conception of science instruction as *observations.*

Table 15

Number of Participants' Narrative Conceptions of Science Instruction as Students Observing Scientific Phenomena (Observations)

Science instruction as students observing scientific phenomena (*Observations*).	N	%

Observations	1	
Observation + Demonstration + Experiment + Engagement	1	
Total	2	2

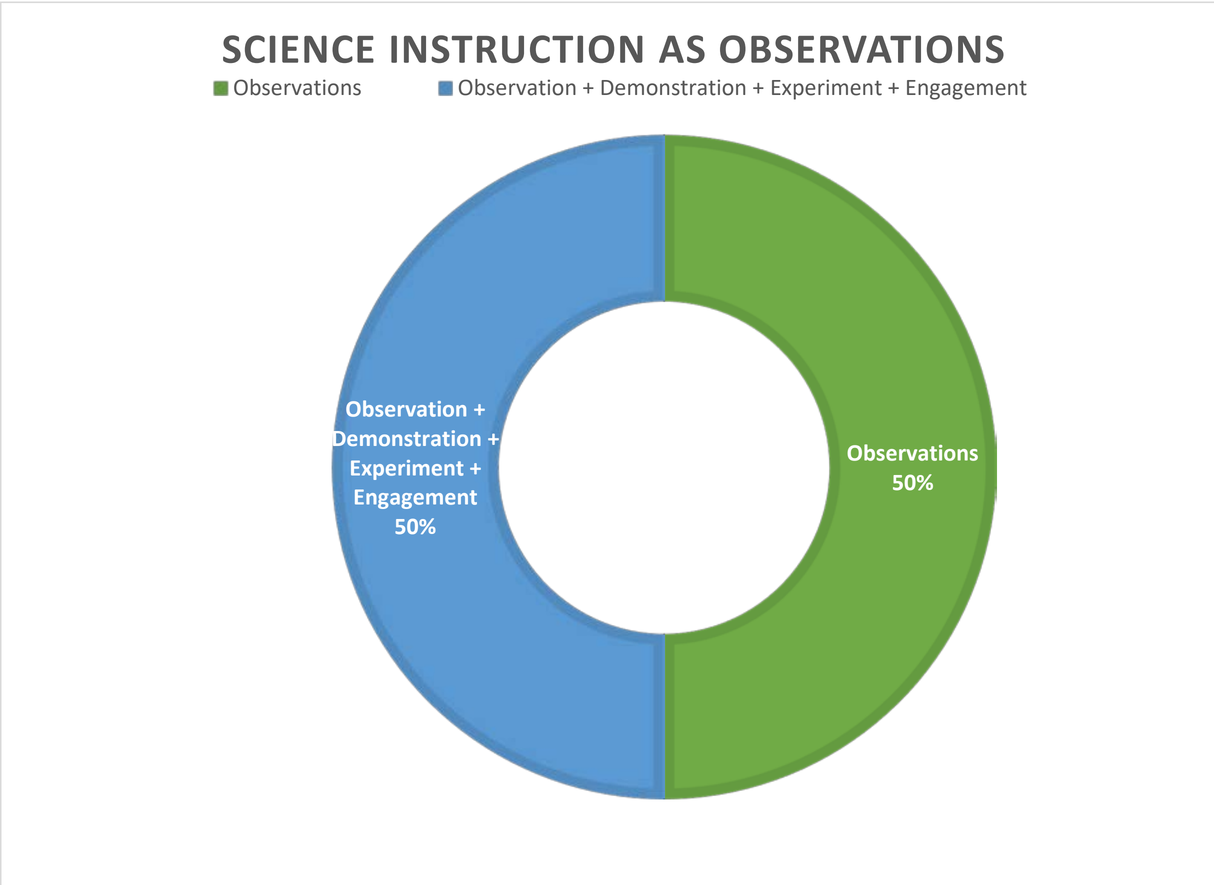


Figure 23. Diagram of the percentages of participants' narrative conceptions of science instruction as students observing scientific phenomena (*observations*) (in active learning).

Table 16

Excerpts from Participants' Narratives Conceptions of Science Instruction as Observations

Participant		Science Content
	Observation	
Cora	The teacher is teaching her students the process of photosynthesis. The kids are observing the sun giving off light, the flower taking in the light & CO2 and then giving off oxygen. The kids are learning that this is how plants make food and help humans.	Photosynthesis

Participant		Science Content
	Observation + Demonstration + Experiment + Engagement	
Lillian	The kids are watching her as she demonstrates the experiment. She is making elephant toothpaste. It is engaging while introducing chemistry.	Chemical Reaction

The conception of science instruction as students observing scientific phenomena (Observations) was mentioned by only two participants in the study. For these two participants, science instruction was centered on their students “observing” and “watching” scientific phenomena like photosynthesis and a chemical reaction. For Cora, this conception was focused on the process of photosynthesis while Lillian situated the conception of science instruction as observing scientific phenomena with the conceptions of science instruction as demonstration, experiment, and engagement.

Enjoyment

Analysis of narrative data indicated that for those participants who conceptualized science instruction as enjoyment, this conceptualization was predominantly associated with the conception of experiment, and the conception of science instruction as enjoyment being predominantly associated with the conception of Safety led to the use of observation science activities with students (Table 17). Figure 24 presents a pie-chart that illustrates the variations and percentages of participants’ narrative conceptions of science instruction as *enjoyment.* Table 18 provides excerpts from participants’ narratives that predominantly conceptualized science instruction as *enjoyment.*

Table 17

Number of Participants' Narrative Conceptions of Science Instruction as Enjoyment.

Science instruction as enjoyment	N	%
Enjoyment + Experiment	1	
Enjoyment + Safety + Observation	1	
Total	2	2

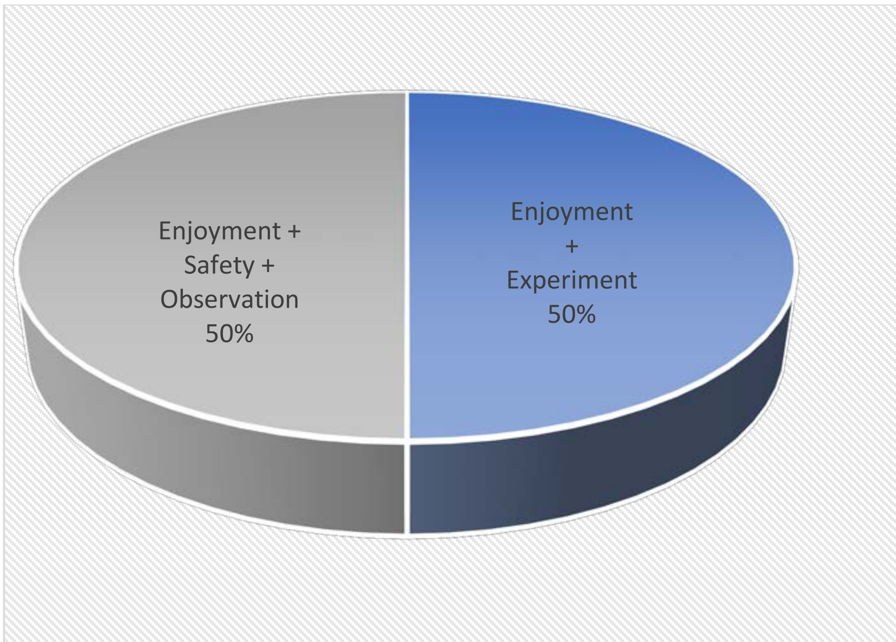


Figure 24. Diagram of the percentages of participants' narrative conceptions of science instruction as enjoyment (passive learning).

