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Teachers' Practices in Preschool Science Education:

A Comparison Study Between USA and China

A dissertation submitted in partial satisfaction of the

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in Education

by

Yating Qi

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ABSTRACT OF THE DISSERTATION

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Professor Edith Omwami, Chair

This dissertation investigated teachers' practices in preschool science education between China and United States, especially focusing on the factors that affected teachers' instruction in early childhood science education, teachers' pedagogical practices in teaching children science, and teachers' classroom discourse methods used in teaching science. Teachers usually maintain a leadership role in designing curriculum, conducting, and guiding activities/experiments and asking questions in the learning processes (Ravanis, 2017). For this reason, it is important to pay attention to teachers' pedagogical practices in early childhood science education.

Data was collected from fieldwork in kindergartens between China and United States. There was one kindergarten in Beijing, China and another kindergarten in Los Angeles, CA (United States). For each of the kindergartens, there were two classes and two teachers who participated in this study. This fieldwork included observing science classes, including how the teachers taught children science, and how they conducted science activities and experiments. I interviewed four teachers who taught science in the selected classes, analyzed textbooks, and documents relating to science education.

The results showed the purpose for early childhood science education in the kindergartens in China and the United States were similar. Both strived to give children more chances to discover and explore by themselves, so that children could have more hands-on experiences and enjoy the process of science exploration. But in terms of the implementation of teaching children science, there were differences between kindergartens in China and the United States. For the kindergarten in China, because of the more structured curriculum and learning environment, science education was more teacher-centered and observation-oriented. Compared with the kindergarten in the United States, the curriculum design and the learning environment was more flexible and diverse, so that the science education was more student-centered and exploration-oriented. Although teachers' beliefs towards teaching children science in the kindergartens in China and United States illuminated goals to embolden more opportunities for children to explore, teachers in the Chinese kindergarten still emphasized more on measuring learning outcomes whereas the teachers in the American kindergarten afforded more attention to the process of exploration.

The dissertation of Yating Qi is approved.

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With the completion of my dissertation, the journey for my doctoral degree in UCLA is approaching the end. I suddenly can't help feeling slightly wistful. Under the influence of the COVID-19 pandemic, I had spent almost half of the time in my dissertation writing at home during my doctoral studies. Speaking of the greatest regret during my doctoral career, I think it would be my inability to return to the campus and absence from the graduation ceremony, making my doctoral journey close without sufficient sense of ceremony. In spite of the difficulties and challenges all the way, I still had a grand time full of fulfillment and rewarding. I hereby would like to take this opportunity to express my infinite and sincere gratitude and thankfulness to everyone who have helped and encouraged me all through the way.

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CHAPTER 1 INTRODUCTION

According to the U.S. Bureau of Labor Statistics (2015), most of the work in today's society requires some technical expertise, and in the next decade, this proportion is expected to increase to 77%. The U.S. Department of Commerce (2011) states that science, technology, engineering, mathematic (STEM) jobs will grow three times as fast compared to the non-STEM job market. From 2004 to 2014, STEM-related employment increased 11.4 percent while other job sectors increased 4.5 percent, and it is expected that this growth will continue this above average trend. In the United States, although the workers in STEM fields are in high demand, the number of undergraduate students receiving STEM degrees in 2012 was only 16%, and U.S. science graduates are ranked 38th among the 40 most developed countries (Science, Technology and Industry Scoreboard report, 2015). Under these circumstances, in order to remain competitive in the global market, it is important for the United States to better stimulate children's desire to explore and discover the world, and encourage them to participate in STEM courses.

In contrast, President Xi Jinping's "Chinese Dream" set a goal for China to become a world-class innovator by 2050. In order to achieve this goal and transition from a manufacturing-based economy to an innovation-driven, knowledge-based economy, the development of science and technology plays an important role (Han & Appelbaum, 2018). For China to become a global high-tech leader in industries, many professional graduates in STEM-related fields are needed. Under this social environment, the rapidly increasing job market for STEM professionals makes science education important in the world (ESA, 2011).

According to Andersson and Gullberg (2012), "science teaching is the development of children's conceptual understanding" and "children's early familiarity with scientific language can positively influence the development of scientific concepts and, thereby, scientific thinking" (p. 276). Moreover, science education in preschool not only contributes to children's learning and development, but also supports children's interest and curiosity in science related knowledge and improve their competence in learning science (Conezio & French, 2002). If children have a positive experience with learning science at an early age, it would increase their interests in learning science in the future (Worth, 2010). Although science education should be given continuously in every stage of education, preschool serves as the foundation for children to learn knowledge and skill; thus, it is necessary to begin science education at an early age.

Because young children are "natural scientists" and have the ability to observe, explore, and discover the world, it is an important period for them to form the cognition of the world (Worth, 2010). In addition, according to Piaget's (1964) theory of cognitive development, children develop knowledge and know the world through sensory and motor abilities before they reach the age of two. Young children have ability to ask questions and make predictions to perform cognitive skills, which is the basis of science thinking and learning (Sackes, 2014). The National Research Council (2012) concluded that if children are exposed to science as early as possible, they would have better performance in science study in the future.

Scientific learning experiences suitable for children's development can promote the early development of children's scientific knowledge and skills and lay the foundation for children's scientific study throughout their academic career (Sackes, 2014). Since children's curiosity will continue to develop, all the science related knowledge they have learned would increase their future success in learning science. In addition, for children, mastery of knowledge in science-related fields can influence their potential to pursue careers in this field and make them more competitive in the global market as they grow older. (Trundle, 2010). According to the National

Science Teachers Association (NSTA) (2014), early science learning can inspire children's interest and curiosity to explore the world around them, and it also could lay the foundation for their lifelong scientific study.

This study examined preschool children's science education, especially focusing on what teachers' practices were for developing children's knowledge and understanding of science concepts, and how teachers' verbal intervention during class affected children's learning in science-related knowledge. This study also compared preschool science education in China and the United States.

Statement of the Research Problem

Although existing research has discussed teachers' pedagogical practice in teaching children science, more research is needed to further explore if teachers' pedagogical practice in early childhood science education varies under different social and cultural contexts. Further, examinations of whether teachers' classroom discourse methods differ given their diverging teaching environments also requires further research. Particularly, it is still unclear whether the requirements, goals, and final implementations of early childhood science education in the United States and China are consistent. Additionally, a nuanced analysis of possible challenges experienced by teachers and kindergarteners during their learning processes of conducting science education also need to be represented in educational research. To respond to these research gaps, this research first investigated the factors that would affect teachers' pedagogical practices in teaching children science in the United States and China. In doing so, it explored different cultural and social contexts, teachers' training and experiences, kindergarteners' learning contexts, rules, routines, and the requirements of the science education framework/standards which impacted teachers' different pedagogical practices in these two countries. This research then examined teachers' pedagogical practices and classroom discourse methods that they used when they taught children science. I conducted classroom observations and interviews; these data sets aided the investigation of how teachers instructed children about science and conducted science-related activities in their classes, thereby unfolding the classroom discourse methods teachers used in teaching children science.

In terms of the context of early childhood science education in the United States and China, this research was informed by world system theory. World system theory was originally proposed by Fernand Braudel and Immanuel Wallerstein to explain the global expansion of capitalism and argued that almost the whole world is being integrated into a unified economic system (Clayton, 1998). Inspired by the world system theory, some comparative education scholars have explored the interactions between global economic, cultural forces, and local contexts in the field of comparative education (Arnove, 2009 & Clayton, 1998). Schools' investment in science education can increase professional and technical talents in the field of science, which may have a positive impact on the country's innovation and technological progress. Advanced technology can promote the development of the national economy, thereby enhancing the global competitiveness of the country (Drori, 2000). As one of the leading countries in the world, the United States views science education as an important factor for increasing national competitiveness (U.S. Department of Education, 2016). Since there is still very little research in the field of early childhood science education in China, this research utilized a comparison perspective and explored the differences of early childhood science education between the United States and China.

Additionally, this research also used sociocultural theory and activity theory; this aided analyses of teachers' pedagogical practices and classroom discourse methods used during children's instructional time related to science lessons. According to sociocultural theory, educational institutions are part of a social system--learning and teaching occur in different cultural contexts with different historical backgrounds (John-Steiner & Mahn, 1996). This comparative study explored the factors that affected teachers' pedagogical practices in teaching children science in the United States and China. Moreover, in terms of activity theory, it afforded lenses to unpack the interactions between human activities, human consciousness, and the context in which these activities take place (Jonassen & Rohrer-Murphy, 1999). According to Engeström (1987)'s model of an activity system, subject, object, tools and means, rules, community, and division of labor would all affect human activity. For this research, it applied this model as a tool to explore how cultural factors affected preschool teachers' science activities design related to their specific cultural and social backgrounds as well as what kinds of science activities were conducted by preschool teachers in these two countries.

In sum, the goal of this research is to explore the different approaches Chinese and U.S. early childhood educators use in teaching children science. This study focuses on what teachers' practices are in developing children's knowledge and understanding of science concepts. In addition, the intent for this research is to examine the interaction in the classroom between children and teacher, including what types of questions teachers ask to help children keep curiosity, and also what kind of words the teacher uses that are helpful in guiding children toward learning about science. According to Ravanis (2017), in terms of children's learning, teachers usually maintain a leadership role including "setting the working topics, proposing and presenting experiments and guiding the teaching activities, asking questions and giving the ‘right’ answers”, while the children in the process of learning follow the teachers, participate in the activities, and answer questions (p. 285). In addition, for science learning, it is important for teachers to provide an environment that include science activities in which children “explore, play and learn”, and during the process of learning, teachers should guide children by “supporting self-regulation skills, asking probe questions, focusing the children’s attention to causes and effects or helping them reflect on what was found” (Dejonckheere, et al., 2016, p. 539).

For children to learn science, adults play an important role in preparing the environment for scientific exploration and paying attention to the observation of children (NSTA, 2014). Adults should also provide time to discuss what has been done and what they have seen, which can make the best contribution to scientific learning. For this research, in order to explore early childhood science education, it is important to know how preschool teachers provide a study environment for children to learn science and how they design/modify their curriculum and activities during the process of observation/interaction with children to help the students improve their interests in learning science. According to Worth (2010), based on teachers' understanding of children's knowledge and the pedagogy they use to teach science, teachers play an important role in children's scientific knowledge learning. This research focused on how teachers’ pedagogy and practices, including active engagement, intervention, and activities/curriculum design that affected children’s science knowledge learning in the class. Furthermore, teachers’ language, especially academic language used and interaction quality in the classroom have important implications for students' learning processes and achievements, active engagement, learning motivation and interest formation (Sierens, et.al, 2009). Based on this reason, this research also focused on teachers' verbal intervention in teaching children science-related knowledge.

Research Questions

The research focused on the comparison of teachers' development of the science curriculum and pedagogical practices in early childhood science education in America and China. It specifically seeked to examine:

1) What principles/factors inform teachers' pedagogical practices in early childhood science education (cultural characteristics, the way early childhood teachers were trained & the policy by the countries' education ministry, teachers' understanding/belief towards early childhood science education)?
2) What are the science learning pedagogical practices of teachers in early childhood classrooms?
    a) What kind of science related activities do they create for their students?
    b) What is the nature of the discourse on the topics covered?

Significance of the Study

First, since people's interests come from their positive experiences (Fredrickson, 2001), early childhood educators play an important role in shaping the thoughts and opinions of children toward science, and the positive experience in learning science could motivate children to learn and explore more science-related knowledge. In addition, in order to provide effective science education to children, it is important for early childhood teachers to know which curricula and activities are effective for evoking children's interest in learning science. Since early childhood educators have great influence on a child's potential to seek out a career in science, based on the understanding of their attitudes and beliefs towards science education at the early age, it could to some extent benefit the future job market in science related field.

As a researcher, the understanding of early childhood education could give me a broad understanding about the process of education at early age, including which subjects early childhood education mostly focuses on, the development trend of early childhood education, and what gaps there are in current early childhood education research. Understanding of early childhood education processes could help me form my own research.

Organization of Chapters

This dissertation includes seven chapters. The first chapter provides a general overview of the study, including the background of the research problem, the major research questions, the significance of this research, and the organization of the chapters. Chapter two reviews the literature in four parts: the first part reviews early childhood education in the United States and China, including the backgrounds of early childhood education, the history of early childhood education, and the differences of early childhood science education in the United States and China. Further, the second part discusses the relationship between teacher-child interaction and early childhood education. Next, the third part reviews teachers' verbal and non-verbal intervention in the practice of teaching children. Lastly, the fourth part reviews teachers' practices in the development of children's understanding of science knowledge and concepts. Chapter three discusses the conceptual framework and theoretical framework that situated and informed this research, including world system theory, sociocultural theory, and activity theory.

Chapter four explains the methodology utilized in this study, introducing the school sites, participants, research methods, and the approaches of collecting and analyzing the data.

Chapters five and six present the analysis of the data, including the factors affecting teachers' pedagogical practices in teaching children science, teachers' pedagogical practices in teaching children science, and teachers' classroom discourse in teaching children science in the United States and China. Chapter five concludes the cultural characteristics, including teachers' professional training, family-school collaborative partnerships, and the learning contexts, rules, and routines in China that affected teachers' pedagogical practices during their science instruction. Moreover, this chapter also discusses the pedagogical practices in teaching children science in China that is teacher-centered and observation-oriented. In the end, this chapter presents teachers' classroom discourse in teaching children science in China. Compared with chapter 5, chapter 6 focuses on the factors affecting teachers' pedagogical practices in teaching children science, teachers' pedagogical practices in teaching children science, and teachers' classroom discourse in teaching children science in the United States. In the United States, teachers' professional backgrounds, Next Generation Science Standards (NGSS), children's interests, and classroom learning environments all affected teachers' pedagogical practices in teaching children science. Lastly, the pedagogical practices in teaching children science in the United States are more student-centered and inquiry-oriented.

Chapter seven is the conclusions chapter in which all the major themes are brought together to confer the similarities and differences of teachers' pedagogical practices in early childhood science education in China and America. It first concludes the requirements by the *Guide for 3- to 6-Year-Old Children's Learning and Development* framework and Next Generation Science Standards (NGSS) as well as the purpose and teachers' beliefs about early childhood science education in the United States and China. Further, it reveals the implementations of science education in the Chinese kindergarten and American kindergarten. Finally, this chapter discusses the gap between the requirements, the purpose, the teachers' beliefs about early childhood science education, and the implementation of teaching children science in China.

CHAPTER 2 LITERATURE REVIEW

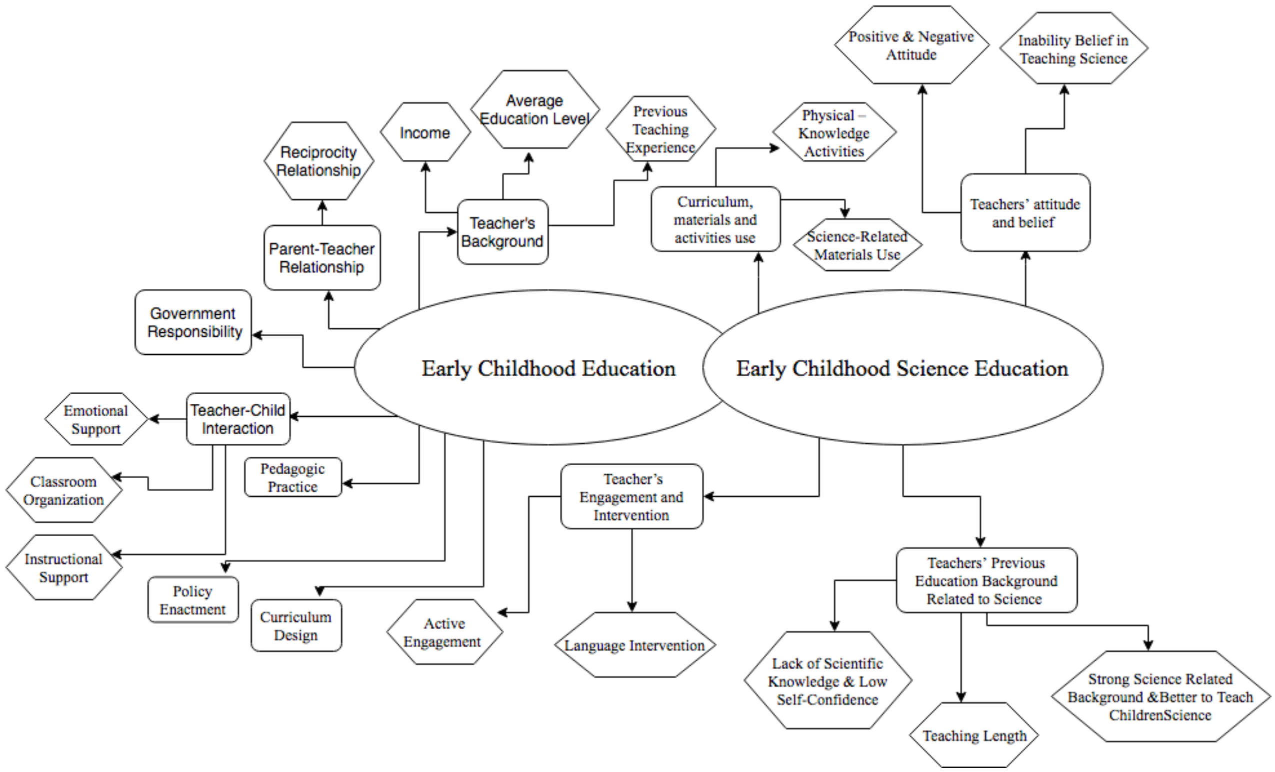


Figure 1. Literature Map

Early Childhood Education in the United States and China

In China, currently there are three types of early childhood education systems: nurseries, kindergartens, and pre-primary programs. Nurseries serve children under age three and mostly focus on children's physical care. Kindergarten serves children from ages 3 to 6, and rather than physical care, the purpose of kindergarten is to provide education preparation for children. In addition, kindergarten programs include three groups: K-1 (Xiao Ban) for 3- to 4-year-olds, K-2 (Zhong Ban) for 4- to 5-year-olds, and K-3 (Da Ban) for 5- to 6-year-olds (Zheng, 2010). Pre-primary programs are a part of elementary school education and serve children 6 years old, the year prior to first grade. In the United States, there are also three types of early childhood programs: daycare, preschool, and kindergarten. In contrast to China's system, kindergarten in the United States is included in elementary school education and serves children around 5 years old. Pre-kindergarten in the United States serves children one year before kindergarten and is the equivalent of the pre-primary program in China that provides preparatory education for elementary school. The daycare program in the United States is similar to nurseries in China that serve children under 3 years old and provides physical care. Preschool in the United States is similar to kindergarten in China which serves children from ages 3 to 6. Based on the difference, my research would focus on the kindergarten education between USA and China.

Formal preschool education in China began later than in the United States. Although the first kindergarten in China began in the early 1930s, it was modelled after kindergartens from other countries. In addition, during the Cultural Revolution in China, Chinese education suffered a serious defeat and was suspended, including preschool. It was not until the 1980s that the education system in China made a full recovery, and only after the 1990s did the government begin to pay attention to preschool education. In June 1989, the release of the Guiding Framework of Kindergarten Education (State Education Commission, 1989) was a milestone in china's preschool and early education (Chan & Mellor, 2002). In contrast, in the United States, the idea of early child education originated during the Industrial Revolution in the beginning of the 19th century. It was based in infant school, which was part of the local education for children aged 4 to 7 years old. In 1860, Elizabeth Peabody founded first English-speaking U.S. kindergarten in Boston, and Susan Blow opened the first public kindergarten in the United States in 1873. In the 1920s, the National Association for the Education of Young Children, dedicated to improving the quality of early child education for children from birth to age 8, was established.

Early childhood science education in China mainly focuses on teaching children ready-made concepts, but seldom focuses on developing children's ability to explore new scientific concepts, while in the United States, science education for children has broad concepts including the skills of scientific exploration processes, scientific knowledge, and scientific attitudes and values (Li, 2007; Worth, 2010). In China, early childhood science education is always teacher-centered in that teachers generally use whole-class lectures, demonstrations, and textbooks in teaching children science knowledge, and children learn scientific knowledge in accordance with instructions. According to Li (2007), teachers usually mechanically carry out teaching activities according to the requirements and steps of the syllabus, but lack independent innovation. In contrast, in the United States, early childhood science education is more child-centered in that teachers tend to use an inquiry-based instruction approach to develop children's ability to explore. Rather than educate children on what scientists are discovering, they prefer children understand the process of activities conducted by scientists and how scientists discover these processes (Li, 2007; Pang & Richey, 2007). Although China is now paying more attention to early childhood science education, there is still very little research in this area. Moreover, the lack of funds to support early childhood science education and the lack of professional teachers in this field will affect the development of early childhood science education in China (Li, 2007).

Early Childhood Education and Teacher-Child Interaction

Previous research in early childhood education has primarily focused on teachers' backgrounds, parent-teacher relationships, curriculum design, and pedagogic practice (Bueno, Darling-Hammond, & Gonzales, 2010; Edwards , 2003; Rouse & O'Brien, 2017; Saracho & Spodek, 2003; Setiawan, 2017). Among those studies, many pertain to the effect of teachers' practices on children's learning. Research on teacher's backgrounds tend to be centered around teacher's average education level, their income as an early childhood education teacher, and their previous teaching experiences (Bueno, Darling-Hammond, & Gonzales, 2010). For example, Setiawan (2017) found that teachers' teaching experience and education level affects their creativity in early childhood education. Moreover, according to Ravanis (2017), teachers usually maintain a leadership role in terms of children's learning, including "setting the working topics, proposing and presenting experiments and guiding the teaching activities, asking questions and giving the 'right' answers" (p. 285), while the children in the process of learning follow the teachers, participate in the activities, and answer questions. Parents and teachers form a reciprocal relationship around early childhood education. In order to promote children's education, besides providing knowledge and information for children, teachers are also the experts in child development and need to create an environment for both themselves and parents that could maintain a reciprocal relationship (Rouse & O'Brien, 2017). In terms of the curriculum design, early childhood teachers need to consider the different cultural backgrounds and learning experiences of the children in their classroom (Edwards , 2003). For the pedagogical use, rather than teacher-centered pedagogy where teachers provide knowledge to children, it is important for children to participate in the learning process, thus a child-initiated, teacher-facilitated teaching approach could improve children's interest in learning and could also enhance children's interpersonal skills (Schweinhart & Weikart, 1998). Involving children in the learning process could strengthen the interaction between teachers and students, as the teacher-child interaction is a critical factor that influences early childhood education (Schweinhart & Weikart, 1998).