Table 18

Excerpts from Participants' Narratives Conceptions of Science Instruction as Observations

Participant		**Science Content**
	Enjoyment + Experiment	
Nina	This is Mr. Scientist in the 1st grade today! The kids are very excited to be involved in some experiments.	No identifiable Science Content
	Enjoyment + Safety + Observation	
Pearl	The teacher is dressed as a "mad scientist." Everybody (including the children) is wearing goggles. The children are watching while maintaining a safe distance. Everybody has a smile because the teacher is making science fun	No identifiable Science Content

Analysis of participants' narratives revealed only two participants who conceptualized science instruction as being centered on enjoyment. For these two participants, Nina and Pearl, their conception of science instruction lacked any association with science content. For Nina, the notion of students being "excited" about being involved in some experiments was central to her conception of science instruction. For Pearl, the conception of science instruction as enjoyment translated into an issue of safety and observation of her dressed as a "mad scientist."

Interaction

Analysis of narrative data indicated that for those participants who conceptualized science instruction as interaction, this conceptualization was predominantly associated with the conception of science instruction as demonstrations (see Table 19). Figure 25 presents a pie-chart that illustrates the percentages of participants' narrative conceptions of science instruction as interaction. Table 20 provides excerpt from participants' narratives that were predominantly associated with the conception of science instruction as being interaction.

Table 19

Number of Participants' Narrative Conceptions of Science Instruction as Interaction

Science instruction as being interaction	N	%
Interaction + Demonstrations	1	
Total	1	1

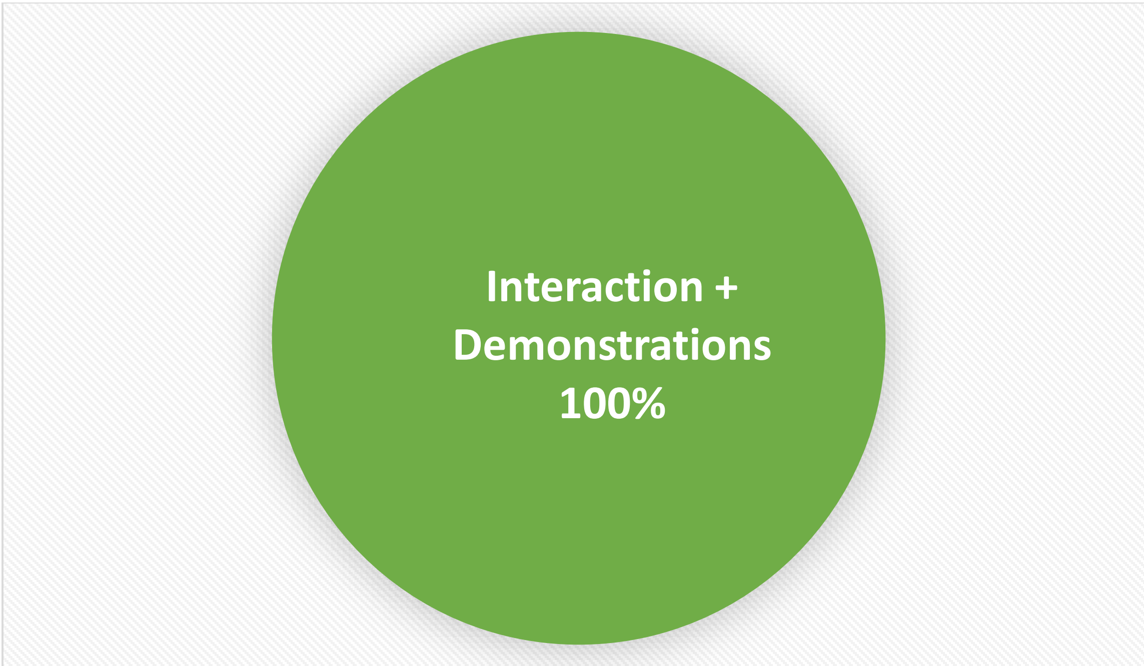


Figure 25. Diagram of the percentages of participants' narrative conceptions of science instruction as *interaction* (in active learning).

Table 20

Excerpts from Participants' Narratives Conceptions of Science Instruction as Interaction

Participant	Interaction + Demonstration	Science Content
Amira	The teacher will join in the classroom activities with students. The product is a classroom activity teaching kids about life science. The teacher uses the model and let kids dance to experience.	Life Science

Only one participant's narrative contained the conception of science instruction as interaction. This interaction involved the teacher joining the students in an activity that used a model and dancing to convey life science content that was not identified.

Synthesis of Findings from Drawings and Narratives

In this section, I present a synthesis merging of the preliminary themes that arose from the analysis of drawings, and from the analysis of narratives. The findings from the STLP3, specifically the dimensions of social, affective, implementation, and cognitive, from the analysis of drawings were related to the conceptions of science instruction resulting from the analysis of narratives. Each conception was read and reread in relation to the supporting data evidence and then correlated with each of four dimensions and with the participants' drawings.

Table 21

Identifying the Numbers of Percentage of Participants' Conceptions of Science Instruction from Participants' Drawings, Participants' Narratives, and Science Content

Conceptions: Drawings	Conceptions: Narratives	Science Content
Social (85%) Participate in scientific activities and learning practices with others, using scientific language and tools. **Affective** (73%) Experience excitement, interest and motivation to learn about phenomena in the natural and physical world. **Implementation** (37%) Manipulate, test, explore, predict, question, observe and make sense of the natural and physical world. **Cognitive** (33%) Come to generate, understand, remember and use concepts, explanations, arguments, models and facts related to science.	• Science instruction as a demonstration (Passive Learning) (40%)-Science instruction as a demonstration (Active Learning) (21%) • Science instruction as engagement (Active) (7%) • Science instruction as engagement (Passive) (2%) • Science instruction as experiment (Active) (9%) • Science instruction as being inquiry-based (Active) (8%) • Science instruction as implementing science safety guidelines (Active) (8%) • Science instruction as students observing scientific phenomena (Active) (2%) • Science instruction as being interaction (Active) (1%)	• No identifiable Science Content (18%) • Physical Science (19%) • Life Science (36%) • Earth and Space Science (14%) • Nature of Science (13%)

Table 22

Examples of Merging Themes of Participants' Conceptions of Science Instruction for Children in Pre-K to 3rd Grade Classroom

Conceptions of Science Instruction	Social	Affective	Implementation	Cognitive
Science instruction as engagement				
Engagement (passive)				
Engagement + Inquiry				

Conceptions of Science Instruction	Social	Affective	Implementation	Cognitive
Engagement + Inquiry + Interaction				
Engagement + Inquiry + Safety				
Engagement + Inquiry + Experiment				
Engagement + Inquiry + Experiment + Interaction				
Engagement + Inquiry + Enjoyment + Experiment				
Engagement + Interaction + Enjoyment (passive)				
Science instruction as inquiry				
Inquiry				
Inquiry + Engagement				
Inquiry + Enjoyment				
Science instruction as interaction				
Interaction + Demonstrations				
Science instruction as observation				
Observations				
Observation + Demonstration + Experiment + Engagement				
Science instruction as implementing science safety guidelines (*Safety*)				
Safety				
Safety + Demonstrations				
Safety + Demonstration + Enjoyment				
Safety + Enjoyment + Interaction				
Safety + Experiment + Interaction + Engagement				
Science instruction as a demonstration - Passive Learning				
Demonstration				
Demonstration + Explaining				
Demonstration + Enjoyment				
Demonstration + Observation				
(i) Demonstration + Safety				
(ii) Demonstration + Safety + Enjoyment				
Demonstration + Experiment + Engagement				

Table 23

Comparing the Participants' Narratives Conceptions of Science Instruction for Children in Pre-K to 3rd Grade between Active Learning and Passive Learning

Active Learning	Passive Learning
Participants' conceptions of science instruction as a demonstration with an active learning component can be categorized as predominantly	Participants' conceptions of science instruction as a demonstration with a passive learning

containing social, implementation, and cognitive dimensions (21%).	component can be categorized as containing affective dimensions (40%).
Participants’ conceptions of science instruction as engagement with an active learning component can be categorized as predominantly containing social, implementation, and cognitive dimensions (7%).	Participants’ conceptions of science instruction as engagement with a passive learning component can be categorized as predominantly containing affective dimensions (2%).
Participants’ conceptions of science instruction as doing experiments can be categorized as predominantly containing social, implementation, and cognitive dimensions (9%).	Participants’ conceptions of science instruction as enjoyment can be categorized as predominantly containing social and affective dimensions (2%).
Participants’ conceptions of science instruction as implementing safety can be categorized as predominantly containing a social dimension (8%).	
Participants’ conceptions of science instruction as inquiry can be categorized as predominantly containing social, implementation, and cognitive dimensions (8%).	
Participants’ conceptions of science instruction as observation can be categorized as predominantly containing social, implementation, and cognitive dimensions (2%).	
Participants’ conceptions of science instruction as an interaction can be categorized as predominantly containing a social dimension (1%).	

As is evident in Table 23, 21% of participants’ conceptions of science instruction as a demonstration within an active learning context can be categorized as predominantly containing social, implementation, and cognitive dimensions. Further, participants’ conceptions of science instruction as engagement with an active learning component accounted for 7% and can be categorized as predominantly containing social, implementation, and cognitive dimensions. Also, 9% of participants’ conceptions of science instruction as doing experiments can be categorized as predominantly containing social, implementation, and cognitive dimensions. In addition, participants’ conceptions of science instruction as inquiry within an active learning context accounted for 8% and can be categorized as predominantly containing social, implementation, and cognitive dimensions. Further, participants' conceptions of science instruction as observation accounted for 2% and can be categorized as predominantly containing social, implementation, and cognitive dimensions. Only one participant's conceptions of science instruction as an interaction can be categorized as predominantly containing a social dimension, and this accounted for 1%.

On the other hand, 40 % of participants' conceptions of science instruction as a demonstration with a passive learning component can be categorized as containing affective dimensions Participants' conceptions of science instruction as engagement with a passive learning component accounted for 2% and can be categorized as predominantly containing affective dimensions. Additionally, participants' conceptions of science instruction as enjoyment accounted for 2% can be categorized as predominantly containing social and affective dimensions.

Summary

Chapter 4 reports the findings from analysis of participants' drawings and participants' narratives of drawings of science instruction for children in pre-K to 3rd grade classrooms. Analysis of participants' drawings using the STLP3 instrument revealed four themes that characterized participants' conceptions of science instruction. These four conceptions were: (a) science instruction in an early childhood classroom is a social activity, (b) science instruction in an early childhood classroom as an affective endeavor, (c) science instruction in an early childhood classroom is the implementation of activities for learning, and (d) science instruction in an early childhood classroom is a cognitive activity. The analysis of participants' narratives revealed that eight conceptions of science instruction for teaching children in pre-K to 3rd grade classrooms were prevalent among participants in this study. These conceptions included science instruction as teachers demonstrating science concepts (Demonstration) (passive learning and active learning), science instruction as making the lesson engaging (Engagement) (active learning and passive learning), science instruction as teachers and students engaging in science experiments (Experiment) (active learning), science instruction as implementing science safety guidelines (Safety) (active learning), science instruction as inquiry-based (Inquiry) (active learning), science instruction as students observing scientific phenomena (Observations) (active learning), science instruction as making the lesson joyful (Enjoyment) (passive learning), and science instruction as students interacting with one another and/or with the teacher in science activities (Interaction) (active learning). Chapter 5 includes discussion of this study, educational implications, and recommendations for future research.

CHAPTER 5

DISCUSSION

The purpose of this study was to investigate participants' conceptions of science instruction prior to the commencement of their early childhood education methods courses. The primary research question for this study was: *What are prospective early childhood teachers' conceptions of science instruction in the early childhood classroom?* In summary, the merging of findings from the analysis of drawings and from the analysis of narratives resulted in the following major themes:

1. Participants' conceptions of science instruction as a demonstration with a passive learning component can be characterized as containing affective dimensions.
2. Participants' conceptions of science instruction as a demonstration with an active learning component can be characterized as predominantly containing social, implementation, and cognitive dimensions.
3. Participants' conceptions of science instruction as engagement with active learning can be characterized as predominantly containing social, implementation and cognitive dimensions.
4. Participants' conceptions of science instruction as engagement with passive learning can be characterized as predominantly containing an affective dimension.
5. Participants' conceptions of science instruction as inquiry can be characterized as predominantly containing social, implementation, and cognitive dimensions.
6. Participants' conceptions of science instruction as an interaction can be characterized as predominantly containing a social dimension.
7. Participants' conceptions of science instruction as observation can be characterized as predominantly containing social, implementation and cognitive dimensions.
8. Participants' conceptions of science instruction as implementing safety can be characterized as predominantly containing a social dimension.
9. Participants' conceptions of science instruction as doing experiments can be characterized as predominantly containing social, implementation and cognitive dimensions.

10. Participants' conceptions of science instruction as enjoyment can be characterized as predominantly containing social and affective dimensions.

Table 24 summarizes the major themes resulting from the merging of preliminary themes organized as *Active Learning* and *Passive Learning*. In summary, each conception was anchored by a unique construct (Demonstration, Engagement, Inquiry, Interaction, Observation, Safety, Experiment, and Enjoyment) and underscored by dimensions (Affective, Social, Implementation, and Cognitive).