In order to promote children's future social and academic development, high quality early childhood education plays an important role, and teacher-child interaction is a critical factor. This interaction is a measure of classroom quality, since the daily interaction between teacher and children promotes children's social, behavioral, emotional, and academic development (Hu et al., 2017). According to Hamre et al. (2014), there are three domains of teacher-child interaction: emotional support, classroom organization, and instructional support. The authors claim that if the teachers build a warm learning environment, children may more easily engage in the class activities and the emotional support from teachers could promote children's social and emotional functioning. Classroom organization refers to teachers' management of children's behavior, attention, and use of time that could maximize children's engagement in class, and if children are in a more organized classroom, it may increase their self-regulation. Instructional support refers to teachers' use of effective strategies that could improve children's thinking skills. According to Hamre et al. (2014), if a classroom has higher instructional support, children have a chance to gain more pre-academic skills. Leyva et al. (2015) argued that children in a more organized classroom with higher instructional support will have better ability in language, writing, and numeracy. All of these studies indicate the importance of the relationship between teacher-child interaction and children's outcomes in learning.

Teachers' Discourse Practice: Verbal and Non-verbal Communication

The strategies teachers use to communicate with students include both verbal and non-verbal communication. Both teachers' verbal and non-verbal immediacy has positive effect on "cognitive learning, student affect and behavioral intent" (Sanders & Wiseman, 1990, p. 341). In terms of verbal communication, teachers use words and sentences to convey information to students through speaking and conversation, and the words have power on the audience. It is important for teachers to use “clear, concise, accurate, polite, correct and rich” expression to transmit their intentions to students (Bambaeeroo & Shokrpour, 2017, p. 54).

Outside of verbal communication, most communication happens through non-verbal cues and sign language, such as eye contact, facial expressions, and gestures (Bambaeeroo & Shokrpour, 2017). Non-verbal language includes “eye contact, gestures, relaxed body position, directing body position toward students, smiling, vocal expressiveness, movement, and proximity” (Sanders & Wiseman, 1990, p. 342). Non-verbal immediacy has a positive effect in reducing physical and psychological distance between teacher and student, and if teachers include non-verbal immediacy in their teaching, it could increase students’ enjoyment of the course and could promote their perception of learning. Teachers who use non-verbal language properly have a better relationship with their students (Witt & Wheeless, 2001). Thus, in order to explore teachers’ practices, especially their discourse practices in teaching children, it is important to consider both teachers’ verbal and non-verbal communication with children.

Early Childhood Science Education

Andersson and Gullberg (2014) stated that “science teaching is the development of children’s conceptual understanding” and “children’s early familiarity with scientific language can positively influence the development of scientific concepts and, thereby, scientific thinking” (p. 276). Science education in preschool not only contributes to children’s learning and development, but also supports children’s interest and curiosity in science-related knowledge and improves their competence in learning science (Conezio & French, 2002). Teachers play an important role in promoting early childhood science education, and based on previous research, there are five main aspects of teachers' practices in the development of children's understanding of science knowledge and concepts:

a) Curriculum, materials, and activities used by teachers in early childhood science education
b) Approaches early childhood teachers use to facilitate children's learning about science concepts and vocabulary
c) Teachers' attitudes and beliefs about early childhood science education
d) Teachers' engagement and intervention in early childhood science education
e) Teachers' previous education background related to science in early childhood science education

Each of these will be described in more detail below.

Curriculum, materials and activities use for teachers in early childhood science education. Many previous studies pertain to the materials and activities early childhood teachers usually use to teach children science. For science learning, it is important for teachers to provide environment that includes science activities in which children "explore, play, and learn", and during the process of learning, teachers should guide children by "supporting self-regulation skills, asking probe questions, focusing the children's attention to causes and effects or helping them reflect on what was found" (Dejonckheere, et al., 2016, p. 539). Tu (2006) explored the availability of science related materials and activities for children in the preschool classroom, and found that science related materials were available and accessible for children in most classrooms, while only a few of the activities the teachers provided in the class were related to science. Based on this finding, Tu (2006) claimed that it was important for preschool teachers to understand different kinds of science, include science related activities in the class, and then make those activities available to children.

Research has also shown appropriate curriculum to be a good approach to teach children science knowledge. Rowell et al. (1999) introduced “science-through-technology curricula,” “learning in technology-centered classrooms,” “learning science by designing technology,” and “problem solving through technology” as useful approaches in the development of children’s science learning. Hjalmarson (2008) defined *curriculum* as not only the text in the textbook, but also as a pedagogical interaction where the teacher and students are using different materials to interact with each other. Worth (2010) stated that the selection of materials is important in teaching children science. He suggested that the materials selected need to be open ended and transparent because these kinds of materials are easier for children to understand and use by themselves.

Approaches early childhood teacher use to facilitate children’s learning about science concepts and vocabulary. Previous research about the approaches that early childhood teachers use to facilitate children’s learning of science concepts and vocabulary include the combination of responsive teaching (RT) and explicit instruction (EI) (Colgrove, 2012; Harlan & Rivkin, 2011; Hong & Diamond, 2012), using children’s literature to introduce science concepts to young children (Monhardt & Monhardt, 2006; Morrow et al., 1997; Sackes, Trundle & Flevares, 2009; Trundle & Troland, 2005), inquiry-based instruction (Dejonckheere, De Wit, Van de Keere & Vervaet, 2016; Duran, Ballone-Duran, Haney & Beltyukova, 2009; Oliveira, 2010; Samarapungavan, Patrick & Mantzicopoulos, 2011), and 3Hs education approach (Inan & Inan, 2015).

The RT approach is a child-initiated and child-directed instructional approach. In the RT approach, teachers provide the materials and opportunities for children to conduct activities by themselves, but do not directly lead the activities. During the activities, teachers observe what children are doing, answer children's questions, and give them implicit suggestions. The purpose of teachers using this approach is to encourage children to conduct self-directed activities (Colgrove, 2012; Harlan & Rivkin, 2011). For early childhood educators to teach children science concepts, vocabulary, and scientific problem-solving skills, it is better to combine the approaches of RT and EI (Hong & Diamond, 2012). With the RT + EI approach, teachers not only provide explicit instruction to children and teach them important science concepts and vocabulary, but also encourage children to explore and conduct child-directed activities by providing more materials and asking them challenge questions (Colgrove, 2012).

The second approach teachers could use to teach children science concepts is via children's literature. Children's literature includes picture books, fiction, and nonfiction (Monhardt & Monhardt, 2006; Sackes et al., 2009). Using children's literature to teach children science could make science concepts more meaningful for children since they could learn the concepts in context, making teaching and learning more relevant. Learning science concepts in a context that is familiar with children helps them make connections between those concepts and the real world or their daily experiences (Monhardt & Monhardt, 2006; Sackes et al., 2009). This approach also has limitations since there may be misconceptions and inaccurate illustrations in children's books. Because of this, teachers need to be cautious in using children's books in their teaching (Sackes et al., 2009; Trundle & Troland, 2005).

Compared to a traditional early childhood science classroom that focuses on the mastery of knowledge and testing whether or not children have learned the particular concepts, in an inquiry-oriented classroom, teachers focus on supporting children's problem-solving skills (Dejonckheere et al., 2016). With this approach, teachers provide opportunities for children that help them understand the world and the environment they live in, and build children's understanding by collecting evidence to test the results. It uses hands-on activities to stimulate children's interests, let children integrate into the whole learning process to enjoy science, help children deeply explore science related topics, and challenge children to express and share what they already know (Dejonckheere et al., 2016; Duran et al., 2009). Rather than answer children's questions directly, with inquiry-based instruction, teachers challenge students by throwing questions back to them and asking open-ended questions to stimulate children's answers in multiple ways (Samarapungavan et al., 2011).

The 3Hs education approach refers to *Hands-on*, *Heads-on* and *Hearts-on* science education (Inan & Inan, 2015). *Hands-on* means children's active engagement in science related activities. *Heads-on* means inquiry-based instruction where teachers ask children questions to stimulate their curiosity and interests in science. *Hearts-on* means interest-based education that represents children's enjoyment and love of science subjects. The design of activities in early childhood science education should include appropriate teacher support, an interesting learning environment, and allowing children to actively and happily participate in science-related explorations (Inan & Inan, 2015).

Teachers' attitude and belief toward early childhood science education. Previous research has shown that teachers' attitudes and beliefs toward teaching play a critical role in their classroom practices, including the quality and content of instruction (Ball & Cohen, 1996; Pendergast, Lieberman-Betz & Vail, 2017). Preschool teachers' positive or negative attitudes toward teaching children science affects children's learning and achievement about science related concepts (Koballa & Crawley, 1985). If preschool teachers consider themselves to lack ability in teaching science (belief), they may feel that they don't like science teaching (Pendergast et al., 2017). If preschool teachers hold the belief that science is a difficult subject to teach and they cannot succeed in teaching children science, then they may avoid teaching science as much as possible (Greenfield et al., 2009). Koballa and Crawley (1985) found that preschool teachers' negative attitudes towards science not only affects themselves, but also affects whether children have incomplete or incorrect information about science. In contrast, their positive attitudes toward science helps young children develop positive attitudes toward science, even for their future study and science related careers. In addition, Sackes (2014) found that teachers' beliefs about the children's ability in learning science at an early age also affects those teachers teaching science related knowledge. Sackes (2014) also noted that teachers' perceptions that young children are incapable of learning science concepts and knowledge may make them spend less time teaching science.

Koballa and Crawley (1985) argued that teachers' attitudes and beliefs affects their behavior in teaching science. If teachers think that they have no ability to teach scientific knowledge, they may feel that they don't like teaching science. Consequently, they may avoid teaching science as much as possible. The authors also claimed that teachers' negative attitudes and beliefs toward teaching science may result from their perception that science is a difficult subject, and also from their pessimistic feelings toward science learning during their own experiences with learning science.

Teacher's engagement and intervention in early childhood science education. In order to teach children science knowledge at an early age, preschool teachers play an important role as a facilitator and instructor in the classroom. Teachers' practices significantly affect the progress of students' school attendance, their learning achievements, and their socio-emotional development (Peguero & Shekarkhar, 2011). Park et al. (2017) revealed that teachers face certain difficulties when they conduct science activities. According to their study, the main reasons science instruction is not delivered effectively are 1) teachers' insufficient subject-matter knowledge and 2) too little time allocated for science activities and instruction. Therefore, it is important to understand how teacher's practices in the preschool classroom contribute to meaningful interaction with children. Kontos and Wilcox-Herzog (1997) found that teachers' roles in supporting children's learning science include socializing with children, modeling the behavior they want to teach, encouraging children's play activities, monitoring children's behaviors for safety, and asking questions to promote critical thinking.

Since early childhood teachers play an important role in children's science knowledge acquisition, much of the literature focuses on their interactions with children, including active engagement and effective intervention during the class. Because our daily life is closely related to scientific knowledge, such as why do people hear thunder after seeing lightning first, it is important for adults to help children learn science, including talking about what they see in their daily observations. These life experiences cannot contribute to science learning without adults' intervention (NAEYC, 2013). Since teachers can be seen as facilitators in the classroom, their interventions play a vital role in science-related learning activities and instructional design (Squire et al., 2003). Anderson-Pence (2017) found that teachers' active and useful guidance in interactions engages children in thinking, and that the teachers could also monitor classroom conversation and decide what to do for the next step in the process of interacting with children. The relationship between teachers' interventions, the tools used in the class, peers, and instructional design is interdependent and each of them affect students' conceptual development in learning science (Säljö, 2010). In addition, teacher's language intervention, especially academic language plays a vital role in providing children with sustained opportunities for science discourse by scaffolding students' language use during science activities (Mercer et al., 2004). Teachers' language use and interaction quality in the classroom have important implications for students' learning processes and achievements, active engagement, learning motivation, and interest formation (Mercer et al., 2004).

Teachers' previous education background related to science in early childhood science education. Preschool teachers' previous education background in a science-related field also affects their teaching of science related knowledge, since the lack of related knowledge reduces their confidence in teaching. According to Garbett (2003), teachers' knowledge reserve in some subjects affects their ability to make the content and ideas accessible to young children. The extent to which they understand the content impacts teachers' ability to ask meaningful and appropriate questions in guiding children's learning. Teachers' lack of scientific knowledge contributes to their low self-confidence, and promoting teacher training programs to help teachers learn science knowledge could improve their teaching about science related topics (Greenfield et al., 2009). In addition, teachers who have studied science concepts or has completed several science methods courses may be more likely to teach science because they have sufficient science knowledge and increased confidence in teaching science concepts (Sackes, 2014). The length of time a teacher has been teaching also affects their teaching performance. Experienced early childhood teachers are more likely to teach science than new teachers because they have confidence and ability to work with children (Sackes, 2014). Due to the lack of scientific knowledge and background, early childhood teachers may prefer to provide language and literacy teaching rather than teach math or science. Limited science instructional practice may also make those early childhood teachers feel unprepared to teach science (Greenfield et al., 2009). Hurd (1970) also said that a professional teacher who has strong science related background, who knows the meaning of science and also understands the pedagogy, is better suited to effectively use new curriculum in teaching children science.

Summary

Although existing research has begun to pay attention to curriculum design, science-related material use, science-related activities conduct, teachers' pedagogy use, and teachers' intervention in early childhood science classrooms, there are only few studies that compare early childhood science education. Since children's real-life experience is important in science learning, and curriculum and activities need to consider students' cultural characteristics, in this study, I explored the different science activities conducted in the classroom under specific cultural contexts in the United States and China. I also examined how these activities include cultural characteristics and consider children's experiences in order to involve children in. There are also few studies that focus on the teachers' interventions in early childhood science education, and even fewer on the conversations between teachers and children. For this research, I analyzed teachers' discourse while teaching children science in the classroom, especially focusing on the questions that teachers asked to stimulate children's curiosity about scientific knowledge, and the words teachers used in teaching children science. The detailed conceptual framework for this research discussed in the next chapter.

CHAPTER 3 CONCEPTUAL FRAMEWORK & THEORETICAL FRAMEWORK

Conceptual Framework

Teacher always maintain a leadership role as a facilitator and instructor in the process of children's learning (Ravanis, 2017), so in order to explore how teachers' practice will affect children's science knowledge learning, it is important to know how they design science related activities in the class and what kind of pedagogy they use in the process of teaching children science knowledge. Moreover, since early childhood teachers play an important role in children's science knowledge acquiring, so their interaction with children, including active engagement and effective intervention during the class also need to be considered. In terms of teachers' engagement and intervention, their academic language, such as the words they use and the questions they ask during the class play an important role in stimulating students' interest in learning science related knowledge and also could motivate students in learning science (Mercer et al., 2004). Based on the above reasons, for this research, it focused on early childhood science education in the U.S. and China, especially payed attention to teachers' practice, engagement and intervention.

Three assumptions form the framework of this research (see Figure 2):

1) If classroom teaching is more democratic with a more open-ended curriculum, the learning environment may be more flexible and children may have more space to explore the world to discover scientific phenomena around them; therefore, they could learn scientific knowledge in a way that is not available through textbooks.
2) If the classroom teaching is more directed with a structured curriculum, the learning environment may be more structured and children may learn science concepts and knowledge directly from teachers.

3) If teachers have appropriate intervention during the class, such as asking children questions to stimulate their curiosity about scientific knowledge, it may make children learn science better.

Since cultural characteristics, the way early childhood teachers were trained, and the preschool policies by the countries' education ministry differ between the United States and China, there may be different learning environments, curriculum design, teaching styles, and pedagogy used in these two countries. Under these circumstances, this research focused on the linkages between learning science and teachers' practices in preschool science education, with special attention on classroom teaching, curriculum design, and pedagogy use.

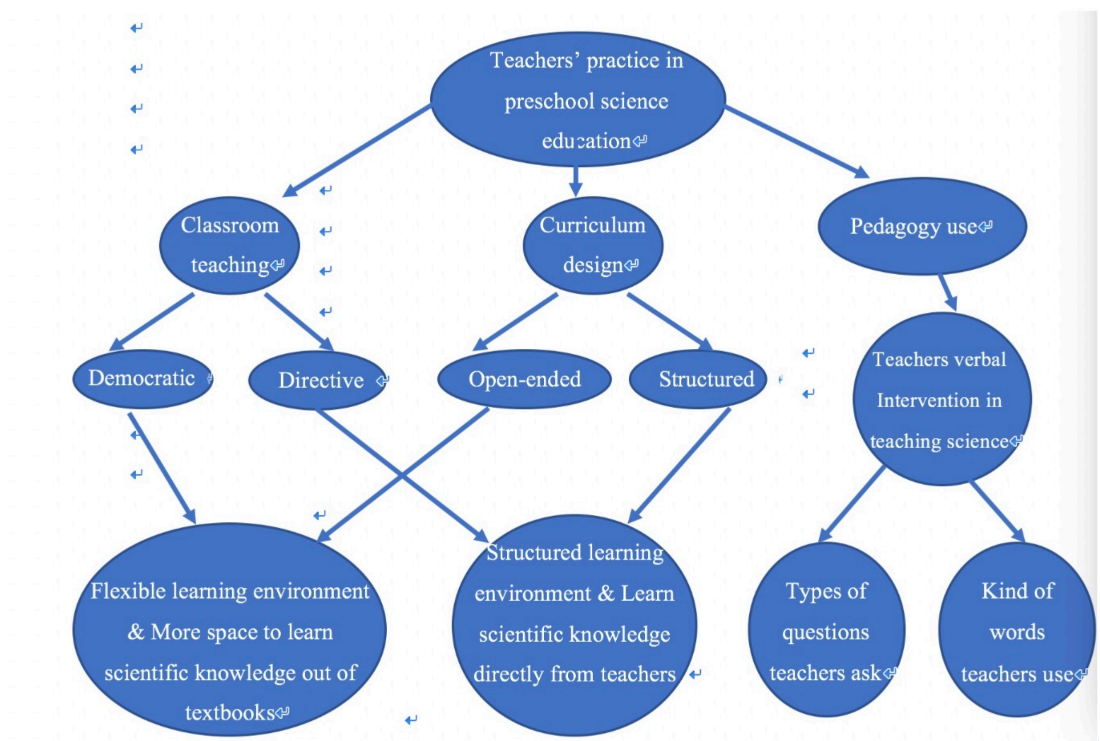


Figure 2. Factors that may Affect Early Childhood Science Education

Theoretical Framework

This research was informed by world systems theory, sociocultural theory, and activity theory. World systems theory contextualizes the importance of science education in the modern world. Under globalization, with the means of commodity, capital, and force, the core countries' control in the world system has changed from colonialism to advanced technology and skilled labor (Sorinel, 2010). Under these circumstances, promoting science education is necessary and important since economic development is associated with advances in technology. Promoting science education could increase innovation, which plays an important role in the development of technology (Lewin, 2000). Since the world system theory provides context at national level, this research also used sociocultural theory and activity theory to explore teachers' practice, including their curriculum design, pedagogy use, and intervention during the class in teaching children science. These three theories discussed in detail below.

World Systems Theory

According to Wallerstein (2004), there are three types of capitalist zones for the international division of labor, including core, semi-peripheral, and peripheral countries. Core zones are economically developed countries with flourishing manufacturing, advanced technology, skilled labor, and high investment that control world wages and monopolize the production of manufactured goods (Chirot & Hall, 1982). These countries not only control international trade through unequal division of labor, but also use the raw materials and cheap labor provided by the periphery regions to produce high value-added products, thus always occupying a monopoly position in the world market. Corresponding to the core countries are the periphery countries that provide cheap labor, original and primary products, such as agricultural products and labor-intensive products, for the modern world system. The semi-periphery countries are not only controlled by the core countries, but also could control the periphery countries (Sorinel, 2010). Increased global competition and economic power make countries move upward or downward in the world system (Chirot & Hall, 1982). The United States is situated in the core zone of the contemporary world-economy and leads the development and social division of labor market (Babones, 2015).

The United States has developed as a global leader based on its scientists, engineers, and innovators. As one of the leading countries in the world, the United States views science education as an important factor for increasing national competitiveness (U.S. Department of Education, 2016). Because quality basic science education has a positive effect on innovation and promotes sustainable development (UNESCO, 2001), it is important to develop science education in order to satisfy the requirement for the competitive global marketplace. The United States is striving to develop science education since it is directly tied to the technological advancement of the country. If the United States is continuously willing to be a global leader in technology and the economy, it is necessary to have students well-educated in science to help the United States have more scientists in the workforce, and more importantly, develop more technological advancements. For this research, an understanding of world systems theory made me think about whether promoting science education in China is also a requirement under global competitiveness, and whether developing science education is a need for China to move upward to a position of economic leadership in the world in comparison to the United States.

According to Drori (2000), investment in science education in schools could increase the professional and skilled talents in the field of science, which may have positive effect on innovation and technological advancement of the country. The advanced technology could promote national economic development, thereby increasing the country's global competitiveness.

In order to conduct a comparative study of education systems, scholars need to focus on the interactions among social context, cultural background, and the global economy (Arnove, 2009, p. 101). To understand today's education system trends, world system analysis is an important guideline to do the research "from curriculum reform to the language of instruction, and the outcomes of school expansion," and the world system analysis could also enhance "our understanding of the sources of change and conflict in the micro system of school and classroom" (Arnove, 1980, p. 62; 2009). This research not only focused on the macro systems: the education policies and systems in both the United States and China that affect preschool children's educations. It also attended to the micro factors of teacher's classroom practices, including curriculum design, pedagogy, and language use, using world system analysis as a guideline. Taking the world system analysis perspective, especially for semi-peripheral and peripheral countries, educational reform and classroom interaction are affected by core countries and reflect imposed "values, languages, institutional forms, and practices" from core countries (Arnove, 1980, p. 62). For this research, since the United States is a core country while China is a semi-peripheral country, it is important to understand the differences in teachers' practices in teaching children science in these two countries and to further explore whether curriculum design, pedagogy use, and language use in teaching children scientific knowledge in China has been influenced by the United States.

Science education in school has a positive effect on national economic development (Drori, 2000), thus this research focused on science education at the early age. In particular, I conducted a comparison study between the United States and China.

Sociocultural Theory

According to John-Steiner and Mahn (1996), taking a sociocultural perspective, human activities occur in cultural contexts and are mediated by different languages, tools, and signs. In order to understand human activities, researchers need to take human activities' historical development into consideration. Since education institutions are part of a social system, and learning and teaching occur in different cultural contexts with different historical backgrounds, it is important to consider "economic, political, historical, social, and cultural factors" in studying teaching and learning in these contexts (John-Steiner & Mahn, 1996, p. 204; Packer & Goicoechea, 2000). Children's mental development is influenced by the different social and cultural backgrounds they live in (Lantolf, 1994). This research acknowledged the importance of considering the interaction and relationship between teachers and children and explored how preschool teachers use different approaches related to children's literacy to teach them science knowledge under different cultural and social contexts.

Human actions, both social and individual, are mediated by semiotics (tools and signs), among which Vygotsky (1981) includes "language; various systems of counting; mnemonic techniques; algebraic symbol systems; works of art; writing; schemes, diagrams, maps and mechanical drawings; all sorts of conventional signs and so on" (p. 137). Understanding how semiotics affect human actions is important in exploring how teachers' classroom language interventions, activities design, and learning environment affects children's learning of science knowledge. This understanding may also inform how the design of activities and the use of different tools in these activities affect children's science knowledge learning. Classroom setup can greatly affect students' attitudes towards learning and study habits. Classrooms are set up in different ways to meet the different learning needs of students and also to suite the design of classroom activities. Cultural characteristics in different contexts would also affect the learning environment setup and the teaching approaches. An open culture tends to bring more communication and interaction, and the learning environment in this cultural context tends to be more flexible (Barnhardt, 1981). Teachers' teaching will be more democratic, meaning that they will have more communication with students and will provide students more space to think and express their ideas. On the other hand, in a relatively conservative cultural context, the learning environment tends to be more structured in that teaching is usually teacher-centered (Flores & Day, 2006). Under these circumstances, it is important to understand how different cultural backgrounds affect teaching approaches and the learning environment setup in teaching children science. In terms of this comparison study, I explored whether the different cultural characteristics in the United States and China affects their classroom settings and teachers' use of pedagogy in teaching children science, such as a flexible classroom with a conservative classroom, and a teacher-centered pedagogy with a child-centered pedagogy.

Sociocultural theory not only focuses on the impact of adults and peers on personal learning, but also pays attention to how cultural beliefs and attitudes influence the instruction and learning (John-Steiner & Mahn, 1996, p. 204; Lemke, 2001; Packer & Goicoechea, 2000). Understanding of sociocultural theory is helpful in understanding the potential differences in pedagogical approaches Chinese and U.S. teachers used in teaching children science, and in order to know how teachers from different cultures understand science education.

Activity Theory

According to Jonassen & Rohrer-Murphy (1999), any activity needs to be analyzed inside the context where it happened. Activity theory explains the interaction among human activities, human consciousness, and the relevant environments in which those activities have occurred. In the process of analyzing human activities, we should not only examine "the kinds of activities that people engage in," but also "who is engaging in that activity, what their goals and intentions are, what objects or products result from the activity, the rules and norms that circumscribe that activity, and the larger community in which the activity occurs" (Jonassen & Rohrer-Murphy, 1999, p. 62). All of these factors are part of the activity system that is important in exploring teachers' practice in the process of learning. According to Engeström (1987)'s model of an activity system, there are six correlative factors that would affect human activity: subject, object, tools and means, rules, community, and division of labor. Activity theory can be used to describe and analyze how a human activity is shaped by its cultural context in a system of practical activities (Bakhurst, 2009). I used it as a tool to explore how cultural factors interact with preschool teachers in the formation of science related activities.

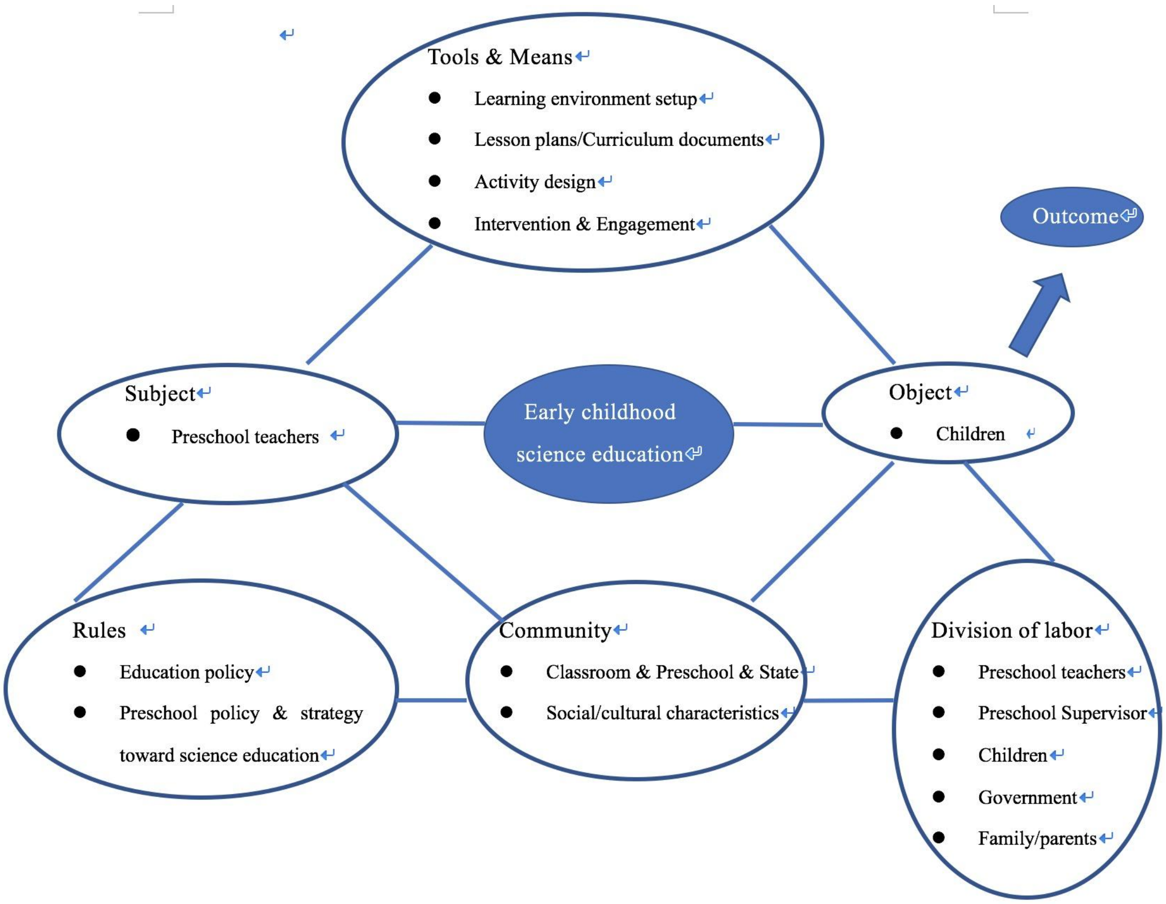


Figure 3. Activity System Model of Early Childhood Education. Adapted from Perspectives on activity theory (p. 30), by Y. Engeström, R. Miettinen and R. L. Punamäki, 1999, Cambridge: Cambridge University Press.

The production of an activity contains "a subject, the object of the activity, the tools that are used in the activity, and the actions that will affect the outcomes of the activity" (Jonassen & Rohrer-Murphy, 1999, p. 62-63). The *subject* of an activityis be an individual or group of people who has conducted the activity, and the *object* acts according to the subject and reflects the intent of the activity. The tools used in the activity could be anything that acts as a medium in the process of the subject acting on the object, and in order to achieve the goal of an activity, there is a chain of actions (Jonassen & Rohrer-Murphy, 1999). For example, in the context of this research, preschool teachers (subject) apply different tools and means (curriculum/pedagogy/language) to children's science education (object). The outcome of children's science education could also be influenced by different preschool policies and cultural characteristics. This research focused on the learning environment setup and tools used in conducting science related activities by preschool teachers in both China and the United States. Since the subject of a human activity could be “an individual or a group of actors in the activity,” in order to analyze human activity, it is important to know who is engaged in the activity and what their goals and intentions are (Jonassen & Rohrer-Murphy, 1999, p. 63). Based on this, in order to explore the science related teaching process, it is important to understand teachers’ (subject) goals and intentions in designing science related curriculum and activities and also the effect of the teachers’ interventions during their interactions with children (object).

This research conducted in two countries with different social and cultural backgrounds. Understanding the development of preschool education policy and the cultural characteristics of these two countries could give me a framework for analyzing early childhood science education under different social and cultural backgrounds with specific education systems and policies. The use of activity theory helped me explore effective pedagogy/approaches that preschool teachers used in teaching children science knowledge in both China and the United States. It also helped me answer the following questions:

- What kind of science activities are needed for preschools in these two countries under the specific cultural and social backgrounds?
- What is the different understanding of science education for the preschool teachers in both China and America?

CHAPTER 4 METHODOLOGY

The goal for this research is to explore the different understanding of early childhood science education between the U.S. and China, and also the different approaches early childhood educators use in teaching children science between the U.S. and China. Although science education is included in preschool education, primary education, secondary education and higher education, this research chose preschool education because children in their early age are usually "natural scientists" and have ability to observe, explore and discover the world, it is an important period for them to form the cognition of the world (Worth, 2010).

As this research focused on the interactions between teachers and children, and also payed attention to teachers' practice and understanding about early childhood science education, I adopted qualitative methodology, which aims for "understanding the meaning people have constructed, how people make sense of their world and the experiences they have in the world" (Merriam & Tisdell, 2015, p. 15). In terms of using qualitative research method, for this research, I used both video-based observations and interviews, including video-cued interviews, as my main approach.

Site Selection

United States. One of a public university affiliated preschool located in Los Angeles, California was chosen to be the ethnographic site. As one of the largest cities in the United States, there are around 4 million people live in Los Angeles (US Population statistics, 2017). In terms of children, there are over 1 million children who are age 3 to 5 and around 3 million children who are under 6 years old in California in 2016 (Kidsdata.org, 2016). In Los Angeles, there are about three hundred and ninety thousand children who are age 3 to 5 and around eight hundred thousand children who are under 6 years old in 2016 (Kid.sdata.org, 2016). In terms of preschool education, in 2014, there are 39.6% of children who are age 3 to 5 not enrolled in preschool or kindergarten. (Kidsdata.org, 2016). From 2016 to 2017, California provided childcare and preschool education subsidies to 434,000 children (Taylor, 2017).

Particularly, this preschool was open to research and video-taping. In terms of this preschool, it focused on science education and inquiry-based instruction, and it also provided professional development programs for teachers, so teachers in this preschool could be especially well prepared to teach science. Based on the above reason, this preschool located in Los Angeles could be the best case scenario for me to do the research about teachers' understanding and practice about early childhood science education.

China. One public preschool located in Beijing was chosen to be the ethnographic site. As one of the largest cities in China, there are about 20 million people live in Beijing in 2017 (National Bureau of Statistics of China, 2017), and there are about seven hundred thousand children who are under age 6 in Beijing based on the sixth nationwide population census in China in 2010. In addition, at the end of 2017, the number of preschools in Beijing has reached 1,957, with about 70,000 faculty members. The number of children in the preschools has exceeded the historical peak level, reaching 446,000 (Zhang, 2018). However, the demand for preschool education in Beijing is still in a period of rapid growth in the next few years, and preschool education still faces the problem of insufficient supply of resources. According to the actual number of births from 2015 to 2017 provided by the Beijing Municipal Health Planning Commission, by 2020, there were 455,000 registered school-age children and 280,000 non-registered school-age children in this city. According to the 85% admission rate required by the Ministry of Education, the city will still face about 170,000 degree gaps. In 2017, the financial investment of preschool education in urban areas in Beijing was 7.818 billion yuan, which was 3.4 times higher than that in 2011. (Zhang, 2018).

As far as China is concerned, in 2001, the Ministry of Education promulgated the "Guidance of Preschool Education". For the first time, "Science" was officially included in the content of preschool education. At present, China has established an implementation system for early childhood science education. Chinese preschools currently focus on five major areas: social field, health field, language field, art field and science field. As the capital of China, many preschools have begun to popularize and implement science education. Particularly for this preschool in Beijing, it was a lab school that focused on the research of child development and early childhood science education, and especially, it was one of the preschool children's astronomy enlightenment practice education bases in Beijing. In addition, the teachers in this preschool were well prepared and this preschool have a professional teacher team Therefore, it was a best case scenario to study preschool science education in China.

Summary. Since both Los Angeles and Beijing have the similar and great demand for preschool education, and both of these cities began to pay attention to early childhood science education, my research focused on the preschools located in these two cities.

The two preschools selected in both Los Angeles and Beijing satisfied these conditions: Firstly, the principles of schools welcomed and supported the researcher to do fieldwork; secondly, both of the preschools were lab school that focused on doing research about children’s education, especially payed attention to early childhood science education. Since this research explored teachers’ understanding and practice about early childhood science education, preschools focused on science education could be the best research site for me to compare early childhood science education in the United States and China. In addition, since these two preschools had well prepared teachers, so my research findings were not confounded by poor preschool pedagogy or under-prepared teachers.

Data Collection

Several methods were used in this research to collect data. They included content analysis, classroom observation, semi-structured interview and video-cued interview with teachers. Data collection lasted from October 2019 to March 2020. First, I contacted the supervisors from the preschools both in the United States and China by sending them email to get their permission to do research in their schools, then I contacted the course instructors to get permission also by email. And when I got permission to observe the course, I asked the teacher if they wanted to participate. In the end, when I confirmed my participants, I asked them to sign the consent form (See *Appendix 4*) and first got approved by the Institutional Review Board (IRB) at UCLA.

Content Analysis

According to Holsti (1969), content analysis is “any technique for making inferences by objectively and systematically identifying specified characteristics of messages" (p. 14). This research technique making inferences by interpreting and coding textual materials, such as newspaper, speeches, films, videotapes, documents and graphics (Holsti, 1969). In terms of the six stages of conducting content analysis, it includes formulate the research question, decide on units of analysis, develop a sampling plan, construct coding categories, coding and intercoder reliability check, and data collection and analysis (Neuman, 2011).

Content analysis in this research was mainly used to understand the two countries' intentions in early childhood science education curriculum and what kinds of science education are promoted by the two countries. The Next Generation Science Standards Systems Implementation Plan for California published by the California department of education in 2014, the Guidance of Preschool Education in China published by the Ministry of Education in China in 2001, and the Guide for 3- to 6-Year-Old Children's Learning and Development published by the Ministry of Education in China in 2012 were analyzed.

The reason to choose Next Generation Science Standards Systems Implementation Plan for California is that the purpose for this plan was to update school curricula to incorporate science and engineering practices into everyday teaching. In addition, for the Guidance of Preschool Education in China, it was the first time that "Science" was officially included in the content of preschool education. And in terms of the Guide for 3- to 6-Year-Old Children's Learning and Development, it mentioned that the core of early childhood science education is to stimulate children's desire to explore and cultivate their inquiry ability. And this guide also emphasized that adults should be good at discovering and protecting children's curiosity, make full use of natural and real life opportunities, and guide children to learn to discover, analyze and solve problems through observation, comparison, operation, experiment and other methods.

Observations

In each preschool, I followed two teachers' classes for their different experiences in educational background, their different teaching approach and teaching style. I assumed teachers' different educational background and understanding of early childhood science education would affect the approach they used in teaching children science. And the children were at the same age in both classrooms.

First, I asked permission to video and record what happens during a class. Since it was difficult for me to notice every interaction between children and teachers, using a video camera helped me record these interactions that show teachers' verbal intervention in teaching science during the class. I set up the camera to specially focus on teachers and recorded their behavior, speech, and interaction during the class. I also used a timesheet (See *Appendix 1*) to record the time, participant name, and what happened during the class, such as participants' interactions with children. I also observed activities outside the classroom since the extracurricular activities were also part of school education that could affect children's scientific knowledge learning. I also asked permission to video these activities and how these children interacted with teachers during the event. Using videos and time sheets helped me document what happened in the class and outside activities. I used these during data analysis to determine what information was useful for research purposes.

Interviews

For the interviews, I conducted four individual semi-structured interviews for the four teachers with whom I did classroom observation in the United States and China. The interviews helped me deeply analyze their understanding of science education and their approaches to teaching science. Each interview lasted 60 to 90 minutes and have been audio-recorded and transcribed by myself. All of the interviews were scheduled at a time and location convenient for the participants. Each of the interview had a guide with a list of questions that have been covered during the conversation, but the questions were flexible and have been edited during the interview process. The questions were open-ended and allowed flexible discussion with interviewees.

According to Seidman's (2013) methods, interviews begin with asking the participants to tell as much as possible about their background information or life history, including their previous education background, their hobbies and the length of time they have been a preschool teacher. This background information helped me understand the teachers' previous experience related to science and science education. In addition, since teachers influenced the results of children's scientific knowledge learning, I continued asking open-ended questions to explore their understanding of early childhood science education, their interpretations of the goals of teaching children science, and their experiences with teaching children science. For all of my follow-up questions, I attempted to get my interviewees to more deeply discuss ideas based on his/her answer. Detailed interview questions can be seen in *Appendix 2: Interview Questions for Teachers.*

Video-Cued Interview

I also used video-cued interview to deeply know what happened in the class and teachers' understanding about early childhood science education (Tobin & Davidson, 1991). In this method, I was: (1) videotaped a day in the class of preschool in both America and China; (2) edited the videotape down to 20 to 30 minutes that focused on the science education activities in the class and also the conversations between teacher and children; (3) showed this edited tape to the teacher in whose classroom I have filmed; (4) asked the teachers their purpose/objective to conduct the activities and conservations, and also the result they expected to achieve after the activities and conservations. Since some questions were too abstract and difficult to answer, such as "what is your understanding of early childhood science education", or "how do you conduct science related activities in the class", so after showing teachers a scene from the video, I asked teachers follow-up questions based on what happened in the video, and also explored teachers' understanding and belief about early childhood science education.

Table 1 summarizes the data collection methods relating to research questions.

Table 1 Research Questions and Research Methods

Research Questions	Methods
What principles/factors inform teachers' pedagogical practices in early childhood science education (cultural characteristics, the way early childhood teachers were trained & the policy by the countries' education ministry, teachers' understanding/belief towards early childhood science education)?	**Interviews & Video-Cued Interviews** - 4 teachers with whom I conducted classroom observations.
	Observations - Classroom observations; - Science education related activities outside the classroom.
What kind of science related activities do they create for their students?	**Interviews & Video-Cued Interviews** - 4 teachers with whom I conducted classroom observations.
	Observations - Classroom observations; - Science education related activities outside the classroom.
What is the nature of the discourse on the topics covered?	**Observations** - Classroom observations; - Science education related activities outside the classroom.

Data Analysis

Data analysis began during the data collection. First, based on my videotaped observations from the classes and activities and also the notes I have taken during the observations, I wrote field notes immediately after each observation. The field notes included the date, time, and place of the observation, a detailed description of the classroom environment, and details of what happened during the classes and activities, such as the interaction between teachers and children, specific words or phrases teachers used in teaching children science knowledge, and the development of science related teaching and activities. I also incorporated non-verbal cues, such as body language and eye contact about my participants into my field notes. For all of the field notes about my observations, they helped me remember what happened during the classes and activities.

I transcribed the audio recordings for each of my interviews. Each transcript has been provided to teachers for member check to verify the findings that are transcribed by me. According to Maxwell (2013), member check also refers to the respondent validation that is a strategy always use in qualitative research to receive feedbacks of the data from the informants. The purpose for member check is for participants to check if the researcher accurately captures the meaning of what they have said and interprets it without researcher's bias and misunderstanding. Member checks provide an opportunity for participants to correct errors/misunderstandings in the transcripts, prevent personal bias from the researcher, and improve validity for the research (Maxwell, 2013).

I then reread my observation field notes and interview transcripts to start my data analysis process by coding (Maxwell, 2013). First, I coded the data that was more descriptive. In terms of my observation field notes, I coded the data related to the detailed description of classroom environment, and the details of what happened during the classes and activities between teachers and children. In the interview transcripts, first I coded teachers' descriptions of their understanding of science education in preschool, their description about the design of science related curriculum and activity, and also their description of experiences in teaching children science. Second, I focused on the *emotion coding* and *value coding* (Saldaña, 2015). According to Saldaña (2015), *emotion codes* are the recall and/or experience from the participants, and also could be the emotions of the participants that are inferred by the researcher. And for *value codes*, it reflects participant's "values, attitudes, beliefs, perspectives and worldview" (Saldaña, 2015, p. 131). In terms of my research, I payed attention to the data that related to teachers' feelings about teaching children science knowledge and also teachers' attitudes and beliefs about early childhood science education. After the first cycle of coding work, I grouped those codes into a smaller number of categories and themes, and then I wrote the analysis/reflection for each category of the codes, which was helpful in writing the final research paper. Table 2 below summarized how I analyzed the data and what kind of categories of codes I have collected.

Table 2 Categories of Codes

	Methods	Categories of Codes
Cultural characteristics	Observation Interview Video-Cued Interview	Classroom setting/design; Teaching style: teacher-centered/child-centered; The way they conducted science-related activities; What kind of science-related activities they conducted and for what purpose; The topics covered for scientific knowledge; The conservation between teachers and children.
The way early childhood teachers were trained	Interview	Educational background; Any training programs they have attended.
The policy by the countries' education ministry	Content Analysis	The Next Generation Science Standards Systems Implementation Plan for California; The Guidance of Preschool Education in China;

		The Guide for 3- to 6-Year-Old Children's Learning and Development in China.
Teachers' understanding/beliefs	Interview Video-Cued Interview	Difficult/easy in teaching children science; Negative/positive attitude in teaching children science; Children have/do not have ability in learning science; Well-prepared/ unprepared in teaching children science; Necessary/unnecessary for early childhood science education.
Pedagogy practices	Observation Interview Video-Cued Interview	Classroom setting/design; Science-related activities design; Conservation between teachers and children; The questions teachers asked to lead a science-related activity and to inspire children's curiosity; The words/phrases teachers used in the process of conducting science-related activities.

CHAPTER 5 TEACHERS' PEDAGOGICAL PRACTICES IN EARLY CHILDHOOD SCIENCE EDUCATION IN CHINA

In this chapter, I articulate how this research study examines multiple factors impacting teachers' pedagogical practices in early childhood science education in China. First, this chapter will discuss the cultural characteristics that affect the ways teachers' shape and implement their pedagogical practices, particularly given their professional backgrounds and the strong role of familial influences on the structure of schooling in China. Next, this chapter will provide a portraiture of the discourse analysis conducted in collaboration with the research participants in this study to showcase examples of teachers' pedagogical practices in early childhood science classrooms.

Factors Affecting Teachers' Pedagogical Design In Early Childhood Science Education

The results of this study revealed a multiplicity of factors that influence teachers' pedagogical strategies in early childhood science education in China. Four salient findings emerged, including: the role of cultural characteristics (i.e. teachers' professional training) influencing teachers' pedagogical approaches, the role of family's in shaping teachers' practices, and the ways in which school-based policies influence teachers' pedagogical methodologies. Moreover, in-depth discourse analysis aids in contextualizing the dynamics of active learning processes that occurred between science teachers and students.

Cultural Characteristics

Early childhood science education in China is primarily shaped by the sociocultural contexts (i.e. histories, traditions, and values) and cultural characteristics prevalent in this geographic region. At the classroom-level, cultural characteristics distinct to China also influence aspects of teachers' professional training. Teachers' cultural heritages and professional training also informs the ways teachers design their syllabi, select curricular texts, and scaffold their pedagogical approaches. Moreover, findings indicate that parental and familial influences also hold much power in influencing teachers' practices at the school-level, particularly in terms of classroom learning design, content selection, etc. The following sections will describe how cultural characteristic factors affect early childhood science teachers' pedagogical practices in China.