Table 24

Major Themes Resulting from Merging of Findings from Drawings and Narratives

Active Learning		Passive Learning
Social, Implementation and Cognitive Dimensions	*Social Dimension*	*Affective dimension*
• *Science instruction as a demonstration with an active learning component (21%)* • *Science instruction as engagement (7%)* • *Science instruction as inquiry (8%)* • *Science instruction as observation (2%)* • *Science instruction as doing experiments (9%)*	• Science instruction as an interaction (1%) • Science instruction as implementing safety (8%)	• Science instruction as a demonstration with a passive learning component (40%) • Science instruction as enjoyment (2%) • Science instruction as engagement (2%)

The final major themes of 100 participants' conceptions of science instruction resulting from the merging of findings from drawings and narratives can be clarified as follows:

1. Science instruction as a demonstration with an active learning component can be characterized as predominantly containing social, implementation, and cognitive dimensions (21%).

2. Science instruction as engagement with an active learning component can be characterized as predominantly containing social, implementation, and cognitive dimensions (7%).

3. Science instruction as doing experiments with an active learning component can be characterized as predominantly containing social, implementation, and cognitive dimensions (9%).

4. Science instruction as inquiry with an active learning component can be characterized as predominantly containing social, implementation, and cognitive dimensions (8%).

5. Science instruction as implementing safety with an active learning component can be characterized as predominantly containing a social dimension (8%).

6. Science instruction as observation with an active learning component can be characterized as predominantly containing social, implementation, and cognitive dimensions (2%).

7. Science instruction as an interaction with an active learning component can be characterized as predominantly containing a social dimension (1%).

8. Science instruction as a demonstration with a passive learning component can be characterized as containing affective dimensions (40%).

9. Science instruction as engagement with a passive learning component can be characterized as predominantly containing affective dimensions (2%).

10. Science instruction as enjoyment can be characterized as predominantly containing social and affective dimensions (2%).

Findings in Relation to Standards

According to the National Association for the Education of Young Children (NAEYC, 2009), the National Science Teacher Association (NSTA, 2014), and the National Research Council (NRC, 2012), science instruction in early childhood is characterized as ideally taking place in an inquiry-based and experiential environment, wherein pre-K to 3rd grade children have the opportunity capacity to engage in scientific practices, and to develop an understanding of science content and science skills at a conceptual level. This development of an inquiry-based and experiential environment must also provide pre-K to 3rd grade children with multiple and varied opportunities to engage in science exploration and discovery, thereby creating communities of science learners. Accordingly, these standards also require that teachers create environments in which they and their students work together as active learners, use assessments of students and of their own teaching continually to plan and conduct their teaching, build strong relationships with students, and include their students as active members of science learning communities. The standards provide guidelines for teachers to employ science teaching and learning strategies which enable children in an early childhood classroom to develop science understanding at a conceptual level through *active learning* and *play*.

The findings in this study are partially in line with the aforementioned standards, specifically, participants' conceptions of science instruction that emphasized active learning with social, implementation, and cognitive dimensions. Table 24 indicates that 56% of participants' conceptions of science instruction were underscored by the notion of active learning, in contrast to the 44% of participants' conceptions of science instruction, which were underscored by the notion of passive learning. Even though participants' conceptions of science instruction revealed an active learning orientation, findings also revealed that science instruction as demonstration, as engagement, as inquiry, as observation, and as doing experiments involved superficial understandings of science content and scientific practices that were not aimed at developing students' learning of science at a grade appropriate level and at a conceptual level. This finding is also important because it shows the impact of the weak science content preparation and weak preparation in scientific practices of future early childhood educators and the resulting impact on their conceptions of science instruction. Most importantly, this finding emphasizes the need for early childhood educators to demonstrate a deep understanding of pure and applied science and have the knowledge and skills required to teach students science in age-appropriate, meaningful ways (NSTA, 2017). This finding from this study therefore indicates that participants in this study had limited prior knowledge of developmentally appropriate instructional strategies for children in pre-K to 3rd grade science instruction.

The use of play in developing concepts and the assessment of student learning were not part of participants' conceptions of science instruction. This is in contrast to the literature that calls for providing support for play as a key instructional strategy for promoting young children's development from the infant/toddler stage to the early grades (NAEYC, 2009; NRC, 2012; NSTA, 2014). Thus, early childhood teachers, like the participants in this study, require assistance in the thoughtful planning of the materials and activities that can make possible the use of play to scaffold for science learning in early childhood classrooms. In contrast, the 44% of participants' whose conceptions of science instruction were underscored by the notion of passive learning did conceptualized the use of an affective component for student learning of science but this overshadowed the cognitive aspects of learning science. The use of play in developing concepts, and the assessment of student learning were also not part of participants' conceptions of science instruction that were underscored by the notion of passive learning.

As mentioned, the participants in this study did not hold conceptions that emphasized play as a means of teaching science to young children. This may be surprising in light of the well-researched agenda and literature on play as a crucial element in enabling young children to build science concepts. Participants in this study and other prospective teachers who are learning to teach science to young children should conceptualize play as an element for the implementation and cognitive dimensions of teaching science. Most importantly, they should not just restrict the notion of play to the affective and social dimensions of teaching science.

Findings in Relation to Current Instructional Strategies: Pre-K to 3rd Grade Science Instruction

In a 2014 position statement, the National Science Teachers Association (NSTA) stressed the need for reflective, inquiry-based science experiences at the early childhood level in order to support and strengthen student learning. The National Research Council recommends the inclusion of inquiry science experiences at the early childhood levels (NRC 2007, 2012). Recommended early science learning experiences related to a guided, inquiry-based approach include the following: identifying and asking questions that can be answered through investigation, designing and conducting investigations, using appropriate tools and equipment, learning to develop logical conclusions, and communicating understandings to peers and others (NSTA 2004). Inquiry-based instruction is an effective early childhood science teaching strategy (Dejonckheere et al., 2016; McLean, Jones & Schaper, 2015; NRC, 2000; Trundle, 2009; Trundle & Sackes, 2015; Van Uum, Verhoeff & Peeters, 2017). Inquiry-based instructional approaches offer the most effective way for young children to engage with and learn science concepts. Children are expected to be active agents in learning activities, as they are engaged in activities such as work in small groups, meaningful science activities, and sense-making.

The findings in this study indicated that only eight participants (8%) conceptualized science instruction as being inquiry-based, that is, as involving science activities having both hands-on components and minds-on (cognitive activities) components**.** Among these eight participants, the conception of science instruction as inquiry-based was associated with a specific science content and this was connected to a minds-on activity, such as “asking questions.” The number of participants who conceptualized science instruction as inquiry-based was very low. Therefore, findings from this study indicate that participants in this study had limited prior knowledge of inquiry-based science instruction as a developmentally appropriate instructional strategy for children in pre-K to 3rd grade science classroom, an approach advocated by the literature (Dejonckheere et al., 2016; McLean, Jones & Schaper, 2015; NRC, 2000; NSTA 2004; Trundle, 2009; Trundle & Sackes, 2015; Van Uum, Verhoeff & Peeters, 2017). Furthermore, the low incidence of inquiry highlights a serious concern that must be addressed in early childhood methods courses, in all teacher education courses, and in content courses taken prior to enrollment in early childhood teacher education programs. For participants in this study, taking four science content courses (*Biology for Educators*, *Environmental Science*, *Earth Science*, and *Conceptual Physics*) provided only limited knowledge of inquiry-based science instruction. This further highlights the importance of engaging science content course instructors and early childhood teacher educators in collaboration on cross-curricular initiatives that will integrate inquiry-based strategies and enable prospective early childhood teachers, like the participants in this study, to experience inquiry-based instruction themselves.