Teachers' Professional Training

Teachers in elementary childhood education in China, particularly in the kindergarten context, do not need to complete a teaching certificate in a certain disciplinary subject. However, aspiring kindergarten teachers instead are required to obtain a teacher certification issued by the local education bureau. In order to gain clearance to teach kindergarten from the local education bureau, individuals who aim to teach kindergarten must complete the Kindergarten Teacher Certification test which primarily examines professional ethics, basic literacy, and theoretical/practitioner-level knowledge to support preschoolers academically and holistically.

However, in terms of early childhood science education, kindergarten teachers are not required to complete disciplinary training in order to teach science in kindergarten classrooms. In turn, many kindergarten teachers lack formal science education which could present difficulty in terms of content knowledge and pedagogical approaches to support early learners' developmental and disciplinary foundations in science education.

Moreover, it is important to note that the majority of kindergarten classrooms in China typically have two teachers responsible for classroom learning and management. For example, one teacher is often responsible with instructional tasks (e.g. daily teaching of math, science, reading, writing, and other subjects) whereas the second teacher is mainly responsible for social-emotional and holistic supports for students' well-being.

Within this research study, I collaborated and conducted interviews with two kindergarten teachers. One teacher graduated from a preschool education program and they also are passionate about music. The other teacher graduated a program with an emphasis on physical education and they are invested in sports. Yet, the research findings indicated that both teacher participants lacked a strong command of disciplinary content knowledge in early science education.

Family-School Collaborative Partnerships

"Family-School Cultivation" is an important concept in Chinese early childhood education at this stage. The "Guidelines for Kindergarten Education (Trial)" states that families are important partners of kindergartens. Based on the principles of respect, equality and cooperation, kindergartens should strive for the understanding, support, and active participation of parents. Further, students need to actively support and help parents to improve their educational ability. The starting point of kindergarten parents' work is to make full use of parental resources to achieve family interaction, cooperation, and common education. Under this circumstance, parents were often involved in the daily instructional practices of teaching science to kindergarteners.

Parents Participation in Kindergarteners' Classroom Learning

In kindergarten classrooms in China, parents are often invited to serve as teaching assistants to support instructional exercises to expand children's' scientific knowledge development. Given the strong cultural characteristics of China which value the wisdoms of parents, guardians, and elders, it was imperative to acknowledge the vast role that parents play in fortifying kindergartener's technical and experiential science dispositions. For example, during an interview with the teacher participant from classroom four, the teacher discussed: "our kindergarten promotes teaching assistant activities, and we must integrate home and school to cultivate children's' interest. Our teachers' stimulation of science, including guidance, is lacking, so how can we use external resources, parents' resources, and let the children share these kinds of resources is very important to us."

Since there are some parents who hold occupations in science-related fields or some have prior educational-training in science, many preschools ask parents to contribute instructional contributions to increase kindergarteners' scientific knowledge. However, the curriculum for early childhood science courses fluctuates based upon what prior knowledge and field experiences parents bring into the science classroom. During my observations in the kindergarten classrooms, I observed a course about lightning disasters and the greenhouse effect; this experience was particularly unique as there was a heavy influence from a parental teaching assistant who worked with the China Meteorological Bureau. Additionally, during this course, one child's mother and her colleague taught children about meteorology. In the beginning of the class, they played a cartoon about lightning disasters to teach children about protective metrics against lightning strikes. After the video, they asked children about what they have learned from this multimodal text. Next, they taught children about the greenhouse effect; they asked the children to do an experiment called, “weather station.” During this experiment, they asked students to observe and record weather phenomena with their own multifunctional weather station. The weather station kit featured: a wind vane, an anemometer, a thermometer, and a rain gauge. Also, the children conducted an experiment about the greenhouse effect through participatory learning approaches, ultimately they created a terrarium in a bottle. During this experiment, many children had difficulty with the technical skill of crafting a weather station independently, especially given this process required the usage of screwdrivers and other tools. The children could not complete the experiment without the teachers’ help. Moreover, the time constraints of the class period also presented a precarious situation to be able to have enough time for students to complete their experiments. Given these constraints, the students’ experiments were not completed during the class. Instead, the teachers asked the children to complete their experiments with parental guidance and supervision at home. Collectively, the results of these classroom observations afforded insights into the challenges of incorporating parental teaching assistants in the classroom in two areas. First, parents who do know have the formal training to understand the cognitive learning capabilities of kindergarten children led to limitations in students’ understanding their pedagogical approaches to teaching science curriculum. Second, there was a disconnect between the early communication between parents and teachers. Given the lack of clarity between teachers and parents about instructional time, this presented difficulties in the sequencing of activities and scaffolded pedagogical approaches to conducting successful scientific experiences with early learners. For instance, during my interview with the teacher from class four, she shared:

> I think parents because they are not professional, they don't know what children at this age are good at, but they are willing to participate, this can be used for reference.

> But there are some places that we need to cut in the later stage. For example, what class is really suitable for kindergarten, and what aspects should parents focus on when they are teaching. We need to be more direct and communicate more with parents to see if the content prepared by parents is too difficult and what needs to be modified, so that our parent teaching assistants may be more successful.

Including parents as teaching assistants in the kindergarten classroom could contribute to scientific disciplinary knowledges of teachers. However, it is evident that strong communication between parents and teachers are necessary in order to convey the developmental appropriateness and scaffolded techniques to teaching science to early learners. By drawing upon parental involvement, teachers can bring in parents as external experts in scientific-related knowledge and occupational fields. Yet, there must be a reciprocal partnership where teachers and parents can work together to support both kindergarteners' cognitive learning processes in conjunction with their developmental learning styles and preferences. Therefore, in order to strengthen successful parental involvement between classroom teachers, parents, and students requires improved communication about instructional and pedagogical design that meets students cognitive and developmental capabilities.

Parents' Participation in Afterschool Learning Programs

Besides parents' participation in kindergarten classroom teaching, kindergarten teachers also ask parents to participate in many afterschool activities. There are three teachers in each of the afterschool classes. One of the teachers is responsible for supporting students' socioemotional well-being whereas the other two teachers are responsible for instructional and pedagogical afterschool learning. Additionally, the afterschool class design often includes twenty-five children per classroom. This often raises challenges for the classroom teachers given the number of pupils especially when completing scientific experiments. Typically, each afterschool science class lasts for approximately 25-30 minutes. In this limited time, it is difficult for the teacher to guide each child and help them complete the experiment. It is necessary for the children to complete the rest of the experiment with the help of their parents after they go home. For example, similar to the aforementioned "weather station" experiment, the disciplinary and technical skills often required the children to take their experimentation kits home with them to receive additional parental guidance and supervision.

During my observation in the afterschool science classes, I witnessed a class about "the formation of water." The teacher created learning opportunities for children to understand and explore the properties of water (e.g., liquid, solid, and gas). The primary learning outcome shared by the teacher was that students would be able to understand how much time it would for water to shift from a liquid to a solid (i.e. by freezing water into ice cubes). Because this experiment takes much time and also requires access to refrigerators, it was difficult for children to complete this experiment in the afterschool kindergarten science class. Therefore, the teacher asked the children to complete the experiment with the help of their parents after class and to then report their findings during the subsequent afterschool class. Moreover, a second learning outcome designed by the teacher was for students to observe water vapor (e.g. at home while a parent was cooking or when they were taking a shower). Once more, there was an observable disconnect between the curricular and pedagogical design crafted by the teacher wherein students would need support from their parents to be able to complete this learning task.

Overall, given the student-teacher ratio (twenty-five students to two teachers) and the limitations of instructional time (25-30 minutes), teachers experienced challenges with completing their originally envisioned learning outcomes for students in their afterschool science class. Once more, the role of familial support became instrumental resources to help guide the completion of students' science experiments that began at school. Furthermore, since some experiments required access to equipment (i.e. refrigerators), the learning activities could not be completed at school and required at-home learning in order to fulfill the science experiments and to meet the learning targets designed by the teachers. Ultimately, without the parents' intervention to support their early learners' development in scientific experimentation, their roles again served as an indispensable part of science disposition development.

Parents' Choice of Private Tutoring

In China, it is a very common cultural characteristic for parents to enroll their children in various after-school tutoring classes. From kindergarten to high school, children always go to various classes after school or on weekends, such as: music, dance, English, and/or mathematics (Liu, 2018; Zhang, 2020). Currently, science education has attracted vast attention in China. In kindergarten, science education was added as a disciplinary area of focus in many schools. Given this shift in early childhood education to feature science as a focus in kindergarten classroom contexts, parents uptick of enrollment for students in extracurricular tutoring in the sciences have increased. During an interview with the teacher from class one, she pontificated:

> Because there are some children who have taken extracurricular tutoring classes outside, such as the "Little Newton" class. During these classes, the teacher will lead the children to do various experiments to stimulate the children's interest in scientific knowledge. For example, there will be experiments that simulate volcanic eruptions. Or the teacher will tell children how to distinguish the different types of whales and so on.

> After attending this kind of class, some children will know more than other children, even more than teachers. This also requires our teachers to learn with children and prepare more difficult content for them. Otherwise, some children who have already learned and knew about the knowledge may do not want to listen or participate in the class in kindergarten.

Given the fluctuations in the types of tutoring programs that some children have access to dependent on whether their parents enroll them in these learning environments, many kindergarten teachers need to differentiate their curricular and pedagogical design in order to meet the needs of different children.

During the observation in the science class, there was a discussion about the difference between baleen whales and toothed whales. The learning outcomes for this activity required students to compare and contrast the differences between baleen whales and toothed whales based on their teeth. After the teacher provided instruction for students to scaffold their analysis of whales' characteristics, one child suggested an approach to generate comparisons based on the weight of both types of whales. During this observation, the teacher appeared to be passive to the students' methodological approach. The teacher did not understand this method of analysis, therefore they did not exhibit a scientific knowledge disposition that could gesticulate whether this child's approach was correct or incorrect. For example, the teacher responded to the student by stating, "Okay, thank you for sharing this with us. We will discuss this method when I learn about it after class." Additionally, during a post-class interview with the teacher, she discussed:

> The kid knows so much because his parents work in the aquarium and often tell him a lot about the ocean. But in this case, as a teacher, I will be a little passive, and I am afraid of being asked questions that I don't understand and don't know. So in this

case, on the one hand, I need to explore with my children together, on the other hand, I also need to prepare more difficult and more supplementary content in my syllabus.

This classroom observation and the interview afterwards with the teacher concluded the need for higher-levels of disciplinary science training in early childhood education for teachers. Additionally, the findings surmised the variation in early childhood learners' levels of scientific knowledge and reasoning which correlated with their levels of access to private tutoring and whether their parents hold occupations in science-related fields which could increase their command of science-related concepts. Moreover, dependent on the students' exposure to private tutoring and whether their family provides additional expertise to guide students' in their development of science dispositions in turn can affect how the teacher may subsequently design their curriculum and pedagogical techniques (Egalite, 2016; Li & Qiu, 2018; Weiser & Riggio, 2010). Given the role of the parental involvement in early childhood education, parents can help their children cultivate their learning habits, which in turn impacts their academic performance (Li & Qiu, 2018). Children with highly educated parents could expand students' "complex speech" and extensive vocabulary" development dependent on whether their parents have advanced language skills (Egalite, 2016, p. 72). The teacher from class one further discussed the role of parents' influence on students' academic performance, noting:

> Nowadays, because of the family background and the knowledge of the parents… all of the parents of the children in our class have a bachelor's degree, and many parents have a doctoral degree. There are still a few children in our class whose father was graduated from Tsinghua University and their mother was graduated from Peking University. The child who are growing up in this atmosphere, including his/her IQ genetics, which is not much worse. In addition, some parents whose major is related

> to science, they will talk to their children at home, therefore, these children often know more than what I have prepared for the syllabus. Just like the lesson I prepared that day on how to distinguish between baleen whales and toothed whales, the original content of the syllabus was to let children know that they can be distinguished by teeth, but because a child mentioned that his parents who work in the aquarium told him that those two whales can also be judged by their weight, so I checked the information after class and discussed this issue in depth in the science class for the next day.

Based on the interview, this study found that although there was a syllabus for teachers to guide children's science knowledge development, sometimes the teacher needed to prepare differentiated instruction for students given their range of scientific content knowledge. In addition, since some parents worked in science-related organizations (i.e. aquariums, planetariums, the China Meteorological Bureau, etc.), many students received informal education from their parents about science at home. Hence, children's interests and understandings of different scientific bodies of knowledge varied which also correlated with the types of questions students posed in class to their teachers and peers. Overall, the results of this observation and discussion with the teacher suggested that teachers' understanding of content knowledge and pedagogical approaches to teaching science, including differentiated instruction, are a viable area for development to improve early childhood science education.

Parents' Classroom Participation Through Social Media

In terms of the two kindergarten classes I have observed, both classes had a group chat which facilitated daily communication between parents and teachers. Daily communication was facilitated through WeChat (a popular social media application in China). Teachers' communication with kindergarteners' parents featured correspondences regarding students' engagement with learning activities (e.g. text-based and video-based communications). Teachers utilized this medium of communication to also request familial support with homework assignments to aid in students' cognition of course material and further practices with learning activities. WeChat harnessed media rich communication between parents and teachers that also invited parents to ask questions or gain clarification on assignments. During classroom observations, I witnessed how teachers always assigned homework for children to complete outside of class and how they asked for their students' parents to share what their children completed (i.e. through WeChat). For example, after students' completed a science class session that explored the properties of water buoyancy, the teacher asked the children to draw the three objects that can float on the water. The teacher asked students to include stones, plastic foam, and plasticine; next, students were tasked to use arrows to mark the position and direction of the buoyancy. After students completed this drawing assignment, parents were required to take pictures and send them to the teacher through WeChat.

Moreover, following a science class that discussed the formation of water, the teacher provided each child with a piece of paper that had a pot with water on it. Next, the teacher asked their students to draw and color the location of where the water would be after it was heated. Again, the teacher invited parents to take photographs and share the images in the WeChat group message. Correspondingly, parents also utilized WeChat to ask the teachers additional questions about their students' learning and they provided responses to classroom videos or photographs shared in the group chat from their children's teacher. According to Weiser and Riggio (2010), parental school involvement could affect students' academic outcomes, and to some extent, would impact teachers' curriculum/activity design. In terms of parental school involvement, it always includes “participation in school activities,” “assistance with homework,” “supervision and monitoring of schoolwork,” and “communication with children about what happened in school” (Weiser & Riggio, 2010, p. 368). Besides the observations in the class, during an interview with teachers, they discussed:

> Sometimes parents also want to know what their children have learned in kindergarten, so I will share some class photos or videos in the group chat from time to time. Under this circumstance, sometimes parents will ask whether the content of the class could be more in-depth, because they have told their children at home what I am talking about in the class, or the children have already understood the content in extracurricular classes. (Teacher form class one)
>
> In class, I also hope that the children can speak freely, express their ideas as much as possible, and we will discuss some scientific knowledge together. But because these videos will be shared in the group chat, sometimes the parents will tell me that they hope to train their children to "obey the rules", such as don't interrupt when the teacher talks, raise your hand and wait until the teacher agrees. But sometimes when I finish talking, the child, he may forget what he was going to say, or he doesn't want to say it anymore. In addition, most of the scientific activities in the classroom are conducting under the leadership by the teacher, and the child is rarely allowed to explore it on his own. For example, just like asking the children to feel the buoyancy. If the children are allowed to explore by themselves, they may get water on the clothes, get the clothes wet, and catch a cold. At this time, the parents may also have concerns, so our activities are basically carried out by the teacher. (Teacher from class four)

Based on the discussion with the teachers, this research study indicated that while the teachers' syllabi provided a strong outline for their curriculum design and course sequence, their syllabi could benefit from regular adaptations given the strong influence of parental feedback (i.e. via WeChat and other correspondences) and external supports they provided regularly in kindergarten classrooms.

Generally speaking, the concept of family-school cultivation is gradually being emphasized in China. The guidelines for kindergarten education point out that family education is an indispensable part of kindergarteners academic and social dispositions. Kindergarten science educators should strive to strengthen communication with parents to guide their understanding and active participation to support their kinders both inside and outside of the classroom. Additionally, kindergarten teachers should make full use of parental resources to achieve the goal of family-school cultivation. The current kindergarten education programmatic design often requires parents to cooperate and participate in daily teaching, but it ignores the parents' thoughts and needs. For example, kindergarten teachers often ask parents to prepare some materials for their children and bring them to the classroom so that teachers can develop games and conduct teaching activities. However, parents often do not understand the content, learning goals, and pedagogical techniques needed to support learning activities designed by teachers. In the long run, parents will be bored, resistant, and may even interfere with the formulation and implementation of the teacher's daily syllabus. Therefore, if the kindergarten teachers want to increase family-school cultivation and make full use of parent resources, teachers should strengthen communication with parents, understand their needs and suggestions, and help them better participate in their children's education.

Kindergarten Learning Contexts, Rules, Routines, and Teachers' Learning Activities

In China, one of the most important things in kindergarten education is to ensure the safety of every child. For this reason, kindergarten learning activities are seldomly conducted off-campus. However, the focal kindergarten classrooms in this research study initially set out to discover alternative examples of approaches for teaching science education to young learners through experiential science classes at the planetarium weekly. However, in order to maintain the safety of children, this learning experience was cancelled. Moreover, an additional policy was set where kindergarten teachers had to hold all classes on-campus. In addition, children needed to sit neatly, remain quiet, and raise their hands in order to answer questions. All of these requirements limited the design and development of classroom activities to a certain extent.

On-campus Activities

Throughout my data collection with kindergarten teachers, all observations and interviews were conducted on site. During an interview with the teacher from class four, they provided additional context abou the requirement to hold science classes on-campus:

> We used to have some off-campus science activities, such as taking the children to the Meteorological Bureau. In fact, this activity is quite good. It is particularly good that the children can experience it for themselves, but the children will not be allowed to go there because our kindergarten feel that going out does not guarantee the safety of the children. Also, there is another class in our kindergarten that is particularly good, which is astronomy. Our astronomy class will detect the stars, the moon, and the distance between the stars and the moon, and so on. We have prepared a lot, including telescopes. But now our teachers are

> not letting the children out, out of school, so the astronomy class is not very well carried out, so we canceled it.

Based on the conversation with the teacher, findings suggested that because of China's national conditions and parental intervention, in order to ensure the absolute safety of children, all scientific activities must be carried out with kindergarteners under the guidance and supervision of teachers. Under this circumstance, this research interviewed another teacher from class one and they stated:

> We usually have some off-campus science activities, but now they are all canceled. In our kindergarten, there are 30 children and 2 teachers in one class. Although off-campus activities may give children more chance to explore, observe, participate, and practice, but currently, safety is the most important factor in our kindergarten, and our two teachers could not guarantee the absolute safety for every child. For this reason, we have to cancel all off-campus activities.

After interviewing these two teachers, it was apparent that it was the teachers' responsibility to guarantee the safety of every child. In order to avoid some uncontrollable unsafe factors, canceling off-campus science activities was the best choice for the kindergarteners and teachers. Although teachers tried their best to create conditions for children to try more experiential scientific activities in the classroom, due to the lack of space, activity equipment and professionals, many activities were still carried out based on the classroom observations.

Classroom Structure and Organization

In terms of the kindergarten classroom, there were a total of four rectangular tables in the classroom; they were divided into two rows and there were two tables in one row. At the top of the table, there was a television for playing videos, and the teacher stood next to the television. The children sat in groups around the table, with an average of 6-8 children per table. During instructional time, children needed to sit in their place, remain quiet, and raise their hands to answer questions or express their opinions. During the science class, this research found that although teachers have tried their best to design some activities for the children to participate, these activities are still carried out on the basis of ensuring classroom order. In many cases, children's participation was limited; these activities tended to focus more on observation. For example, there was a science class on “what is buoyancy?”. At the beginning of the class, the teacher needed to introduce the topic of this class, so she prepared a foam block and a basin of water, and then she said: "I will put this foam block in the water, and do you guys think about whether it will float or sink." At the same time, many children started to stand up and expressed that they wanted to try to place the foam block. In this case, the teacher paused, and then asked the children to sit down; they also used a harsher tone and said that they would put the basin in the middle to ensure that every child could see it. The teacher also said that if everyone sits quietly, she would choose a child with the most upright seat to try.

During this class, this research discovered that the teacher continuously mentioned the words such as quiet, raising hands, sitting well, etc., which showed the importance of classroom order to the teacher. In order to ensure a quiet and orderly classroom order, children's participation in scientific experiment activities was also limited. Usually, only a few children experienced learning applications by themselves, while most children still focused on observation. Based on this classroom observation, I decided to follow-up with the teacher. During our interview, they articulated:

> Although we also promote ‘happy education’ and hope that children can give full play to their nature, explore more, and feel nature, but the actual situation sometimes does not allow it. For example, in our WeChat parent group, the teacher would send videos of the children in the classroom to the parents from time to time. If the classroom order is chaotic and the children do not sit quietly, the parents may give their opinions, hoping that the teacher can cultivate the children to be quiet. Sit in a chair and listen carefully. Raise their hands when they have questions or want to express. These also largely limit the teachers' development of some activities.

According to the *Guide for 3- to 6-Year-Old Children’s Learning and Development,* kindergarten teachers should prioritize contingent scaffolds to guide children’s scientific knowledge development by actively fostering their creativity, curiosity, and inquiry-based cabilities (MOE, 2012). Although kindergarten science education at this time has tried to increase students’ experiential learning activities, but it still limited by many factors (e.g. classroom setting, class order, and parental interventions). In this particular kindergarten classroom environment, children’s autonomy was limited and routines and classroom order were a primary focus (i.e. students’ had to sit neatly/quietly, raise their hands, and rarely were invited to pose their own questions). Even though there are nature corners in the classroom and some educational toys for children to explore, they must use them at specific times under the guidance of their teacher. Secondly, because class order is a value in this learning environment, teachers seldomly permitted every child to participate in hands-on experiments (except for a small selection of students, most students were required to remain in observer/listener roles) in favor of maintain strong classroom management.

Teachers' Training and Experiences Teaching "Feifei Rabbit"

There are two science classes once a week in kindergarten. The main course is named "Feifei rabbit." "Feifei rabbit" is a textbook that kindergarten educators utilized to teach children science. This textbook was designed based on the Guidelines to The Learning And Development Of Children Aged 3-6. The other science class mainly focused on activities, such as the activities that they did not have the time to complete in the "Feifei rabbit" course, the activities conducted by children's parents, or other activities related to children's interests. In terms of instructional time for the "Feifei rabbit" class, it typically included 30 to 40 minutes of guided instruction as well as 20 minutes for activity-related instructional segments.

Since teachers did not need to have a qualification certificate to teach science, they usually did not have a scientific background or prior experience in teaching science. Further, for the "Fei Fei Rabbit" course, kindergarten teachers did receive pre-class training through professional development sessions from an instructional coach. This instructional coach explained the scope of the textbook content, guided teachers in their instructional design, and supported their scaffolded pedagogical approaches.