Findings in Relation to the Sociocultural Theory

According to the sociocultural theory, children learn science through mediation within the zone of proximal development. The zone of proximal development is created by the teacher and student in the context of specific tasks for intersubjective agreement about meaning being made together: it is not simply announced by the teacher but rather is carried out through mutual participation (John-Steiner & Mahn, 1996; Subramaniam, 2007). This theory captures the idea of teachers as experts in the use of cultural tools leading to cultural amplification and the extending of students' cognitive processes. This theory also incorporates the idea of psychological tools (the semiotic tools of speech, writing, language, and thought) and physical tools as mediators of thought and activity within the zone of proximal development. Another essential element of the social interaction is scaffolding. In Vygotsky's view of cognitive development, the adults or other partners in a child's world should provide scaffolding to help children learn new information and develop more complex thinking abilities. In the classroom, the activity structure manifests as the "interactive opportunities" that enable the teacher to select the relevant and suggested content, organize the content and relate it to what their audience already knows. As a result, the teachers make it possible for themselves and their students to " publicly display thinking and reasoning and for their students to gain access to learning and to demonstrate social and academic competence" (Subramaniam, 2007; Weade, 1987: 17).

Findings from this study indicate that participants' conceptions play a role in the mediation process (John-Steiner & Mahn, 1996; Subramaniam, 2007), but the nature of the conceptions, that is, the dimensions which they subscribe to, social, implementation, cognitive, and affective, determine the mediation in the learning of science. The conceptions of science instruction that fell into the categorization of having passive and affective dimensions provided a glimpse into how participants intended to use "fun," "excitement," "motivation," etc., to mediate their future students' learning science content through demonstrations. Unfortunately, the aforementioned conception falls short of indicating how participants intend to enable their students to construct science content after mediation while following an affective approach. The findings indicated that the demonstrations with affective dimensions promoted passive learning through showing, telling, describing, etc. science content to students in a traditional teaching format without any student interaction and/or involvement with the demonstrations.

On the other hand, the conceptions of science instruction that fell into the categories associated with active learning and with social, implementation, and cognitive dimensions provided a glimpse into how participants intend to use mediation and how this mediation extends to students' learning of science content. The nature of mediation as seen through demonstrations, engagements, inquiry, observations, and doing experiments had built-in dimensions of social, implementation, and cognitive dimensions that called for students to be involved in an active process of learning the science content through mediation.

Unique Findings

Unique to this study was the finding that participants' conceptions of science instruction, using the dimensions from the STLP3 and the frameworks guiding the study, were complex in nature and multidimensional. The use of the STLP3 instrument revealed four dimensions underscoring participants' conceptions of science instruction: the A*ffective* dimension, the *Cognitive* dimension, the *Implementation* dimension, and the *Social* dimension. This uniqueness made possible the further classification of participants' conceptions into categories of active learning and passive learning. Furthermore, the complexity, the multidimensionality, and the categorization arising from the results of this study provide a framework in which to situate participants' conceptions of science instruction. The complexity of the framework is inherent in the situating of dimensions within the conceptions of science instruction and thus providing a lens through which to view teachers ' specifications, as well as propositions related to science teaching and learning. The multidimensionality of the framework is inherent in situating conceptions within dimensions and thus provides clarity on teachers' thinking about science teaching and learning. The categories (active, passive, and dimensions) in the framework identify the orientations inherent in teachers ' thinking about science teaching, and their strategies for pre-K to 3rd children's learning of science content.

Limitations

One limitation of this study is the issue of participants' artistic aptitude (Subramaniam, 2013; 2018). It must be noted that not all participants in this study may have had the ability to draw or depict certain images in their drawings of themselves teaching science in the early childhood classroom. This limitation was mitigated through the use of narratives. Participants were asked to write a five to ten sentence narrative about their drawings to clarify what the products and processes depicted in the drawings were (Subramaniam, 2013; 2018). Another limitation of this study involves, the issue of power relations between the participants of this study and the researcher who collected the data in the form of drawing and narratives, who was, an authority figure. The issue of power relations was mitigated because the researcher who collected the data did not teach in the early childhood teacher education program, and he collected the data in the presence of the early childhood methods instructors.

Educational Implications

Implications for the Early Childhood Teacher Educator

The findings of the study provide a framework for focusing on how prospective early childhood teachers conceptualize science instruction for children in pre-K to 3rd grade classrooms and their strategies for helping their future early childhood learners in constructing science content. Early childhood teacher educators must realize that the teaching process is becoming an important variable in the development of their prospective early childhood teachers' epistemological belief, and is now a crucial factor for opening doors to new vistas and stimulating novel alternative solutions and ideas in them. Teacher educators may benefit by helping prospective early childhood teachers to explore their teaching and learning conceptions regarding the students in their classes (Mahasneh, 2018) and to use the resulting knowledge to develop lesson planning and more effective pedagogy in the early childhood science methods courses.

Implications for the Early Childhood Teacher Preparation Programs

The curriculum for early childhood teacher education must incorporate frameworks for understanding the practice of teaching within coursework early on in the early childhood teacher preparation program to enable prospective teachers to reflect on and document their prior knowledge of science instruction. By doing so, it will enable prospective early childhood teachers to look into their own and their peers' complex and multidimensional conceptions of science instruction and situate their prior and new knowledge of early childhood science instruction within theoretical frames rather than simply relying on their knowledge of science instruction from K-12 experiences.

Implications for Future Research

The findings of this study call for more research into the prior knowledge of prospective early childhood teachers. Specifically, future research should study conceptions of science instruction in relation to conceptions of teachers prior to and after the end of early childhood methods courses. From a personal perspective, I would like to compare the conceptions of science instruction between different demographics of early childhood educators, for example between early childhood educators from Thailand and from other countries, such as the U.S.A. Additionally, there is a need for studies that examine early childhood educators' conceptions of science instruction from a multimodal (interviews, metaphors, focus groups, etc.) perspective. Through such work, a holistic understanding of this phenomenon will become possible.

Conclusion

Preparing prospective early childhood teachers to teach science effectively in early childhood classrooms is becoming more important, particularly since science methods courses taken by prospective early childhood teachers will influence their future instruction in early childhood classrooms (Harrell & Subramaniam, 2015; Subramaniam, 2018). In summary, I find that prospective early childhood teachers entering a teacher educating program possess a variety of conceptions about science, teaching, and learning. When they enroll in early childhood education courses, it is important that these conceptions be made explicit, that they be analyzed and discussed critically, and that beginning early childhood teachers be provided with other theoretically-based conceptions of science, teaching, and learning for children in pre-K to 3rd grade classrooms.