Feifei Rabbit-Science Classes

During the "Feifei rabbit" science class, the textbook used by instructors also contained supplementary materials (e.g. videos) and a handbook that guided teachers to facilitate children's development of science content. Teachers understood the course goals, designed the course sequence of topics, prepared materials before class, and adapted guiding questions assist students' development towards the course learning targets. For each course, teachers followed the guidelines (e.g. activities/experiments), they also followed the guideposts provided in the textbook. For example, first the teacher began with an introduction of the daily science topic, and then the teacher asked children to watch a video from the supplementary textbook materials. During each of the supplementary videos, teachers were also able to ask students' questions, provide explanations to the questions, and students in turn received feedback towards their practice questions during the video exercises.. Teachers also were able to deduce any misconceptions students might have about a science concept given the formative science practice exercise, in turn they were able to field students' questions and deepen their understandings of science-related concepts. In addition, if the topic contained an experiment, the video provided teachers with valuable instructional guides to assist them in knowin what materials to prepare, the experiment's process, and potential guiding questions to support students' learning targets. Based on this reason, although the teachers lacked formal training in science content knowledge, they were able to expand their own understanding of scientific foundations given the supplementary materials. Below is an example for one of the science courses from the Feifei rabbit textbook. This book is written in Chinese; the English translation is provided in Appendix I.

In terms of the kindergarten context in China, although some teachers do not have formal training in teaching science beforehand, the detailed guidelines from the textbook provided clear parameters for content design and pedagogical strategies they could utilize in the classroom. Based on the class observation of the science course about "change of water," this research deduced that the teacher primarily relied on the textbook materials, such as: the introduction of this topic as well as the knowledge of water class activity. In the beginning of the course, the teacher played the video of "Feifei rabbit," with the question asked by Feifei: "Hi, boys and girls, have you seen this cup? Guess what is in this cup?" The children exclaimed, "Water!" Next, the teacher asked, "So, why do you think there is water in the cup?" Following this statement, it became clear that the teacher tried to encourage children to find the characteristics of water. Subsequently, the teacher followed their syllabus to inform children about the next area of exploration they would take on which would determine the properties of water transitioning to a solid (e.g. through ice cube formation). Based on the textbook and syllabus guidelines, the teacher took out the ice cubes they had frozen beforehand and let the children touch and feel it. At this time, the teacher discussed with the children which circumstances would aid in water turning into ice. The last requirement in the syllabus was letting children know about the properties of water vapor. Based on this requirement, the teacher asked children: "what will become after the water is heated?" Next, the the teacher used the examples around the children to deepen their understanding of water vapor. The teacher said: "for example, when you came home today, your mother was cooking a pot of soup. When your mother turned on the gas and heated it, what would happen to the soup in the pot?" Through this example, the children discovered the properties of water vapor and how water vapor is formed.

The syllabus design of the kindergarten science class is planned and structured. Although some kindergarten teachers lacked science content knowledge, the syllabus provided ample structure which aided their curricular design and course sequence. I observed that the teacher did not stray from the syllabus given the structural design which also reduced the time that the teacher spent on preparations for their class. For example, the teacher from class four denoted:

> There will be training in science courses like Feifei rabbit. For example, if a teacher is taking this class, there will be a special teacher from Feifei rabbit who will come to train the teacher who wants to take the class. The training content includes how the teacher should

teach this class, what issues should be paid attention to during class, what is the goal of this class, and what kind of questions the teacher should ask in class.

Correspondingly, the teacher from class one also mentioned that: “As far as Feifei rabbit is concerned, the teachers have all been trained. The course of Feifei rabbit is designed by a company, has its own patent, and there will be professional people to train the teachers. Then the teachers also have their own textbooks, so it is not difficult to teach.”

Based on the two teachers’ statements, research findings surmised that although the teachers lacked science content knowledge, the textbook design and professional development training aided kindergarten teachers’ capabilities to teach science to early learners. Additionally, the supplementary materials from the textbook also supported teachers as they strived to deepen students’ science knowledge and application of scientific concepts through activity-based pedagogies. Wati (2011) mentioned that further professionally development could increase teachers’ motivation, confidence, professional knowledge/skills, teachers’ affective filters, and could yield positive learning outcomes for students' science learning targets. Tangentially, teachers’ passion for their disciplinary subject also imbued their performance in their daily teaching practices which in turn could lead to more positive student learning outcomes (Özgün-Koca & Şen, 2006). Therefore, teachers’ professional development in disciplinary science content knowledge as well as supplementary curricular supports aided teachers’ scaffolded pedagogical designs; these factors also increased Chinese teachers’ confidence and beliefs in their capabilities to teach early learners’ science which in turn benefitted students’ learning experiences.

Observation-Oriented Science Experiments and Activities

There are two science courses each week in the Chinese kindergarten contexts. One of the courses is Feifei rabbit, and the other one is an experiment and activity-based science class. In the experiment/activity-based class, teachers usually led children in activities or experiments related to Feifei rabbit science lessons, but sometimes, they still needed to conduct activities or experiments designed outside of the scope of the textbook. During the kindergarten class observations, this research synthesized that although there are lots of science-related experimental supplies in the classroom, teachers seldomly used them. Instead of conducting hands-on activities/experiments using these supplies, teachers always carried out observation-oriented activities, such as observing the roots of the plant. The teacher planted a hydroponic plant in the water, and then asked the children to observe what the root of the hydroponic plant looked like. Another activity in the class was about sharing their scientific observations. The teacher asked the children to go home and check information with their parents to understand the types of whales, what are their species' types, and their physical characteristics. Next, students were taked with reporting what they learned about whales' characteristics with their classmates in the subsequent class session. Based on the activities conducted in the class, this research discovered that students' scientific observations often occurred outside of the classroom. During interviews with teachers, they provided additional context regarding why they rarely conducted hands-on science learning activities. For instance, the teacher from class one described:

> I think it is. . . I think it is something that the child has to participate, and it lacks these things. We are now observing a lot, inquiring, exploring, and observing. How can you make the child participate, like playing a little experiment. For example, the toys in our class have that kind of circuit contact, but the toy teacher has to study how to make it. We need

support in this area and guidance in this area. Need the guidance of relevant science teachers in this area. Because sometimes, like this kind of special high-end toy, the teacher will not use it, so it is just there.

The teacher in class four also further contextualized similar reflections to the teacher from class one, noting:

> Like the scientific activities in the class, they are usually observation-oriented. Like that plant specimen, have you seen it over there? We just let the children observe. And like that circuit toy, that is too difficult to play, and it is a challenge for our teacher. Moreover, the time of our science class a week is limited. If the teacher studies it by himself/herself, it will take a long time to learn how to play with the toys of this circuit, and there is no time to teach the children at all. So, at most, the teacher will show it to the children after learning. It is very difficult for teachers to explore with children together.

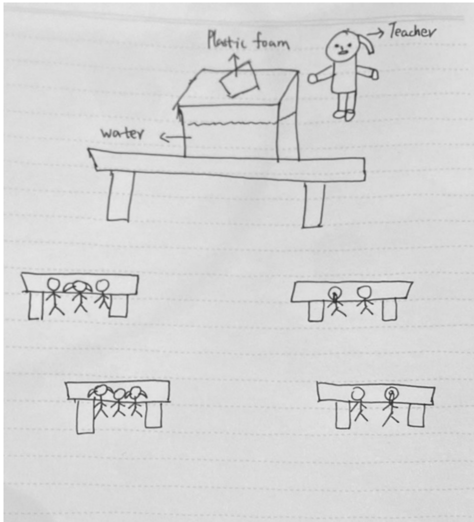
Based on the interviews with teachers, this research found although there was professional training for teachers towards the Feifei rabbit science class, they received no professional development to guide the curricular and pedagogical design for the other activity/experiment class. Since most of the teachers lacked professional scientific backgrounds, it was a challenge for them to carry out science-related experiments or activities independently. Compared with experiments or activities that require hands-on abilities, they were more inclined to carry out simple observational scientific activities. In this case, although teachers had access to science experiment supplies, the teachers did not regularly utilize these resources because they did not received the training needed to implement them in their daily classroom teaching.

Teachers' Pedagogical Practices in Teaching Children Science

In this section, this research focused on how teachers pedagogical practices teaching children science. The results showed that although there were science-related activities and experiments conducted in the class, the primary pedagogical features were mostly teacher-centered. In terms of the science activities and experiments, they were mainly based on collecting observations; the children were less involved in hands-on activities. Moreover, drawing was widely used in science classes. Teachers often asked children to craft drawings to express their understanding of certain scientific phenomena and concepts.

Teacher-centered Pedagogical Practices and Students' Scientific Observations

Based on the Guide for 3- to 6-Year-Old Children's Learning and Development, current early childhood science education in China needs to focus on fostering children's creativity, curiosity and inquiry abilities. Rather than teaching children science content knowledge alone, the Guide for 3- to 6-Year-Old Children's Learning and Development asks teachers to pay attention to children's exploration skills (MOE, 2012). Further this text suggests that teachers design activities that could help children engage in experiential science activities. Although teachers tended to design science activities that could give children more chances to participate, cultural characteristics prevalent in China (e.g. parent intervention, class order, classroom setting, teachers' training and other factors), science-related activities in the kindergarten were mainly based on teachers' direct teaching demonstrations and children's scientific observations. Below is an example of discourse between a teacher and children during a science class about water buoyancy (see figure 4):



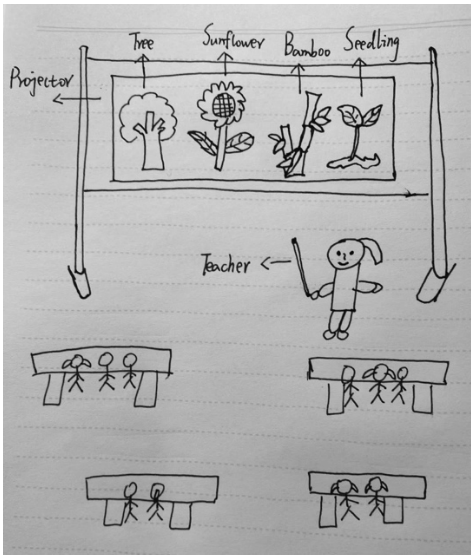
Teacher: “I already prepared a plastic foam and water in this container, I’m going to put this plastic foam in the water, think about what is going to happen?” (The teacher asked children first and then did what she said).

Children: the foam will float (The children were answering the teacher’s question).

Figure 4. Example from Classroom Observation about Water Buoyancy

First, the teacher introduced the lecture-based instruction to the children that she had prepared before class. Next, she told the children what she was about to model about water buoyancy and demonstrated the whole scientific process to students. During the teachers’ direct instruction, children passively listened to the teacher's explanation and watched her demonstration. Instead of students’ conducting their own experiments autonomously, the children sat behind the table, listened to the teacher, and watched what the teacher was doing. Based on the classroom observation, the children gained a conceptual understanding of buoyance mainly from the teacher’s demonstration. During this process, children received no opportunities to explore water buoyancy by themselves. Although the teacher designed an experiment to demonstrate buoyancy to students, this experiment was still based on the teacher’s modeling and the children did not have the opportunity to engage in inquiry or engage in their own experimentations of water buoyancy.

In addition, the same situation happened in another class about the “exploration” of different plants, including the difference between the roots and leaves of these plants. The picture below shows how the teacher carried out this class (see figure 5).



Teacher: there are different plants on the projector, please think about what are these plants? What's the difference between their roots and their leaves?

Children: Tree, Sunflower… the color for their leaves are different, the root of the tree is thick… (Children are all answer the questions).

Figure 5. Example from Classroom Observation about Plants

In terms of this class, first, the teacher chose the plants that she wanted the children to know. Further, she determined what the children observed and considered, such as examining the differences between the roots and leaves of these plants. During the lesson, although the children observed the teacher's lesson and thought independently, they still passively learned the knowledge that the teacher wanted them to know. For this class, the teacher was always the leader; she decided which plants the children needed to know about. Therefore, this class was still teacher-centered and the children were observers.

Homework and Painting

In the end of each science class, children completed homework after their class sessions. The purpose for assigning homework was to help children deepen what they have learned about science that day and whether they grasped the topics and concepts from class. Homework assignments also helped teachers formatively assess and adjust their science content and pedagogical methods in subsequent classes based on children's misconceptions. The most common homework assigned by kindergarten teachers was to ask children to create drawings about what they learned that day. Based on the interviews with kindergarten teachers, they all mentioned that drawing was easier for children because they liked drawing. The teacher from class one synthesized, “Because kindergarten children are relatively young, if the homework is difficult and boring for them, it is difficult for them to concentrate on completing it for a long time. And drawing is fun and easy for most children to do, so they prefer to do it. Based on this reason, I often use painting in my daily teaching.”

Comparatively, the teacher in class four also mentioned, “Our current kindergarten curriculum involves five areas, including science, society, health, art and mathematics. And painting is also a part of art, so I incorporate it into my daily teaching. And our children generally prefer to draw, so I think it is very interesting to draw what they have learned and their own understanding.”

Based on the interviews with teachers, this research found the teacher combined science and painting together in their daily teaching and used painting to help children learn science knowledge. For example, in the science class about buoyancy, in the end of the class, the teacher assigned homework to children that requested them to "draw objects that can float on water." Next, the teacher asked the children to draw the objects they thought could float on the water, including stones, plasticine, small plastic cups, foam boards, plastic straws and toothpicks. Additionally, students had to draw an arrow to show how the buoyancy impacted these items. This homework helped the teacher to check for students’ understanding of buoyancy as well as provide additional instruction to ensure students’ mastery of their conceptual understandings.

Moroever, painting was a key pedagogical tool regularly used in other science classes (e.g. the teacher asked the children to draw what water looked like when it is heated). The teacher gave each child a piece of paper with a picture of a pot on it. Next, the teacher asked the children to go home and watch their parents cook, and then draw water vapor on the pot. In another class about plants, the teacher also handed out a piece of paper to each of the children after class with various plants on it. Then the teacher asked the children to color the leaves and roots of these plants when they went home. Thus, painting has become an indispensable pedagogical feature of kindergarten science classrooms. Artistic expressions not only enhanced children's interest in learning science and made abstract scientific knowledge more palatable, but also allowed children to express what they learned in a simple format, which in turn informed teachers' evlautions of their students' learning achievements.

Classroom Discourse in Teaching Children Science

Initiation, Response, and Feedback (IRF) Sequence

In terms of the science classes in the kindergarten, they are mostly teacher-centered. Classroom discourse usually followed with the IRF (Initiation – Response – Feedback) sequence (Rymes, 2015). Regarding to the feedback turn, it usually included evaluation and feedback together. During a conversation, it usually started with teacher's initiation which often was motivated by a guiding question. Below is a conversation in a science class about the form of the water.

Teacher: Can you guess what's in this cup?

Children: It's water.

Teacher: It's water, and how do you know it is water?

During this conversation, the teacher started with a question to introduce students to the science topic. Next, children provided their responses towards their teacher's question. After children's responses, the teacher repeated what the children said with an affirmative tone. This repetition served as an evaluation of the children's response and often provided guidance about whether their answers were accuratet. During this conversation, the teacher followed up with students by providing feedback staing, “how do you know it is water?”. Based on the teacher’s feedback, children were invited to justify their scientific reasoning. Because of the teacher’s follow-up question, the teacher and children started another conversation about the characteristics of water.

Subsequently, the teacher discussed another form of the water. To start this conversation, the teacher also used an open-ended question, “If the water doesn't flow, what does it do? Why is that?” After this question, the children scrambled to respond to the teacher, posing, "it is solid." In terms of the next turn for this conversation, the teacher resposnded, “it is solid, so under what circumstances does it become solid?” For the statement, “it is solid,” the teacher used an affirmative tone which could be an evaluation by the teacher regarding the children’s response. The other question which followed after this evaluation encouraged children to think about the conditions that water transitions into a solid. Other than these two conversations, this research found during this science class, the teacher used most of the IRF turn in her teaching, such as:

Teacher: Like water at very, very cold temperatures, like below 0 degrees, what does it become? (I)

Children: Ice. (R)

Teacher: Ice (E), is ice the same as water(F), and what is water? (I)

Children: Liquid. (R)

Teacher: Liquid. (E) What about ice? (F) What is ice? (I)

Children: Solid. (R)

Teacher: Solid. (E) Let’s think about it, what will happen to the water if it is heated? （F & I）

Children: Will melt. / Will become very hot. / Will flow. (R)

Teacher: Will water melt when heated? (Questioning tone: E) This is water, are there any other children who want to talk about it? (F & I)

Children: When you heat it, it will turn into boiling water, and it will be hot. (R)

Teacher: Very hot, right? (Rhetorical tone: E) Anything else? What form will it take? (F & I)

Based on the above conversation, this research found in terms of the science class in the kindergarten, the teacher usually used IRF turn in teaching children science knowledge. For the initiation (I) part, it usually started with an open-ended question that involved children's class discussions and encouraged children's critical thinking. For the feedback (F) component, it always followed after the teacher's evaluation (E). After children's responses, the teacher provided students with the evaluation about their answer to let them know if their answer was right or wrong. According to the teacher's evaluations, if the children's answer was right, the teacher always repeated the children's answer with an affirmative tone, but if the children's answer was wrong or they gave an irrelevant answer, the teacher often used rhetorical questioning tones to remind children that their answer was not the right one and encouraged them to keep thinking. In order to ask children to continue thinking or to move on to another point, there always was teacher feedback after their evaluation. In terms of the teacher's feedback, it always became the initiation for continuing conversations with students to expand their scientific understandings.

Resulting from the interview with the teacher, this research found the repetition of the children's words always represented a kind of affirmation and encouragement to the children's answer. During the interview, the teacher posed: "Repeat what the child said, because sometimes your repetition is definitely an encouragement to him/her. For example, if you said that a certain child's expression is very good, some children may not dare to raise their hands or express their thoughts, but if you repeat what he/she said, in fact, your repetition is a kind of affirmation to him/her. So that other children would dare to raise their hands and share their ideas." Repetition was used frequently in the class with IRF turn. On the one hand, rather than the teacher providing only "yes" or "right" verbal cues after children's responses, repetition about the children's words or sentences provided them with affirmations, and also could enhanced their confidence in learning science knowledge. On the other hand, repetition also encouraged children to share more about their ideas and invited more children's participation in class discussions.

Inquiry-oriented Teaching Pedagogies

Because a lot of scientific concepts are difficult for kindergarten children to grasp, kindergarten teachers' science classes centered inquiry-based approaches. In these classes, the teacher usually knew the right answer for the questions, but rather than telling children the answer directly, their purpose was to involve more children in the class discussion and encourage children to think independently. Take one science class in the kindergarten as an example, this class was about plants. In this class, the teacher introduced photosynthesis to children. For instance: Teacher: "Photosynthesis in plants, what is photosynthesis? Let's talk about it first, and then think about what benefits does plant photosynthesis do for human beings, for us?". In terms of this question about photosynthesis, although the teacher knew the answer, kindergarten children exhibited difficultly explaining photosynthesis clearly. The teacher's purpose was not to search for the right answer for students, but instead they wanted to guide children's independent inquiry which involved class discussion. After asking students' probing questions, there were no responses; hence the teacher repeated the question and asked one child to answer by calling his name.

Teacher: Guoren (fake name), for example, what benefits do you think plant photosynthesis has for humans?

Guoren: I think sunlight is very good for human beings. Like, you know, you're gonna get taller.

Teacher: Have a seat. Who else has a different idea? XRZ (fake name).

XRZ: We can take in a lot of air now, and if there's no, there's no leaves, we'll just hold our noses and give it a try. We will be like this.

Teacher: You're gonna be so out of breath, it's like pinching your nose, right? Please take a seat. YY (fake name) said.

YY: I think it is, it will be good for our body and we will grow taller.

Teacher: Oh, he said that photosynthesis is good for human beings, and then we humans can absorb photosynthesis to make us taller. Say your thoughts. (points to another kid who hasn't spoken yet)

TT (fake name): The photosynthesis of a plant if it absorbs water, nutrients, air and photosynthesis, it can produce delicious fruit.

Based on the above conversation, this research found that inquiry-based classes typically did not include an evaluation turn. The purpose for these classes involved most of the children engaging in class discussions and sharing their opinions. Rather than searching for the right answer, inquiry-based dialogue yield deeper levels of students' exploration, critical thinking, and verbalizing of their understanding of scientific concepts. Resulting from the above conversation, after each children's shared their ideas, the teacher did not judge whether the children's answers were right or wrong, but instead invited all children to exchange their own thoughts and views. During the interview with the teacher, she also mentioned that in the class, she provided every child an opportunity to express their opinions whether their answers were right or wrong; she did not interrupt their statements even if they discussed something that was irrelevant to the class topic. According to the interview, the teacher said:

> You can see that a child said today, and his answer to my question is not what I asked, but I think he has a need to say it, and this needs to be encouraged. He may not have the point, but he has the courage to raise his hand, and I think that needs to be encouraged. But I generally remain neutral to such an answer, neither affirming nor commending it. For example, if I ask a question, and he answers a lot that are irrelevant to my question, I will say please take a seat. Are there other children who have other ideas want to share?

Rather than the teacher solely relying on direct instruction, inquiry-based pedagogies encouraged children to focus more on their learning processes instead of whether their answere were correct, incorrect, or irrelevant. During an inquiry-based science class, there were no evaluations provided by the teacher. The significant purpose for the teacher utilizing inquiry-based approaches with the class was to involve more children in class discussions and to encourage more children to share their opinions.

Using Inclusive Words

Science classes in the kindergarten may be difficult and boring to the children. For this reason, teachers should structure their science classes to yield student engagement that is inclusive. In addition, there were some children who learned science knowledge in after-school classes, or there were also some children who learned more science knowledge from their parents at home. Under these circumstances, if the topic of the science class was a little difficult and unfamiliar with most of the children, this class might be dominated by the children who possessed more exposure to scientific knowledge. Since the other children were unfamiliar with many scientific concepts, they might not want to participate and share their opinions. For example, in terms of the class talking about photosynthesis in plants, if the teacher asked children “what is photosynthesis in plants,” it might be difficult for some of the children depending on their prior knowledge. For this reason, children who knew the concept of “photosynthesis” wanted to participate in the class discussions and share their opinions. But on the other hand, if the teacher changed her question with inclusive words, like “what are the benefits of photosynthesis in plants for us,” it would be better than the previous question because it helped students to consider their own relationship with scientific concepts in their everyday lives. In the previous question example, when the teacher used the word "us," the children perceived that this question had a connection with each of them, and in turn made them feel more involved so they were more willing to think and participate in class discussions.

In terms of the inclusive words, the teacher always used “us,” “we,” “you,” and “XX (children’s name)” when asking questions. For example, in the science class about photosynthesis in plants, rather than asking children “how is carbon dioxide converted to oxygen?,” the teacher asked the children, “do we have carbon dioxide in our lives?, and what do we need most to survive?”. Through these two questions, the teacher guided the children to think about how plants help convert carbon dioxide into the oxygen we need in our daily life. And in these two questions, the teacher used the word "we." On the one hand, this could make the children feel that this question was related to each of them, and on the other hand, it could better make every child think about it and participate in class discussions.

In addition to using the word "we," teachers often used words such as "you" and "XX (children's name)" to make every child feel involved. In the class that talked about the form of water, rather than asking children "what are the characteristics of water?," the teacher asked children, "we have all bought mineral water. If we tear off the paper from the outside of the mineral water bottle, what kind of water do you see?," and "how about you take a sip? what does it taste like?". The teacher used the words "we" and "you" in the questions and it could make children feel involved and encourage them to participate in the discussion. Through these questions, children could learn that water has no color and no taste.

The other words teachers always used was children's names. On the one hand, the teacher would include children's names in asking them question, like "XX (a child's name), could you please share what do you think about…" or "what's your opinion XX (a child's name)?". Since the teacher included the children's name in the question, the children might feel this question was directed at him/her and that he/she needed to share his/her opinion. In addition, if there were some children who always functioned as a listener, when their teacher included their names in the questions this could encourage them to participate in the class discussion. On the other hand, sometimes the teacher would use the name of one of the children as examples to explain some scientific concepts, and because the children were familiar with the example child, they would participate more actively in the discussion. For example, in the class talked about buoyancy, in order to let the children understand the relationship between the force area and buoyancy, the teacher used a child in the class as an example, and she said, "if I throw XX (a child's name) and the stone into the water now, who do you think will sink?". For this question, using of the inclusive word “XX” (a child’s name in the class) could not only attract children's attention and make them willing to think, but because the name was familiar to them, it could also help them understand the problem more intuitively and encourage them to express their thoughts. By using the inclusive words in the classroom, it could help children feel included and also could promote their critical thinking during class discussion.

Avoid Terminology

In terms of the science knowledge, there were lots of terminology that were unfamiliar to children and were difficult for them to understand. Under this circumstance, in the process of teaching children science knowledge, teachers usually avoided using terminology and instead used some simple, easy-to-understand words to make it easier for children to understand. Take one science class in the kindergarten which talked about buoyancy as an example. In order to start this class, the teacher wanted to introduce the concept “buoyancy” to the children. But if the teacher asked the children directly,“what is buoyance?,” it would be difficult for the children to understand, and there may even be some children who have never heard of the word at all. Based on this reason, in the beginning of the class, the teacher prepared a basin of water and a plastic foam. Then the teacher asked the children, "Do you think it will float or sink after I put it (pointing to the plastic foam) down (pointing to the water in the basin)?". Rather than using the word “buoyancy,” the terms “sink” and “float” were relatively more easy to understand by the children. In order to help children understand the concept of “buoyancy,” including what is buoyancy and how is buoyancy created, the teacher continued asking children questions with easy and simple language, such as “Why do the plastic foam float on the water?” and “You feel like there is a force pulling it, right?”. These questions were better than directly asking, “How is buoyance created?" because these questions were more accessible using developmentally appropriate vocabularly, they were more understandable for children.

Using Common Contextualization Cues

In terms of the science class in the kindergarten, the teacher always used examples with common contextualization for children in their daily teaching, such as something that every child has done, a place that every child has been to, or a scene that every child has seen. Since science concepts usually became abstract and difficult to understand for kindergarten children, teachers included examples that children were familiar with which in turn could help them understand the science concepts easier.

In the class talking about buoyancy, in order to help children learn and understand this abstract concept, the teacher used an example "swim" to help children understand the relationship between the stressed area in water and buoyancy. In this kindergarten classroom context, there were swimming classes every week for the children. For this reason, "swimming class" and "swim" could be a common schematic contextualization for children. Moreover, the teacher said, "when you swim in the swimming class, you will take off the floating boards in the end, right? At that time, if you stretch yourself out and hand over your body to the water from head to toe, see if you will sink down?". This example sparked lively discussions in the classroom through the children's prior knowledge and their own lived experiences. Through the personal experience that children could float on the water by straightening their bodies, the students also understood what buoyancy was and the relationship between buoyancy and the force area on the water. This was easier for children to accept and understand than to tell them the concept directly.

In addition, common contextualization cues were used in another science class talking about photosynthesis in plants. Since it is difficult for children to understand the process that plants absorb carbon dioxide from the air through sunlight, thereby releasing oxygen, the teacher took an example with children's familiar place and scene to help them understand this complex process. During the class, the teacher said, "we know that our kindergarten was renovated last year, right? For example, just after laying the floor and painting the walls, we will put some plants in the classroom, why? Why can't people come in? If there is smell in the renovated house, we need to put some plants in, what does it do? There is formaldehyde in the newly renovated classroom, we all know it, right? There will be some pungent smell, which is harmful to our body. Then we will put some green plants in the classroom, why? What does it do?". Through this example, because children were very familiar with this scene and this matter, it could better help them think and understand. On the one hand, it let students' deduce what photosynthesis was, and on the other hand, it could also let them understand what the photosynthesis of plants does.

Common contextualization was widely used in daily science teaching. Because these common scenes, places, events and experiences resonated with children and stimulated their thinking and discussion during the class. The common contextualization also made it easier for children to understand complex and abstract scientific concepts. For example, in the science class talking about the form of water, in order to help children understand which conditions water turns into water vapor, and how does water vapor turn back into water, the teacher used examples that children were familiar with. First, the teacher asked children to think back to when their mother was cooking. She said that when your mother made the soup, she poured cold water into the pot at first. Then when their mothers turned on the gas, and after a while the water became hot and water vapor was produced. Taking this scene that the children have seen as an example, it aided children's intuitive understandings that water would turn into water vapor by heating. Second, the teacher took another example about when the children took a bath, suggesting that the mirror in the bathroom would become blurred due to the production of water vapor caused by hot water. After the temperature drops after the bath, the water vapor on the mirror will turn into small water droplets. Because the teacher provided examples connected with students' lived experiences they were more prone to understand the phenomenon that water vapor turns into water when it gets cold.

CHAPTER 6 TEACHERS' PEDAGOGICAL PRACTICES IN EARLY CHILDHOOD SCIENCE EDUCATION IN AMERICA

In this chapter, I situate how my research study focuses on early childhood science education in America. First, I discuss an examination of factors that affect teachers' pedagogical practices in early childhood science education. Second, I synthesize findings which emerged from discourse analysis of teachers' pedagogical practices in early childhood science education.

Factors Affecting Teachers' Pedagogical Practices in Early Childhood Science Education

The results of this research study revealed that several factors converged and influenced teachers' pedagogical practices in early childhood science education. Findings reveal four factors impacting teachers' pedagogical approaches in early childhood science classroom contexts, including: teachers' professional background characteristics, Next Generation Science Standards (NGSS), children's interests, and the learning environment for science activities. Through discourse analysis, I examined the multilayered dynamics that occurred during active learning processes constructed by teachers which involved the exchanges between the science education teacher and the early learners.

Teachers' Professional Background

There were two teachers in each of the kindergarten classrooms in the United States who participated in this research study. One teacher was responsible for providing most of the daily instruction (e.g. reading, writing, mathematics, and science). The other teacher was typically a teaching assistant; they provided some instruction and also led guided group reading and writing instruction for students when needed. The teaching assistant also monitored children during their lunch and recess periods outside the classroom. Both classroom teachers had backgrounds in education and held state-approved teaching credentials. However, neither teacher had a specialized credential specifically in science instruction.

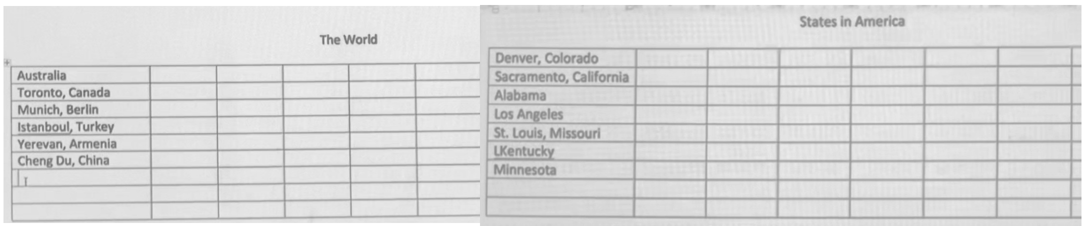
Based on the interviews with two class teachers, one of the teachers majored in English literature and political sociology for her undergraduate studies; she also obtained her multiple-subject teaching credentials from a graduate school of education. Moreover, she achieved her master's degree in human development and arts education. At the time this study was conducted, this research participant also was enrolled in a doctoral program focused on educational leadership. The other classroom teacher obtained their bachelor's degree with a double-major in linguistics and Spanish with a minor in education. She also obtained a master's degree in education. Despite both teachers' backgrounds in higher education, they specialized more so in humanities-related content areas; neither teacher had prior professional training in pedagogical approaches to teaching science to early learners.

Next Generation Science Standards (NGSS)

Based on the interviews with the two teacher participants, this research found that these particular kindergarten teachers followed the NGSS framework. The NGSS framework was released in April of 2013; it was adopted by the State Board of Education (SBE) for California Public Schools, Kindergarten through Grade Twelve. Based on this framework, there were three aspects that kindergarten children need to know about science, including: living and non-living things, weather, and push and pull. To assess kindergarten students' mastery-levels of these three scientific concepts, children need to answer questions like what plants and animals need to survive, what is the weather today, and if you push or pull something, what will happen. The kindergarten teachers mainly focused on curricular design that prioritized themes in these three aspects when they designed science curriculum, activities, and experiments. Based on classroom observations, this research deduced that multiple science classes featured coursework and pedagogical supports designed around themes pertaining to weather and living and non-living things.

In accordance with the NGSS science curriculum for Californian kindergarteners regarding explorations about weather, children conducted qualitative observations to describe different kinds of weather (e.g. sunny, cloudy, snowy). On the other hand, they collected quantitative observations to describe weather based on statistical data, such as, how many sunny days occurred in a month, and which place was colder or warmer. One of the main curricular units in kindergarten was "checking the weather." Teachers often created lessons and pedagogical scaffolds which supported students as they observed and learned about weather patterns, weather variations in different spatial areas, the purpose of weather forecasts, and how to prepare for and deal with extreme weather.

This research found for both of the two classes, one of the most important thematic focus featured lessons wherein students were "checking the weather." One pedagogical scaffold that teachers provided was a graphic organizer which contained a table (see Figure 6). The vertical axis of the table was the name of different locations, such as: cities in the United States and other geographic regions around the world. The horizontal axis of the table provided space for students where they recorded the temperature, which at times was also completed by the teacher if a student needed assistance completing this column. The teacher and the children checked temperatures for each of the geographic areas daily; they also recorded it in the tables on the vertical axis. This recording activity was ongoing. After recording for a sustained period of time, the teacher discussed with the children the temperature in different places, such as, how many days were sunny and how many days were rainy. Additionally, the teacher also discussed with children which locations exhibited the warmest and coldest temperatures each day. Below is an example of tables created by teachers:



The World

Australia					
Toronto, Canada					
Munich, Berlin					
Istanboul, Turkey					
Yerevan, Armenia					
Cheng Du, China					

States in America

Denver, Colorado							
Sacramento, California							
Alabama							
Los Angeles							
St. Louis, Missouri							
UKentucky							
Minnesota							

Figure 6. “Checking the Weather” Pedagogical Scaffold

This pedagogical tool designed by the teacher satisfied the requirement by NGSS science standards since children conducted quantitative observations and created observations about the frequency of weather patterns in diverging geographic locations. During this activity, children not only needed to use numbers to describe weathers in different places, but they also needed to use these numbers to generate comparisons to find where the warmest and coldest places were located.

Another important curricular focus in the science classes about weather was shaped by the teachers’ guiding question, “what do you know about the weather?”. For these lessons, the teachers asked students to share what types of weather they know about or experienced. This pedagogical scaffold permitted teachers’ to assess students’ prior knowledge about weather based off of their lived experiences. During one science class, the teacher began their lesson by playing a video that contained different pictures about weather characteristics. The video provided visual cues that were accessible for early learners; the images showed different kinds of weather (e.g. cloudy, foggy, rainy, etc.). To further hone students’ focus on weather characteristics, the teacher provided probing questions which asked students to use descriptive language to express what they observed about the weather they saw in the visual components of their video text. To aid in students' application of constructing descriptive observations, the teacher also provided guiding oral prompts to help guide students' observations while the teacher played the video. See Figure 7 below for screenshots collected from the video utilized by these teachers as well as a dialogic exchange collected during this classroom observation (See Excerpt 1):

Screenshot 1:

Screenshot 2:

Figure 7. Screenshots from Teachers' Introduction Video to Guide Students' Observations About Weather

Excerpt 1: Teacher and Student Dialogue During Introduction to Students' Observations About Weather

Conversation about screenshot 1:

Teacher: What word do you think they might use for this?

Children: Cloudy.

Teacher: Let's find out.

Video: Cloudy.

Teacher: Did you know? You already know!

Conversation about screenshot 2:

Teacher: What type of weather is it?

Children: Snowy.

Teacher: Snowy? Let’s find out.

Video: Snowing.

Children: It’s not snowy, it’s snowing.

Based on the two example conversations between the teacher and children, this research found in order to guide children’s observations about different types of weather and their characteristics, visual aids combined with the teacher’s guiding questions aided in students’ accuracy of observations about weather while also creating an opportunity to let children express what they perceived each of the varying weather conditions were like.

In addition, another important lesson sequence in the science class was focused on supporting students’ understanding of living and non-living things. According to the NGSS Science Standards, children are expected to obtain skills to be able to describe what plants and animals need to survive. Through classroom observations, this research found teachers used different ways to talk about living and non-living things with children, such as pictures, text-based readings, and videos. During one science class, the teacher provided direct instruction about living and non-living things by providing an example. In the beginning of the class, the teacher showed children a picture that they took on the day the kindergarteners were cutting trees. Based on this picture, the teacher wanted children to find things that were living and not living in the photo. To activate students’ prior knowledge, the teacher first led the children to recall together what elements were needed for anything to live (see Excerpt 2).

Excerpt 2: Teacher's and Student’s Dialogic Exchange about Living and Non-living Things

Teacher: What makes something living?

Child: Living things are like trees and bushes.

Teacher: Okay, what makes something living?

Child: By the rain?

Teacher: No, no. Remember the criteria that we used, for instance, I'll give you an example, something living needs to breathe. What else does something living need to do?

Child: Oh, water.

Teacher: All living things…

Child: Eat, eat.

Teacher: All living things eat, all living things breathe.

…

Based on the conversation between the teacher and the child, it was evident that the teacher provided different probing questions in order to help the student answer the questions. For example, the teacher guided the student in an analytic process to deduce what factors animals/plants needed to survive. When the teacher assessed that the child needed additional guidance, they took another approach to ask the child about the same topic, but they adapted their pedagogical questioning protocol by asking the child to describe some characteristics about what something living needs to do, in this case, they posed: "All living things eat, all living things breathe." Rather than telling the student the correct answer, (such as: animals/plants need water, air, food, and light to survive) the teacher engaged the student through an inquiry-based process that was more age-level appropriate to help the child hypothesize what living things need to do based on their daily observations and experiences. After the children understood what living things needed to survive, the teacher asked children to circle things that were living and non-living based on the photo the teacher provided.

In the course of the classroom observation in this class, this research found that the two main topics came focused on in the kindergarten classes were connected with the NGSS Science Standards. Although teachers designed the curriculum and activities autonomously and strived to make them age-level and socio-culturally relevant, the main topics for their curriculum were about weather and living and non-living things. During their daily instruction, they guided children as they learned about different types of weather, different temperatures in varying geographic locations, and what living things needed to survive. Based on the interviews with the teachers, they all mentioned that their science curriculum design was guided by the NGSS Standards. According to the two teachers, they stated the following (see Excerpt 3):

Excerpt 3: Teachers' Discussion about Science Curricular Design and NGSS Science Standards

Teacher 1:"My understanding of science education is, first of all, there is an NGSS national standards. So we follow those standards, we use that at kind of a guide…, so we are interested in weather, with learning about the weather, which is national… you know, the NGSS framework."

Teacher 2: "So that kind of guide, the big ideas that we've done, like living and nonliving, weather, push and pull is going to be in the spring. And so those are kind of the big themes that we know that we need to study."

According to the teachers' statements, the NGSS Standards were an instrumental framework which aided in their curricular design. Most of the class topics followed this guide and teachers needed to help children learn about concepts related to weather, living and nonliving things given the requirements articulated in the NGSS Standards. Although the standard did not have a detailed curriculum about what the teachers needed to teach or what pedagogical structures to utilize in their activities and experiments, the teachers still needed to the main topics for the teachers to follow the requirements by the NGSS Standards.

Children's' Interests

Although there were NGSS standards that teachers needed to follow in their science curricular and activity-based designs, children's interests were also an important factor for teachers to consider in teaching science. According to the interviews with teachers, they all mentioned that children's interests were integral to their curricular and pedagogical designs. Sometimes the teachers did not know what they would talk about during the next science class since some topics were suddenly introduced into science classes based on children's interests. During the observations in the kindergarten, this research found that teachers often adapted their lessons and pedagogical approaches when children would share more about their interests in the classroom; therefore, this kind of situation often happened wherein teachers would rapidly adapt their teaching in the moment.

During one science class, a child inquired about steam, On a particularly rainy day when this class was held, children played outside of the classroom and discovered white gas rising from a wooden slide that they played on every day on the campus. At this time, the children were very excited and curious about why and how this structure produced gas. Given the children's observations and questions to their teacher, the following conversation occurred (see Excerpt 4):

Excerpt 4: Teacher's and Students' Dialogue about Steam

Children: Look, there is steam coming up from the brown structure (the wooden slide).

Teacher: Oh, yeah, there is steam coming up. Can you guys see that?

Children: Yeah. Why there is steam coming up?

Child: Maybe the cold water from the rain was on the roof, and then the sun made hot water.

Teacher: XX said that the steam comes from the water getting hot. So when the water goes up into the air, does anybody know, there's a big scientific..., there's a big scientific word for that. Do you know what it is?

Child: Evaporation.

Based on this short conversation, the teacher found children were interested in why the steam was rising and how the steam was produced. For this reason, the teacher talked about the topic of steam, evaporation, and condensation in the following science class. Although these concepts and words were a little difficult for the children to grasp, since they were interested in this topic, the teacher included a lesson to expand students' knowledge about this topic as a part of their later instruction. The teacher from the class described:

Excerpt 5: Teacher's Reflection about Teaching about Steam Given Students' Interests

"There's things that come up, like the steam, that's not… like, it connects to weather, it's not really part of weather, or like properties of matters in first grade or second grade. But they were interested in it, so we went with it. If they were really focused on the steam, we could tie that into weather and do more investigation that way."

According to the teacher's statement, although the big themes for the science class needed to follow the NGSS Standards, considering children's interests was also important in designing science socio-culturally connected curriculum and activities relevant to students' intellectual curiosities. The teacher later reflected, "curriculum is created by teachers, and it's very responsive to the kids." In terms of this science class, children were valued as important co-

constructors of knowledge and therefore the teacher designed curriculum that was student-centered based on their interests. Further, a teacher in another class also described (Excerpt 6):

Excerpt 6: Another Teacher's Reflection on Student-centered Learning in Kindergarten Science Classrooms

"So those components are what kind of frames how we do science here and also really listen to kids and know what their interests are. If they are interested in something, you wanna make sure you are open enough to take that route and help them learn. So we are interested in weather, with learning about weather, which is the NGSS framework, and some kids are really interested in hurricanes, like they become really interested, so we will talk about that.".

The teacher's statement surmised that although the requirement for kindergarten sciences classes are connected with the NGSS Standards (e.g. as mentioned earlier regarding aiding students' understanding of weather patterns and variations), it was of equal importance to ensure children's interests were incorporated in classroom instruction (e.g. such as exploring extreme weather phenomena like hurricanes, tornados, and blizzards). During one of the science classes, after describing different types of the weather, the teacher asked the children: *"What questions might you have? We've been learning a lot about the weather. What questions might you have about weather, or what else would you like to learn more about?".* Based on the question posed by the teacher, it was clear that inquiry-based questions helped the science teacher deduce children's interests which they then used to construct more student-centered learning activities. This also provided student voice and invited students into the design of their classroom learning, which yielded higher levels of student engagement. After the teacher asked students these questions, the children energetically shared what they wanted to learn and know more about regarding weather (see Excerpt 7).

Excerpt 7: Students' Interests in Additional Weather-related Explorations

Child 1: Can we learn about tornadoes?

Teacher: Tornado, okay.

Child 2: Snowy weather.

Teacher: Like to learn more about snowy weather. All right. What would you like more about… learn about the weather? Or, what would you like to learn more about in terms of weather?

Child 3: Hurricanes.

Teacher: Hurricanes, all right.

Child 4: I want to learn about rainstorms.

Teacher: So think about it, rainstorms. What do you want to know about rainstorms?

Child 4: I want to know, like how they form.

Teacher: How they form, okay. That's a good question, I'm gonna just add rainstorms and how do they form.

With regard to the conversation excerpt from the science class, it was clear that after the teacher covered primary themes required by the NGSS Standards, the teacher always asked children to share what they wanted to learn. Next, the teacher adapted their curricular and pedagogical practices to incorporate children's interests in their science instruction. Based on the observations in the class, this research found every weather characteristic mentioned by the children was explained to them in depth by the teacher in the science classes that followed. Moreover, for the question of "how do rainstorms form," the teacher also conducted an experiment with their students to help children expand their knowledge about this weather-related occurrence.

Other than following the NGSS Standards, children's interests were another important factor for teachers to design science curriculum and activities. In terms of the science class, it was student-centered and children's voices steered the teacher's instructional and pedagogical practices. Given the teacher's goals to meet the NGSS requirements and their desire to incorporate students' interests, their syllabus for the science class was not only based on the requirements by the NGSS standards, but was also adapted to feature children's interests. The teacher created the curriculum, but they also prioritized socio-culturally relevant instruction interrelated with children's interests.

Classroom Learning Environment

The kindergarten classroom learning environment contained different areas for children to study and play. There were spaces provided for teaching, a science corner, a painting area, a space for students to complete their writing as well as a block and play nook. For the teaching area, there was a whiteboard at the front of the classroom. The teacher used this whiteboard to provide visual and text-based information that needed to be seen by the children. The teacher also used the whiteboard to project some videos or photos for the children to observer. There was also a rectangular rug in front of the whiteboard. During most of the class time, the children and the teacher sat on the rug in a circle. Since the teacher and children sat together frequently, rather than standing up to provide instruction while the students were seated at desks, the teacher always cultivated a participatory environment wherein actively engaged in class discussions and activities.