APPENDIX A

IRB

UNT
EST. 1890

THE OFFICE OF RESEARCH AND INNOVATION
Research and Economic Development

February 26, 2019

PI: Karthigeyan Subramaniam
Study Title: Prospective Early Childhood Teachers' Conceptions of Science Instruction

RE: Human Subjects Application # IRB-19-51

Dear Dr. Karthigeyan Subramaniam:

In accordance with 45 CFR Part 46 Section 46.104, your study titled "Prospective Early Childhood Teachers' Conceptions of Science Instruction" has been determined to qualify for an exemption from further review by the UNT Institutional Review Board (IRB).

No changes may be made to your study's procedures or forms without prior written approval from the UNT IRB. Please contact The Office of Research Integrity and Compliance at 940-565-4643 if you wish to make any such changes. Any changes to your procedures or forms after 3 years will require completion of a new IRB application.

We wish you success with your study.

Sincerely,

Shelley Riggs, Ph.D.
Professor
Chair, Institutional Review Board

SR:jm

APPENDIX B

SCIENCE TEACHING AND LEARNING PORTRAYALS OF PROFESSIONAL PRACTICE (STLP3)

SCORING RUBRIC

Science Teaching and Learning Portrayals of Professional Practices (STLP3) Scoring Rubric
Experience excitement, interest and motivation to learn about phenomena in the natural and physical world [affective] (Goal 1)

Score	Description
4	Smiling figures with specific indicators such as the use of descriptive words "fun" or other exclamations of excitement, interest and motivation
3	Smiling figures, but no specific indicators of excitement, interest and motivation
2	Figures with facial expressions but ambiguous in regard to excitement, motivation, and interest
1	Negative facial expressions or comments suggesting lack of interest or motivation
0	No evidence (facial expression or comments) of excitement, interest, or motivation in the drawing

Come to generate, understand, remember and use concepts, explanations, arguments, models and facts related to science [cognitive] (Goal 2)

Score	Description
4	Evidence in thought bubbles, comments, or models of concepts, explanations, arguments, models, or facts (4 or more present)
3	Evidence in thought bubbles, comments, or models of concepts, explanations, arguments, models, or facts (3 present)
2	Evidence in thought bubbles, comments, or models of concepts, explanations, arguments, models, or facts (2 present)
1	Evidence in thought bubbles, comments, or models of concepts, explanations, arguments, models, or facts (1 present)
0	No evidence of concepts, explanations, arguments, models, or facts present

Manipulate, test, explore, predict, question, observe and make sense of the natural and physical world [implementation] (Goal 3)

Score	Description
4	Evidence in thought bubbles, comments, or activities of manipulating, testing, exploring, predicting, questioning, observing, or sense-making (4 or more present)

Score	Description
3	Evidence in thought bubbles, comments, or activities of manipulating, testing, exploring, predicting, questioning, observing, or sense-making (3 present)
2	Evidence in thought bubbles, comments, or activities of manipulating, testing, exploring, predicting, questioning, observing, or sense-making (2 present)
1	Evidence in thought bubbles, comments, or activities of manipulating, testing, exploring, predicting, questioning, observing, or sense-making (1 present)
0	No evidence of manipulating, testing, exploring, predicting, questioning, observing, or sense-making

Participate in scientific activities and learning practices with others, using scientific language and tools [social] (Goal 5)

Score	Description
4	Evidence of learning with others, using scientific language and using scientific tools. 2 or more present)
3	Evidence of learning with others, using scientific language and using scientific tools. (1 present)
2	Ambiguous connection to science
1	Students not participating in a science activity or practice
0	No evidence of learning with others, using scientific language, or using scientific tools

APPENDIX C

SCORING RUBRIC SUPPLEMENTAL INFORMATION SHEET

Scoring Rubric Supplemental Information Sheet

Goal 1: Experience excitement, interest and motivation to learn about phenomena in the natural and physical world.

-Look to the mouth on the figures present. If anyone is smiling, give credit (that is, if only the teacher is smiling but the students are not, give credit for smiling or the reverse). If faces are not visible, look for specific indicators of excitement, interest and motivation in thought bubbles or comments.

Excitement - thought bubbles or comments expressing excitement (e.g., exclamation marks)

Interest - thought bubbles or comments about what is occurring

Motivation - thought bubbles or comments expressing eagerness (e.g., "I can't wait to do this", "Let's get started")

Goal 2: Come to generate, understand, remember and use concepts, explanations, arguments, models and facts related to science.

-Identify concepts, explanations, arguments, models and facts using these descriptions.

Concepts - thought bubbles or comments about bigger science ideas (e.g. energy, evolution)

Explanations - thought bubbles or comments about how things are happening

Arguments - thought bubbles or comments that compare or respond to alternatives

Models - a visual model of three dimensions related to scientific phenomena (not classroom management)

Facts - a statement of science learning (e.g. deciduous trees lose leaves in the fall here)

Goal 3: Manipulate, test, explore, predict, question, observe and make sense of the natural and physical world.

-Identify manipulating, testing, exploring, predicting, questioning, observing, and sense-making using these descriptions:

Manipulating - each learner has access to materials in reach or is shown actually touching items (note: manipulating variables for an experiment, see testing below)

Testing - thought bubbles or comments that illustrate a trial ("what will happen if..."); presence of testing tools (manipulating variables for an experiment)

Exploring - engaged in active science (not only reading books and writing)

Predicting - thought bubbles or comments stating what might happen

Questioning - students have question marks or actual questions visible

Observing - looking intently as individuals or groups at an object or phenomena

Sense-making-thought bubbles or comments that indicate students or the teacher are trying to "figure things out," phrases that begin with "maybe"...

Goal 5: Participate in scientific activities and learning practices with others, using scientific language and tools.

-Identify participating in scientific activities and learning practices with others, using scientific language, and tools using these descriptions:

Participate in scientific activities and learning practices with others - students grouped for interaction