During one science class, the teacher planned to conduct an experiment about how bread reacted to germs. In terms of this class, the teacher prepared two pieces of bread. In the beginning of this class, the teacher asked children to make a hypothesis about what happened to a piece of bread if it was touched with clean and dirty hands to deduce which piece of bread would form mold sooner. After making hypotheses, instead of putting one piece of bread touched with clean hands and another touched with dirty hands solely as a teacher-led demonstration, the teacher instead asked the children to conduct an observation. The teacher involved every child and guided their participation in the experiment (see Excerpt 8):

Excerpt 8: Teacher and Student Discourse about Bread and Guided Hypothesis Formation

Teacher: We're gonna do the experiment with the clean hands and dirty hands. Okay, everybody go get your hands dirty. Touch that rug.

During this time, every child was excited, and they touched the rug and floor to make their hands dirty. And then the children said:

"My hands are dirty enough".

Teacher: Are your hands dirty enough? My hands are really dirty right now, so I am going to touch the bread.

The teacher touched the bread first and then she passed the bread to the child sit near her and said: "not only touch it with your hands, you're gonnna cough on it too. Okay, pass it on to the next person".

This piece of bread was passed from one child to another until every child got a chance to touch this bread with their dirty hands. After doing this, the teacher then asked the children to wash their hands and get their hands clean. Moreover, the teacher passed another piece of bread to the children one by one and they all touched this bread with clean hands. After doing the whole experiment, the teacher put the two pieces of bread in the sealing bags and put the two bags in front of the white board so that children could observe the changes each day and collect anecdotal evidence.

In terms of this experiment, the teacher and children sat together in a circle that could help children see what the teacher was doing more clearly. Since they sat together, this invited the children's participation in the experiment; it also expanded class discussions between the teacher and students which revealed a lowering of students' affective filters. Other than this experiment, there were lots of science-related activities and experiments conducted in the class. For each activity and experiment, the teacher asked children to sit with her, participate in the activity and experiment, share their ideas, and discuss their thoughts with the whole class. Rather than asking children to observe what the teacher was doing, the teacher always involved every child in the class activities and experiments so that the children could get more hands-on experiences during the class. The teacher's pedagogical approaches not only increased children's interests in learning new scientific knowledge, but it also strengthened their understanding of scientific knowledge through personal experiences and enhance their desire for scientific inquiries.

Play Area with Blocks

According to the NGSS Science Standards, another important science concept that kindergarten children need to know is motion and stability. In terms of this concept, teachers need to conduct activities or investigations to help children know the effect of pushing and pulling forces of different intensities or directions on the motion of an object. In terms of the classroom in the kindergarten, there was a big play area with different shaped blocks for children to play by themselves. Most of the playing time, there were lots of children playing with the blocks. Children played by themselves with no teachers' guidance. Through building the blocks, on the one hand, children could constantly try to know how to make these blocks of different shapes; they often built high and stable structures. There were also many children who tried to build slopes with different angles and tried to know under what conditions the spherical blocks slid down quickly. Through children's own exploration and experimentation, they gained a preliminary understanding of the concepts of shape, stability, slope, motion trajectory, etc., and also stimulated their desire for continuous exploration and improved their interests in exploring scientific knowledge.

For example, based on the observation in the class, this research found there were two boys playing in the blocks area and they wanted to build the blocks higher. First, they placed one block horizontally at the bottom, and put another two blocks vertically on the top. After doing this, they continued putting one block on the top of the two vertical blocks and repeated this action. In the beginning, it was difficult for the children to make the whole blocks stable, so they kept repositioning the two vertical blocks to keep the entire blocks balanced and stable. In addition, after they finished building the blocks, one of the boys put another cuboid block and triangle block on the top of the completed blocks, and then the entire block structure fell. At this time, the boys began to rebuild the blocks that followed the previous steps. And for this time, when he tried to stack the last horizontal block, he found that the whole blocks became unstable and could collapse at any time. In turn, he tried to adjust the position of the vertical block until he found that when he adjusted the two vertical blocks to the same line and in the middle position, the blocks became stable again. Finally, he experimented with how to keep the last block stable, until he basically aligned the center of the block with the vertical block, and he succeeded in stabilizing the whole block.

Based on this observation, this research found although the blocks area was only for children to play by themselves and the teacher would not teach children how two build the blocks, this autonomous learning environment motivated children's initiative, enthusiasm, and stimulated their desire to explore. It also cultivated their hands-on learning capabilities and creativity, allowing them to experience the joy of inquiry. By raising the blocks high and keeping them from falling, children developed understandings of concepts, such as: shape, sense of space, stability, etc. which also stimulated their interests in learning scientific knowledge. The building blocks area also served an important role in kindergarten science education. Although the teacher did not design science activities specifically for building blocks, children could freely try and explore, and became interested in scientific concepts and scientific knowledge; they also experienced the joy of scientific inquiry by engaging with scientific concepts through play.

Science Area

For each of the classrooms, there was a science corner with different kinds of plants for children to observe, and there was a poster for children to post their questions about science on it. Based on children's questions, the teacher designed class instruction and activities to help children find the answer. For example, in terms of questions children were interested in that are shown on the picture below, this research found most of the questions were about living and nonliving things, animals and plants.

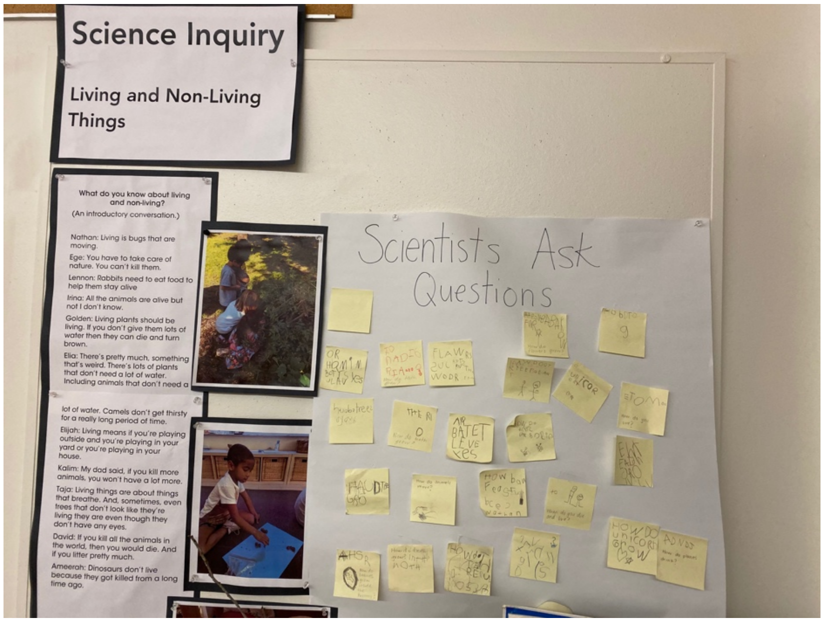


Figure 8. Scientific Inquiry in the Science Area

Since most of the children could not write complete words, they used letters to instead. In terms of children's questions, they asked like "ETOM (earthworm), how do you live," "how do animals move," "how do plants drink," "how do flowers grow," "how do trees grow," and so on. Based on these questions, the teacher found that children liked learning about living and nonliving things. For this reason, the teacher conducted different kinds of exploration activities to help children observe, explore and recognize living and nonliving things, and also asked children what they did know about living and nonliving things.

Based on this science inquiry corner, the children expressed their thoughts about science and asked questions based on their curiosities. For teachers, it was a strong pedagogical tool to invite children to think critically and explore by themselves. The teachers also observed the students' interests and inquiries which they utilized to inform their curricular and pedagogical designs to ensure they were age-level appropriate and socio-culturally relevant.

In addition, other than the science inquiry corner, the teacher also planted various plants in the science corner which the children to observed by themselves. Through the children's observations, they examined the growth rate of different plants, the conditions required for the plants' growth, and the differences in the roots of different plants. In terms of the science corner, it was an engaging way for children to learn science. First, the children conducted easier explorations in the class periods and some occurred afterwards, such as observing the roots of the plants. And it also was a rife opportunity for children to do a long-time observation by examining the growth of different plants. Moreover, by changing the content of the science corner, such as: planting various plants, to observing small animals like earthworms, children learned about plants and animals through autonomous learning and exploration. The whole process not only cultivated the enthusiasm and initiative of children to explore independently, but also did not need to take up a lot of teachers' instructional time. Therefore, the establishment of a science corner in the class was a very useful pedagogical structure for children to explore scientific knowledge by themselves.

Exploration Activities on Campus

The kindergarten has a large campus with many different kinds of flowers and trees, so teachers always used the campus environment for students' scientific exploration activities. Through these activities, children engaged with nature, and on the other hand, they relied on their intuition to discover new scientific knowledge, such as: recognizing the roots of different plants, discovering the difference between living and non-living things on campus, and understanding small animals like earthworms.

One of the science classes discussed the leaves of plants. In the beginning of the class, the teacher took lots of leaves with different colors, shapes, and sizes to class and showed the leaves to the children. Next, the teacher led the children outside of the classroom and asked them to look for different green leaves around the campus (e.g. light green, dark green, etc). Throughout the exploration activity, the teacher guided the children to guess why the leaves were different in color through observation. In the end, the children not only aroused their interest in exploring nature through immersion, but they also attained a process for looking at leaves. They also learned that different temperatures and the degrees of sunlight exposure could affect the different colors of leaves.

Moreover, there were other exploration activities implemented outside of classroom throughout the campus. For example, in order to help children know different animals, the teacher used paper shells and color pens to make some different small animals and placed them in different places in the kindergarten (such as: trees, grass, or flowers). Then the teacher organized the children to have an exploration activity and learn about the animals. During the whole process, children felt like they were in a zoo. They had a strong interest in exploration, and through exploration activities and the guidance of their teachers, they recognized the living habits of different small animals, especially regarding animals' appearance characteristics, eating characteristics, and living environments.

Moreover, if children were interested in some special plants or animals, the teacher then designed exploration activities to help children deeply understand those plants and animals. For example, when some children were curious about earthworms, the teacher let children explore the campus to observe the earthworms. First, through the observation and exploration, the children analyzed earthworms' characteristics, such as: living in the soil and that they have no eyes and bones. Second, under the guidance of teachers, the children learned more about the earthworm (for example, that they are small animals and are beneficial to the growth of plants). When children showcased curiousity about dandelions, the teacher let the children walk out and find dandelions on the campus. The teacher told the children that the white pompon on the dandelion have seeds, so they would be carried by the wind to various places, spreading the seeds. Finally, the teacher led the children to spread the dandelion seeds throughout the campus. Based on those exploration activities conducted outside the classroom and on campus, this research surmised that the outdoor environment for kindergarteners is an important component for children to learn science, especially when they are learning about plants and animals. First, the children explored campus by themselves and sparked their interest in exploration. Second, children were immersed in nature and intuitively knew different animals and plants given their teachers' pedagogical approach to create opportunities for active and experiential learning.

Exploration Activities Off-campus

Other than the exploration activities carried out on campus, there were lots of activities conducted off campus, such as for each year, there was a field trip that the teacher would take children to the botanical garden or TreePeople[1] to do some exploration. Based on these exploration field trips, the children gained more hands-on experience. They learned about nature, such as the specific ecosystems, different kinds of animals and plants. They investigated ecosystems during the field trip. In terms of the field trip to TreePeople, the children experienced lessons about conversation, ecosystems, and nature. Moreover, they also children also participated in some guided tours.

During one field trip to the botanical garden, children explored different kinds of plants and recognized living and nonliving things in the garden. First, the teacher guided the children as they recalled the characteristics of living and nonliving things. Then each child was given a piece

[1] TreePeople is an educational and training environmental advocacy organization based in Los Angeles, California. It engages, supports and empowers students, teachers and communities with knowledge, skills, and understanding of the environment and partners alongside them to take action through hands-on meaningful projects.

of paper and a pen, and the teacher asked children to draw the plants or animals that they were interested in or impressed by during their exploration process. Then the teacher facilitated the children as they explored the botanical garden together. Throughout the process, children became curious about different trees and asked many questions, such as: “why are its’ leaves shaped like this?," "why is this tree so tall?," "why are there leaves in different colors?". Through these questions, on the one hand, teachers could understand how much children have known about plants and what questions they were interested in about plants, which could help them better carry out subsequent scientific activities and courses. On the other hand, the teacher explored with the children together, helped them find answers to their questions, and let the children know about different plants.

In addition, there were lots of small animals in the garden and the children also had the opportunity to observe different kinds of animals, such as: little birds, fish, and turtles. Through these off-campus field trips, on the one hand, children had a chance to get close to the nature that inspired their interest in exploration. On the other hand, through these field trips, children had more hands-on experiences. In order to help children know more about plants and animals, rather than teaching children the knowledge or concepts in the class, the teachers always conducted outdoor activities for children to create scientific observations and explorations by themselves.

Teachers’ Pedagogical Practices in Teaching Children Science

In this section, this research focused on how teachers instructed children about science. The results showed that the design of the science curriculum and activities were student-centered. The children in the class had more chances to participate in the activities and explore by themselves. In terms of teachers in the class, they were more like facilitators who created hands-on experiences for children to explore. Next, they guided children as they learned science knowledge based on their explorations. The themes for the science activities also came from children's interests and life experiences. Moreover, in order to support children's expanded dispositions about different kinds of weather, the teachers used painting as a medium of expression for students to showcase their learning. This created the opportunity to pique children's interest in science and provide an accessible pedagogical tool for students to express their understandings and for the teacher's assessment of their learning about weather.

More Student-centered Explorations

In terms of the teachers' pedagogical practices in teaching children science in the kindergarten, it was more student-centered. On the one hand, the teachers chose the science classes' topics and designed science activities/experiments based on children's interests. On the other hand, the teachers always provided children more time to observe and explore. During the time when the children were exploring by themselves, the teachers asked questions or guided activities which encouraged children's scientific thinking.

There were two kinds of student-centered science activities conducted in the class. The first kind of scientific activity was structured through problem-based inquiry..The teacher used the materials to embolden the children's interest in inquiry, and then the children conducted free inquiry by themselves. In this process, the teacher guided and organized the children to carry out purposeful and planned inquiry activities. The children were at the center of all the activities. During the activity time, the children explored and observed first by themselves, and the teachers guided the children to answer their questions during their explorations. For example, the background of this science activity was that during an extracurricular activity, the teacher observed that the children developed a strong curiosity about earthworms in the grass and garden outside the classroom and they also generated a series of questions. Usually children liked small animals, but they did not know much about earthworms. Some children were even afraid of earthworms. For this reason, the teacher designed this activity to help the children get to know and understand earthworms. The picture below showed how the teacher carried out this activity:

Teacher: The teacher let the children observe worms freely and she was observing the children's activity.

Children: The children were observing worms with a magnifying glass and also used their eyes to observe and use their hands to touch and feel worms. They were talking about what they were observing, such as: "they are wrinkle."

Figure 9. Student-Centered Explorations and Field Notes

As for this science activity class, first, this was a free inquiry-based scientific activity. The teacher first amplified the children's interest in inquiry by giving them earthworms, and then the children conducted free exploration; the teacher played a guiding role in this process. The teacher designed various questions to guide the children to learn more about earthworms, such as letting the children feel whether the earthworms were cold or warm by touching them, and letting the children observe what earthworms looked like with a magnifying glass. The teacher asked the children whether the earthworms' skin was smooth or wrinkled. In addition, the teacher asked more questions like, "who is brave enough to protect the earthworms?". The teacher also encouraged children to touch earthworms, and by using the word "protect," it also let children know that earthworms were good animals and lowered their possible biophobias.

In the guidance process, the relationship between the teacher and the children was equal-the children were respected. For example, the teacher said, “if you don't want to hold an earthworm, you just need to tell me no, thanks.” In terms of the teachers’ guidance, it was mainly student-centered. For example, teachers let children explore and discover problems by themselves, and then gave guidance in a timely manner. During the whole process, they also afforded attention to consider the feelings of the children, allowed the children to refuse to touch the earthworms, and found other ways to guide the children’s learning. This activity stimulated children's interest in learning science, cultivated their initiative, enthusiasm, and stimulated their desire to explore. It also cultivated children's hands-on capabilities and creativity.

In addition, another kind of science activity conducted in the class was starting from some life experiences or topics of interest to the children. The teacher allowed the children to make guesses and assumptions about certain scientific phenomena and problems. Then the teacher provided instruction where the children verified whether they guessed accurate results through activities and explanations. The development of this kind of science activity was also student-centered. First, the topics of the activity were based on some life experiences or phenomena that the children were interested in. Secondly, during the activity verification process, the teacher led the children to operate and verify by themselves, and the teacher served as a facilitator.

During one science class activity, the teacher asked the children to wash their hands before eating because there were germs on their hands. But many children did not pay much attention to washing their hands. They probably knew that there were germs on their hands, but because they were not visibly aware that germs existed, they did not take handwashing very seriously. For this reason, the teacher designed this scientific activity to help children verify that bacteria existed. The picture below showed how this activity was conducted in the class.

Teacher: The teacher let the children touch the two pieces of bread with their clean and dirty hands.

Children: The children passed and touched the breads one by one, and the teacher guided the children during this process by saying: "make your hands dirty and touch the bread, you could also cough on it."

Figure 10. Bacteria Verfication and Field Notes

In terms of this activity, first, the teacher prepared two slices of bread and two sealed bags. Then she asked each child to touch two slices of bread with their clean and dirty hands. Finally, the teacher put the two slices of bread into two sealed bags and put them in the classroom for the children to observe. A week later, the children clearly saw "green hairs" growing on the bread they touched with their dirty hands. Based on this activity, the teacher successfully scaffolded children's realizations that bacteria exists which verified that they needed to wash their hands before eating.

Through this activity, this research found this kind of science activity conducted in the class was also start connected with children's lives. The design and development of activities were mainly based on the life experiences of children, or topics and phenomena that the children were interested in. Throughout this learning process, the teacher was more of a facilitator than a sage on the stage. Compared with simply letting children observe, the children participated in such activities and gleaned results through personal experience and experimentation. For example, in the activity about bacteria, the teacher asked each child to touch the two slices of bread. On the one hand, it improved the enthusiasm of each child to participate and stimulate their desire to explore. On the other hand, the teacher guided children through direct participation, experience, and practice in their science learning that could help children experience the fun of exploration.

Based on the interviews with teachers, they all mentioned that as teachers, they were more so facilitators in the process of teaching children science. Instead of providing information and telling children the answer, it was better to guide children as they explored by themselves. The teachers from the two classes articulated: "With younger kids, you don't need to give them too much information. It's more about the experiences and uncovering vocabulary science, science terminology, um… concepts that are just out their experience, it's an experiential." "We are known as teacher, facilitators, and we constantly learning together." Based on what the teacher stated, rather than directly providing information and answers to children, as a teacher, she always served as a facilitator learning with the children together. The other teacher from the class also mentioned that, "I'm the moderator. So, I'm the, like, seed of here. So, I might like an idea of what we're doing. I'm the role of the facilitator, so some of... Like, it's listening to their ideas, and taking those ideas and providing opportunities for them to explore, like, they don't know how to find information yet." As teacher, facilitator, and moderator, in order to conduct science related activities and teach children science knowledge, the teachers always began their lessons by inviting children to share their ideas. Next, they designed the curriculum and activities based on children's ideas, interests, and experiences. During the process in learning science and carrying out the activity, teachers always gave children more chances to experience and explore by themselves and provided timely guidance.

Painting and Weather

One of the important aspects of kindergarten science education mentioned in the NGSS Science Standards is weather. In the science classes, the teacher not only led the children to know the temperature of different places by numbers, and compared which place was the hottest or coldest, but they also paid attention to let the children know what kind of phenomenon different weather could produce, and how the different weather would affect them. The teacher also let children know how to protect themselves in different weather conditions, especially under extreme weather. Because the formation of many weather causes were too complicated for kindergarten children, it was not necessary to learn the causes of weather. Therefore, as a teacher, it was more important to help children understand how different weather affected them and how they should protect themselves in different weather conditions, especially extreme weather. Since this knowledge was closely related to children's lives, it aided in their engagement with the learning materials.

In order to help children know how different weather conditions would affect them, the teachers used painting as a pedagogical tool in science classes. Since children liked painting and it was difficult for some children to describe certain weathers using written or oral words, the teacher asked the children to draw the weather they knew about and how they could protect themselves in these weather conditions. For the children, they drew all kinds of weather, ranging from common weather like rainy days or sunny days to extreme weather like heavy rain, blizzards, hurricanes, etc. In children's paintings they would express what the weather was like and how it was formed, and on the other hand, they showed how to protect themselves in this weather. After the children finished drawing, the teacher shared the children's drawings with the whole class and guided the children to recognize different weather. Taking one science class about weather as an example, in the beginning of this class, the teacher asked children to draw the weather they knew about. After the children completed their drawing, the teacher shared the pictures from the children with the whole class and discussed different kinds of weather with the children together. Below the picture showed how this class carried out.

Teacher: The teacher shared children's painting in the class and guided the children to describe their painting and also guided the children to learn different kinds of weather.

Children: The children described what they have drawn in the picture and shared their understanding of the weather I the class.

Figure 11. Drawings about Weather and Field Notes

In terms of this class, first, the teacher asked children to draw what they knew about weather. After the children finished drawing, the teacher guided the children to share their work in the whole class. In the beginning, the teacher asked the child who have drawn the picture to share it in the class, and during the time the child was sharing, the teacher would ask questions to help the child describe and know more about the weather. For example, when the teacher saw one of the children who have drawn a picture with lots of things in the picture, she began to ask questions to help children describe what he has drawn and guide the child to know more about the weather. Figure 12 showed original picture the child has drawn, and how the teacher guided the child to add labels on the picture.