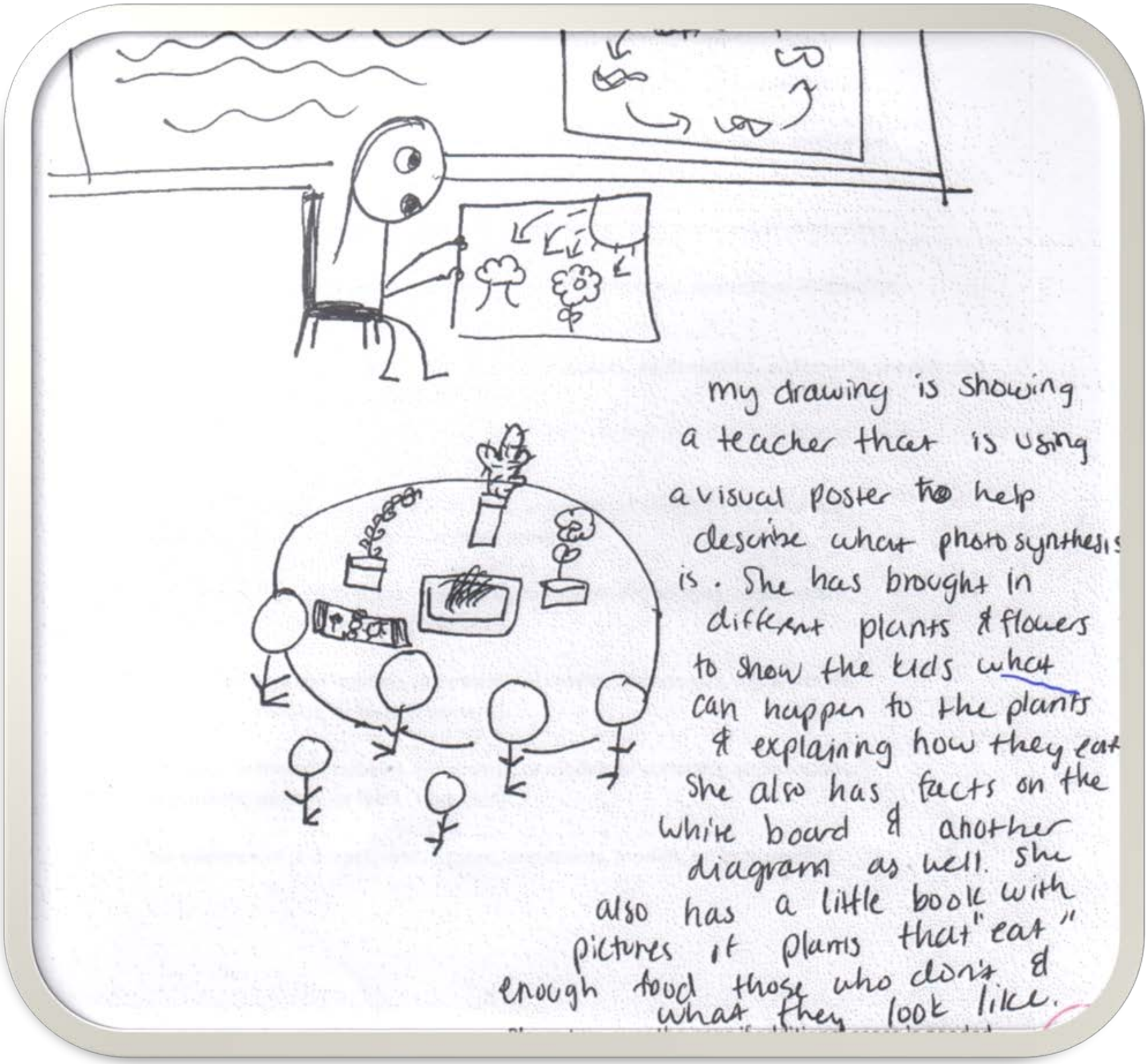
Scientific language - use of terms associated with science (such as, comparisons, questions about how)

Tools - clearly drawn or unclearly drawn (squiggles) materials available to all learners

http://www.drawntoscience.org/researchers/scoring-rubric/rubric-instructions.html

APPENDIX D

EXAMPLES OF PARTICIPANTS' DRAWINGS


my drawing is showing a teacher that is using a visual poster to help describe what photosynthesis is. She has brought in different plants & flowers to show the kids what can happen to the plants & explaining how they eat She also has facts on the white board & another diagram as well. She also has a little book with pictures of plants that "eat" enough food those who don't & what they look like.

The teacher will let students hold equipment if appropriate for their age. Science should be a hands-on subject especially for grades 1-3. The teacher should explain what each instrum[illegible] does and then let the child hold it themselves. Teacher should allow students to ask questions about the topic they are learni[illegible] Teacher should address each question that the students ask.

- children are learning about the life cycle of a plant & how it utilizes the process of photosynthesis
- The teacher utilizes white flowers and adding dye to the soil to demonstrate how water is absorbed through the roots.
- She wears safety equipment to teach early on safety guidelines.
- She engages the children by allowing them to water the plants.

Please turn over the page if additional space is needed.

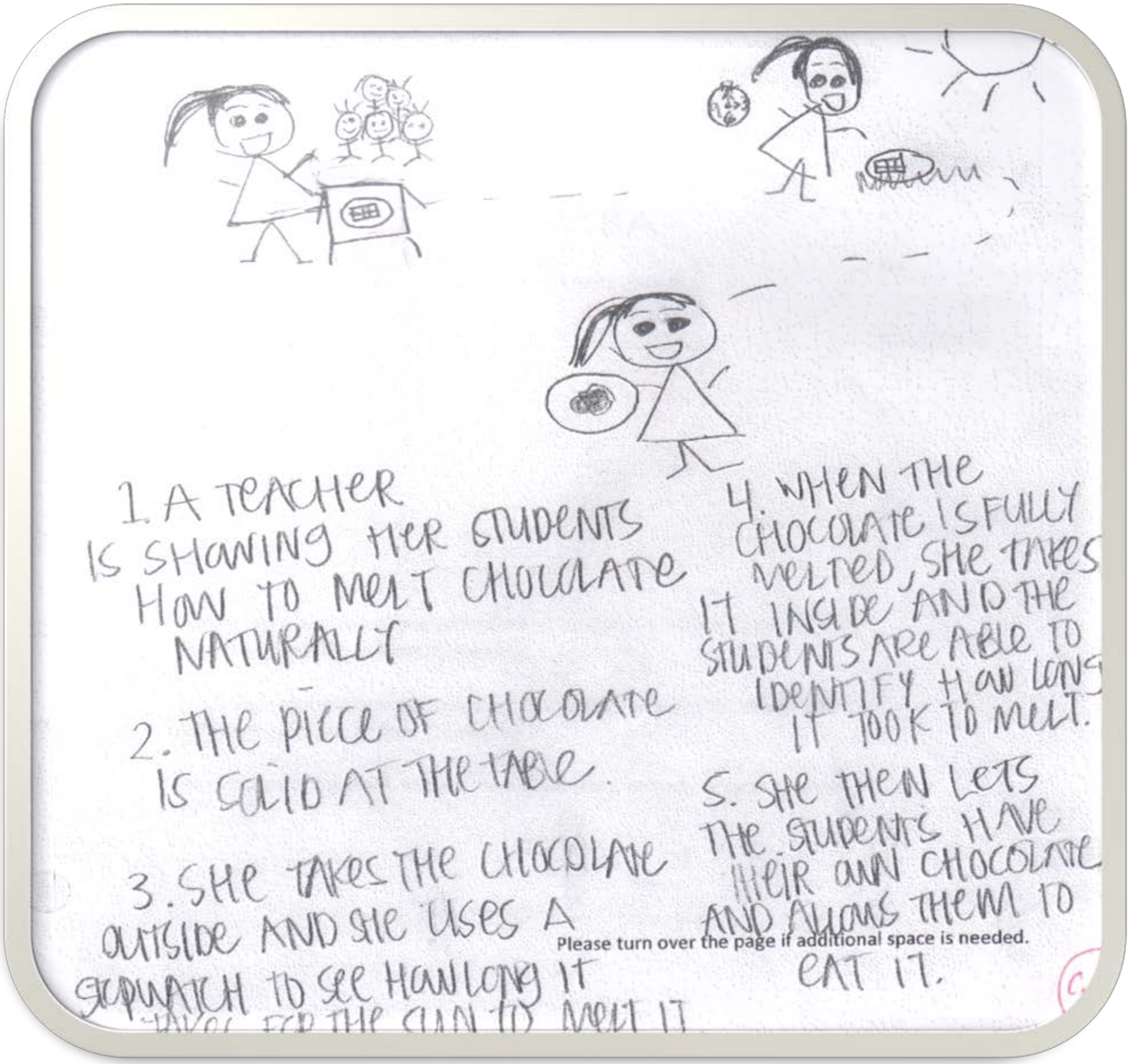
- She speaks through out the whole process explaining everything.

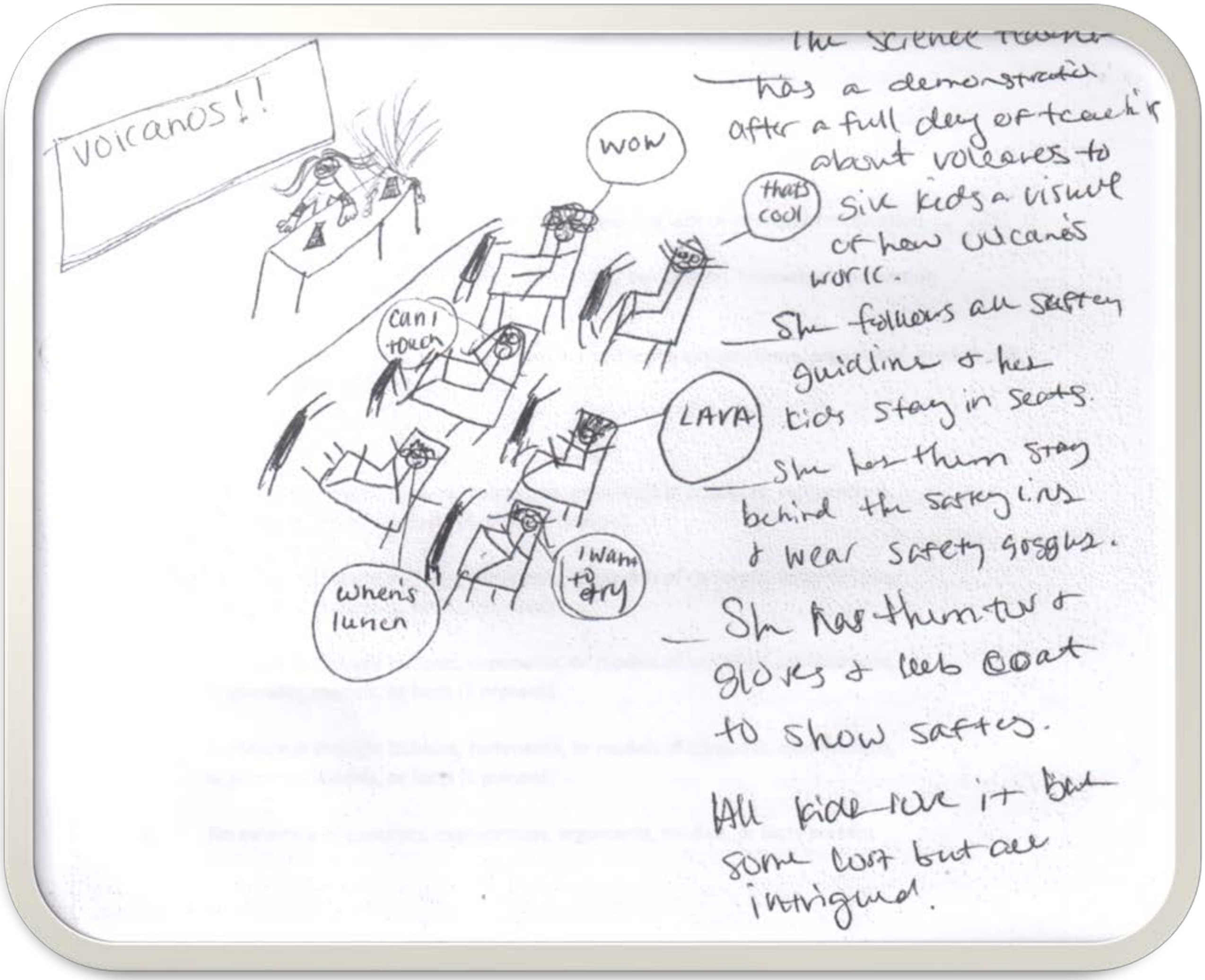
Science should be full of hands-on activities so that it's fun for kids. If it's fun for the kids, there's a good chance that they will remember the information. Science tends to be dreaded by some students, so we should try to make it as painless as possible.

Mrs. Haggetry is showing her class an interesting science experiment today involving baking soda & vinegar. She is using a graduated cylinder to hold her ingredients. She first places baking soda in the cylinder and then the vinegar. The mixture then starts to bubble and fizz making the students go "ooo" & "ahh". Mrs. Haggetry then gets burned because she forgot to wear gloves, ~~and~~ a hair net & goggles. :)

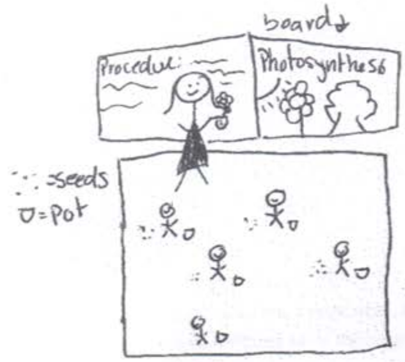
Please turn over the page if additional space is needed.

The End


1. A TEACHER IS SHOWING HER STUDENTS HOW TO MELT CHOCOLATE NATURALLY
2. THE PIECE OF CHOCOLATE IS SOLID AT THE TABLE.
3. SHE TAKES THE CHOCOLATE OUTSIDE AND SHE USES A STOPWATCH TO SEE HOW LONG IT
4. WHEN THE CHOCOLATE IS FULLY MELTED, SHE TAKES IT INSIDE AND THE STUDENTS ARE ABLE TO IDENTIFY HOW LONG IT TOOK TO MELT.
5. SHE THEN LETS THE STUDENTS HAVE THEIR OWN CHOCOLATE AND ALLOWS THEM TO EAT IT.
Please turn over the page if additional space is needed.



Volcanos!!
WOW
that's cool
can I touch
LAVA
I want to try
when's lunch
The science teacher
has a demonstration
after a full day of teaching
about volcanoes to
give kids a visual
of how volcanos
work.
She follows all saftey
guidline & her
kids stay in seats.
She has them stay
behind the safety lins
& wear safety goggles.
gloves & lab coat
to show saftey.
some lost but all
intrigued.



The teacher is working with the students in learning the process of Photosynthesis. The class will be using seeds and small planter pots to grow their own plant and learn hands on how Photosynthesis occurs. The teacher has written the procedure on the board and walk's the students through the steps by demonstrating at the front of the class.

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