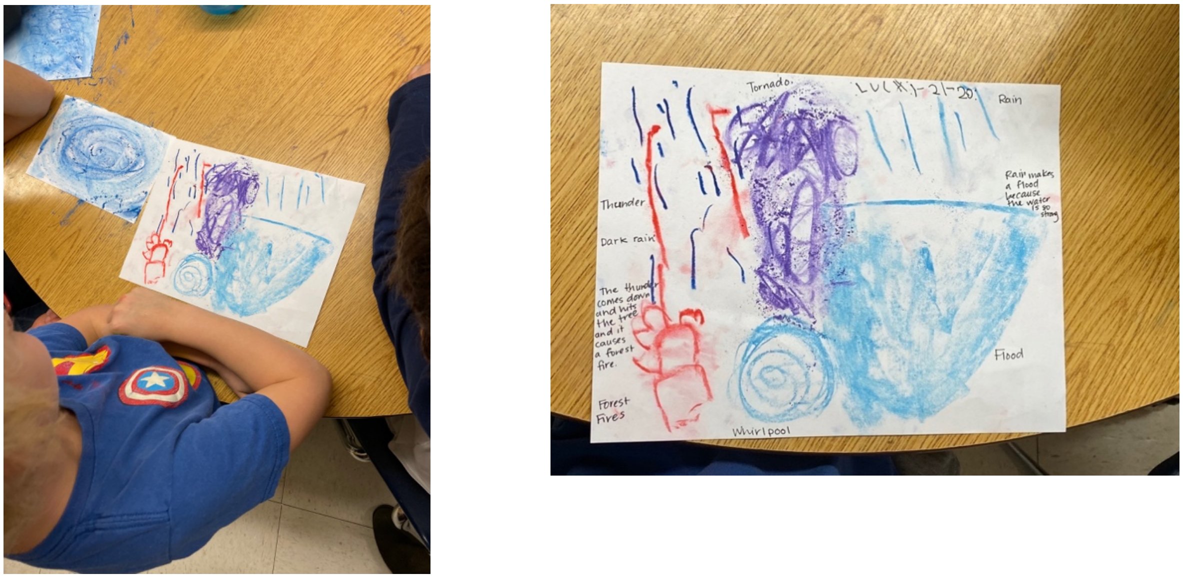


Figure 12. Original Picture the Child has Drawn & Picture After the Child Added Label

The picture from figure 12 was difficult for other people to clearly understand what the child wanted to draw. For this reason, the teacher asked the child questions like, “What’s this?,” “Why did you draw this here?,” and “What do you want to tell us about this?”. Based on these questions, the child and the teacher added labels together for this picture that could make them easier to understand the picture for others. In addition, based on the children’s answer, on the one hand, the teacher were able to assess how the child knew about the formation of the weather. For instance, when the child drew a flood in the picture, the teacher asked him, “do you know how flood was formed?,” and then the child responded, “rain makes the flood, because the water is so strong,” The picture helped the teacher know what the child knew about this kind of weather, such as whether the child could recall why he drew the fire on the picture because “the thunder comes down and hits the tree and it causes a forest fire.”

Based on painting of weather, the teacher know what weather the children have known, and what kind of knowledge and understanding they have about these weather conditions. By painting, children learned how to use language to describe what they painted and this let the children understand how different weather would affect them and how to protect themselves in varying weather conditions. During the whole process, the teacher's guidance was based on the children's paintings. For example, the teacher asked questions like: "what kinds of things do you wear when it is so hot outside?" and "what are some things that can help protect you from the heat?". These probing questions guided the children to put on short sleeves and umbrellas for the boy in the painting to tell the children that they could use umbrellas to protect themselves from sunburn on sunny days. When the teacher saw a child's painting of a rainy day and a little boy was standing in the rain, the teacher said that: "Could he have an umbrella? An umbrella can protect him from the rain. You could do it right here to protect the person or if the person likes to be in the rain, you could add it on the back if you wanted." Based on the teacher’s guidance, the children could also knew that the umbrella could not only block the sun, but also protected them from being drenched in the rain. Guided by painting, it was easier to increase children's interest than to directly instruct them about how a certain type of weather was formed; it also allowed them to understand different weather more intuitively.

In addition, sometimes there might be differences between what the children wanted to express and what the teacher thought they wanted to express, so by letting the children draw what they thought about helped the teacher better understand the ideas of the children. For example, when the teacher saw a child who drew a flower in a rainy day, she thought it was for decoration until the child shared in the class and said the reason why he drew a flower here. The child describe: “because it's to show that rain makes the flower grow in the grass.” There was also a girl who drew a picture of tornado, clouds, and rain on it. When she described her painting in the class, the teacher noticed that rather than drawing white clouds, she drew the clouds with gray and black colors. For this reason, the teacher asked her, “Why did you make them gray and black?". The girl replied, "because on the side when it's, when the clouds are gray there's water, there rain clouds." Based on the children's paintings, teachers could know that the children sometimes knew more than what the teachers thought. By using artistic expressions to teach children about weather, it expanded children's interest in learning about science, but also provided a pedagogical scaffold for children to creatively express their ideas.

Classroom Discourse in Teaching Children Science

Initiation, Response and Feedback (IRF) Turn

In terms of the science class in the kindergarten, although there were more student-centered explorations and hands-on learning experiences, teacher's instruction and pedagogical processes used the IRF (Initiation – Response – Feedback) sequence (Rymes, 2015). First, the conversation between children and teachers was always initiated by the teachers. In terms of the initiation, it usually started with an open-ended question. The purpose behind why teachers asked questions was to guide the children to make assumptions or predictions. Through this method, the conversation was initiated by the teacher, but the teacher invited the children to make hypotheses first, and then they guided children's critical thinking processes. The children still had the option to explore and express their thoughts. For the feedback turn, rather than providing feedback for children to guide and encourage them think more, the teachers always gave evaluations (E) for children's responses before providing feedback. For the evaluation, on the one hand, the teachers would use words like "yes," "alright," "okay," "good," "great." to affirm children that their thoughts or ideas were correct. On the other hand, another way that teachers provided evaluations was by repeating what the children said with an affirmative tone. In this way, the teacher was able to guide children to deduce when their answers were correct. After providing feedback, sometimes the teachers would give a summary (S) to close the conversation. For the summary, teachers usually summarized what the children talked about in a more clear synthesis.

For one of the science classes, the purpose for the teacher in this class was to do an experiment about how rain forms. Before the experiment started, the teacher prepared a pot of hot water, a bowl full of ice cubes, and a glass bottle. Then the teacher poured hot water into the glass bottle and put the bowl full of ice cubes on top of the glass bottle to let the children observe what would happen. Below was part of the conversation from the class and the teacher mainly used IRF turn in this conversation. Before providing feedback, the teacher usually provided an evaluation to the children's oral discussion first. For example (see excerpt 1):

Excerpt 1: Evaluation Sample

Teacher: My goal. What do you think you, I might see underneath? (I)

Children: Water. (R)

Teacher: Water. (E) Why would water be there? (F)

Children: From the ice. (I)

Teacher: From the ice? And? (E & F)

Children: Rain. (R)

Teacher: From the ice. (E) Look what happened to the ice. They were all solid. How did the ice melt? (F)

Children: It melt in hot water. (R)

Teacher: Okay. I'm going to raise this. So, some of you hypothesized there would be water on top. Okay. (E)

…

Teacher: So, I am going to try to see if I can raise it enough for me to see, because I'm curious. Oh, yes. Do you see all those little droplets? (I)

Children: It's raining. It's raining. (R)

Teacher: We, we're done. (E) So, our goal was to see how the rain forms, so the hot air… (S)

During this conversation, rather than direct instruction, the teacher guided children towards the goal for this experiment. The openly discussed the objective was to see how the rain forms. The teacher used a question to start this conversation. Based on this question, the children had a chance to think, observe, and explore by themselves. Through their hypotheses and observations, they discovered there was rain occurring in the bottle. Through this exploration, instead of telling children exactly what the experiment was about, the teacher guided the children to observe and explore by asking questions, such as "What do you think you, I might see underneath?," "Why would water be there?". Based on these questions, the children deciphered what happened in the bottle and what this experiment was about step by step by themselves. After children's responses, the teacher provided children with an evaluation by repeating what they said, or using the words like "okay" to affirm children's observations were correct. After providing evaluations, the teacher would also incorporated feedback that yielded follow-up conversation. In terms of the feedback, it served as another initiation for the following conversation. For this conversation, after children said that there was water underneath, first, the teacher repeated what the children said with an affirmative tone to let children know their answer was correct. Subsequently, the teacher asked another question that afforded them feedback for what the children discussed. Based on the question of "Why would water be there?", children were inspired to continue thinking and exploring, and they tried to get a result for this experiment. Rather than closing this conversation by just saying “we are done,” the teacher gave children a summary about this experiment. In terms of the summary, the teacher repeated the process of the experiment, what they have observed during the process, and clearly told children the process of how the rain forms. Based on the summary, the children grasped the formation process of rain more clearly, and deepened their skills regarding conducting experimental processes and developing results.

In addition, there was another science class which talked about different types of weather. In this class, the teacher also mainly used the IRF turn to carry out their conversation. The conversation between teacher and children included (see excerpt 2):

Excerpt 2: Discourse Example

Teacher: What type of weather have you experienced or know about? (I)

Child: Sunny. (R)

Teacher: You know about sunny weather. Okay. (E) So sunny weather makes you warm, and what? Tell me more about sunny weather. (F)

This conversation was also initiated with a question asked by the teacher. Diverging from asking children to make predictions or hypotheses, the purpose for this question was to let children share their thoughts and ideas first before the class. Based on this question, although this conversation was created and started by the teacher, but to some extent, the children dominated the following themes for this class. Rather than choosing some types of weather by the teacher, for this conversation, the children had chance to share what types of weather they were interested in and knew about. Moreover, through what the children were shared, the teacher could know what the children have known about weather which would be helpful for their further curriculum design and teaching. For the feedback turn, first the teacher gave an example to the children and they said, “sunny weather makes you warm.” After giving the example, the teacher asked the children to think more about the sunny weather. Based on this statement, the conversation would not be closed and the children could think more about the weather, and it could be an initiation for another conversation.

Generally speaking, in the kindergarten, the teacher mainly used IRF turn to teach children science. Although the class conversations were always initiated by the teachers, it was not teacher-centric. In terms of the initiation by the teachers, they usually asked open-ended questions to permit children to make predictions and hypotheses for the experiment that they would do next, or they let the children share what they knew and what they were interested in based on their lived experiences. Under this situation, in terms of the experiments, the children made hypotheses, observed, explored and gathered results by themselves. The teacher’s role in the exploration process was more like a facilitator. And in terms of the science knowledge instruction, although the teacher chose the broad topics like weather for children to learn, the teacher created opportunities for them to share what they were interested in and what they wanted to know more about for this topic.

Inquiry-based Teaching

The core of science education in the kindergarten was inquiry. For this reason, whether it was the teacher's instructional approaches, or the development of activities and the design of experiments, their purpose was to stimulate children's curiosity and enthusiasm for scientific exploration. A primary learning outcome was for children to be able to find answers to questions through exploration and experiential learning through the process and joy of inquiry. Based on the interviews with teachers, they mentioned that: “The core of science education is really about inquiry. Using children's understanding, and what they think about things, and their questions is guiding you through the process." Based on the teacher's statement, this research discovered that the science education in the kindergarten was mainly inquiry-based and student-centered. In the process of teaching children science, teachers acted more as facilitators and their purpose was to conduct science activities or experiments with children to guide their self-explorations by themselves and have more hands-on experiences. For this reason, the discourse strategy used by teachers was not about searching for the right answer, but to encourage children to think more critically through observations and explorations. In terms of the science classes talking about weather, the teachers needed to let children know about different types of weather. But for an inquiry-based class, rather than giving children the right answer about how different types of weather forms, this kind of class paid more attention to children's inquiry-based process. In this case, the discourse strategy teachers used in the class was trying to involve more children in class discussion, give every child chance the space to share their opinions, and let every child have a chance to explore and share what they have learned in the class. The conversation between teachers and children in the class that about learning different types of weather usually occurred as follows:

Excerpt 3: Discourse Sample

Teacher: XX (a child's name), What type of weather do you know about?

Child 1: Rainy weather.

Teacher: Rainy weather. Tell me what does that do?

Child 1: It makes you want to stay inside. Then go out with an umbrella on.

Teacher: Makes you want to stay inside, then go out with an umbrella. All right. Um, XX, what type of weather do you know about?

Child 2: Foggy.

Teacher: Foggy weather. Tell me more about foggy weather.

Child 2: You- you can't see that good. So you ... so ... you can't see that good, so everything just like blank a little. And you only can see, like, like, a few things.

Teacher: Blank? That's a good description. XX, what type of weather do you know about?

Child 3: I know about cold weather.

Teacher: Cold weather. Tell me more about that.

Child 3: Cold weather makes me want to wear a jacket.

Teacher: Yes. XX, what type of weather do you know about?

Child 4: Um, I know about rainy weather. It makes you really chilly if you're not wearing the right clothes.

Teacher: Rainy weather makes you chilly if you are not wearing the right clothes. Okay. Uh, XX?

Child 5: Rainy weather helps the plants. Plants grow so you can breathe.

Teacher: Breathe. Oh, I love that! And what other weather do you guys know about? ... XX?...

The teacher's purpose in this conversation was to include every child in the class discussion and could provide time to express their thoughts. The teacher called the name of different children to let them share their ideas. After each child's response, the teacher provided praises or affirmations to their responses that increased their confidence and encouraged the following children to share their thoughts. There were several children who wanted to talk about rainy weather. Under this situation, rather than interrupting students and saying things like, "We have already talked about this weather, could you please change another one or share something different?," the teacher encouraged every child to share whatever they wanted. In the end, this research found although they all talked about rainy weather, what they described varied. Child 1 said, "Rainy weather makes you want to stay inside. Then go out with an umbrella on" whereas child 2 posited "Rainy weather makes you really chilly if you're not wearing the right clothes". Later child 3, stated: "Rainy weather helps the plants. Plants grow so you can breathe." Based on their speaking, they articulated different aspects regarding their understanding about rainy weather. Using inquiry-based discourse strategies provided every child a chance to express their thoughts; it was an important pedagogical approach for teaching children about science.

In the inquiry-based science class, the teacher always using inquiry-related vocabulary to provide children with an inquiry-based learning environment. For example, during the learning process, the teacher told the children that they were scientists, and that their community would find out the answer to the question together. In the process of guiding children to explore, the teacher always used terminology like "discover," "investigate," and "notice." This guidedl children that they were not learning the science knowledge through transmission or sit and get instruction, but instead that they had to do some explorations as scientist. By using these words, it made children feel that they were scientists now and this stimulated their interests and enthusiasm for scientific explorations.

Scaffolded Approaches to Support Students' Understanding of Process in Exploration Activities

In terms of this discourse strategy used in the science class, the teacher always assisted children in the process of exploration by giving them clues, prompts, and hints. Since the purpose was for teachers to conduct science-related activities and experiments was letting children think, explore, and observe by themselves. Rather than telling children what this experiment was about, what should they do next, or what was the answer to the was question directly, the teacher was willing to give children time to explore and find the answer by themselves. However, children's ideas were often varied, and they might not necessarily explore according to the teacher's expectations and assumptions. In this case, the teacher needed to guide the children to explore the results of the experiment and find the answer to the question. Therefore, the teacher gave the children some prompts to guide them through their processes of exploration.

During one science exploration experiment, the teacher created this activity with the purpose for the teacher to model this experiment to let children know how rain forms. In order to promote children’s exploration, the teacher asked children questions and the conversation discussed (see excerpt 4):

Excerpt 4: Discourse Sample

Teacher: Why do you think I'm putting ice?

Children: Um. To make it colder?

Teacher: What could happen?

Children: It might melt. The ice is gonna turn into water!

Teacher: Well, that could be melting. Oh, let's see what's happening inside... what do you think you see?

Children: It's getting hotter. / It's getting colder!

Teacher: But do you see what's developing here? What do you think is developing?

Children: It's mist! / Mist and fog! / Fog! / Fog, on the glass!

Teacher: Yes.

Children: Maybe you can put one of the ice cubes in, inside the hot water.

Teacher: No, then what would happen? My goal is for us to see how the water right now... is gonna be... coming to the cold and, you know what it creates? Like fog, or...

Based on the conversation, the purpose was for the teacher was to let children observe and explore the phenomenon. After the teacher poured hot water into the glass bottle, they filled the bowl full of ice cubes on top of the glass bottle. The hot air in the glass bottle would rise and meet the cold, and then condensed into small water droplets and dripped down. The whole process simulated how rain forms. But the children always thought and observed differently from their teachers. For example, when the teacher asked, “What could happen?”, rather than focus on what happened inside the glass bottle, the children noticed that the ice cubes in the bowl melted. The teacher began to give children hints by asking, “What's happening inside? What do you think you see?” to guide children to notice what happened inside the glass bottle. Based on the hints, the children were successful and paid attention to what happened inside the glass bottle. But they were more focused on whether the water in the bottle was getting colder. In this case, in order to guide children’s exploration, the teacher continued giving clues by asking children: “What’s developing here?” and “What does it create?”. By using the words “developing” and “create,” finally the children noticed that there was fog inside the bottle. Under this circumstance, the teacher continued guiding children to discover that other than the fog created inside the bottle, there were water droplets dripping down. Based on this observation and exploration, the children finally knew how rain forms.

In terms of this exploration experiment in the science class, this research found that as teachers, providing clues, prompts, and hints to children were important in guiding them to observe and explore by themselves. Rather than telling children the next step for the experiment or what they needed to observe, giving children hints cultivated children's interest in inquiry, improved their enthusiasm, guided their scientific inquiry, and let them feel the joy of exploration. In addition, this discourse strategy also used in lots of science exploration activities. the beginning of the earthworm activity, the teacher gave each of the child am earthworm and let the children observe and explore first by themselves. At this time, the children were more curious about earthworms, and most of them were playing with earthworms in their hands. By observing the children's discussions, the teacher found that some children said that the earthworms looked like monsters, and some said that the earthworms were squirming in their hands and making them feel itchy. Because the purpose for the teacher was to carry out this activity and to let the children understand earthworms through observation and exploration, this activity guided children to examine the shape characteristics of earthworms and their living habits. In this case, the teacher needed to give the children some hints to guide them to explore. For example, the teacher said, "Do you look at the earthworm through the magnifying glass? Is its skin smooth or wrinkled?" to prompt and guide the children to observe the external physical characteristics of the earthworm. Secondly, the teacher also reminded the children that they could learn about the earthworm by touching it by asking the children, "You can touch the earthworm to feel whether it is cold or warm." Finally, the teacher guided the children to observe the place where the activity was carried out by asking, "Do you know why we are doing this activity here?”. The environment included shady grass without sun, and the teacher further told the children that earthworms like to live in a dark and humid environment.

In conclusion, teacher’s scaffolded children’s understanding of process in exploration activities was an important and useful discourse strategy for teachers to conduct science activities and experiments for children. On the one hand, through giving children hints and clues, teachers guided children to discover the answers to questions and get to know small animals through exploration. Secondly, through these prompts and hints, it promoted children's thinking, improved their enthusiasm for scientific inquiry, and led them to carry out inquiry activities and learn scientific knowledge by themselves.

Ask Children for Description or Meanings

This discourse strategy means that the teachers always asked children to describe or give the meaning of some difficult concepts or terminology in science class. Since the children's ability in learning science were different, there were some children who knew a lot more than other children about science-related knowledge. At this time, when the teachers noticed this, they would not interrupt or limit the children's expression and sharing, so that every child would have the opportunity to express their own ideas. In this process, because some of the scientific concepts or terminology mentioned by the child were difficult for other children to understand, in this case, the teacher would ask the child to explain and describe the concepts or terminology that he/she mentioned, so that other children could understand. On the one hand, this strategy would not discourage the enthusiasm of the child who shared their ideas and would not make him/her unwilling to share in future classes. On the other hand, by guiding the child to explain the difficult concepts or terminology, other children could have chance to acquire more scientific knowledge. This discourse strategy also reflected that the purpose of science education in the kindergarten was to pay attention to children and guide them in scientific exploration based on their interests and lived experiences.

In terms of the science class which talked about different types of weather, one of the children mentioned air pressure as a type of weather. The teacher did not stop him or inform him that air pressure was not a type of weather, but instead the teacher let the child share with the class about air pressure and asked why he did think it was a type of weather. Based on the child's response, the teacher noticed that he thought air pressure was related to rainy weather and during the sharing process, he also mentioned the concepts "evaporation" and "condensation." Since some of children might not understand what the meaning of these two concepts was, the teacher asked the child to explain the terms to the whole class (see excerpt 5).

Excerpt 5: Discourse Sample

Teacher: Can you tell us what evaporation is?

Child: It's when water goes up and then the condensation.

Teacher: What's condensation?

Child: It's when… much the evaporation turns into clouds and then there's precipitation.

Based on this conversation, although the child could not explain clearly that what was "evaporation" and "condensation," the teacher still invited the child to complete his explanation. After the child's description, the teacher gave the whole class a summary with a clear explanation about condensation and evaporation. In terms of this discourse strategy, the purpose for teachers was not for searching for the correct answers for the students' understanding of concepts or terminology. What the teachers wanted to do was protect children's desire to share, enhance children's confidence in learning scientific knowledge, and provide them with more opportunities to express their ideas. For this reason, it was not the most important for children to explain the scientific concepts or terminology correctly or not, because the teacher would make summaries and give children the correct explanation at the end. For the children, the courage to share and express their ideas was the most important thing in scientific exploration.

Express Praises and Affirmations

The last discourse strategy teachers always used was expressing praise and affirmation to children after their sharing. Because some of the children were afraid or did not want to express their thoughts in front of the class, giving praise or affirmation to other children who have completed sharing encouraged students who felt afraid to express their own thoughts bravely. The words teachers usually used to express praise and affirmation included “great,” “yes,” and “alright.” Sometimes, even if the children said something that were not related to the class topics or the questions teacher were asked, as teachers, they would not directly say that their answer was irrelevant or wrong because that could make the children unwilling to share their ideas in the future classes. Moreover, at this time, the teacher always said “this is a good description,” “I love what you said,” or “this is a great idea” to affirm what the children expressed and build their confidence to continue expressing their ideas in the future.

Science education in the kindergarten was primarily inquiry-based. The purpose for teachers to conduct science activities or experiments was to serve as facilitators that could guide children to explore by themselves. In the process of exploration, giving praises and affirmation could not only afford children confidence to express their findings and thoughts, but it also encouraged children to participate in the exploration and have a positive and optimistic attitude towards the study of scientific knowledge and scientific inquiry activities.

CHAPTER 7 CONCLUSION AND DISCUSSION: SIMILIARITIES AND DIFFERENCES OF TEACHERS' PEDAGOGICAL PRACTICES IN EARLY CHILDHOOD SCIENCE EDUCATION IN CHINA AND AMERICA

This study has explored the factors that would affect early childhood science education in China and America, including the curriculum design and the activities and experiments conducted. It has also discovered how teachers structure curriculum to instruct children about science in these two countries, including what pedagogical approaches they used to facilitate children's learning about science, what kind of science activities/experiments they conducted to support children's exploration in learning science, and what classroom discourse methods they used to guide children in learning science knowledge.

This chapter reviews the similarities of teachers' pedagogical practices in early childhood science education in China and America. Next, it concludes the differences of teachers' pedagogical practices in early childhood science education in both countries. Finally, this chapter discusses the gap between the requirements by the *Guide for 3- to 6-Year-Old Children's Learning and Development* framework, the purpose and teachers' beliefs about early childhood science education, and the implementation of teaching children science in the Chinese kindergarten. Furthermore, it also discusses the basic consistency of the goals and implementation of science education in this kindergarten in the United States.

It should be mentioned that the study does not aim to generalize its' findings to the whole of China and America, as the teachers' practices in these two kindergartens and the views of those four teachers cannot be assumed to represent those of other kindergarteners and individuals in other regions. Rather, through showing the teachers' pedagogical practices in teaching children science in these two kindergartens in China and America, this study aims to provide other researchers in this field and kindergarten teachers an opportunity to understand the differences in early childhood science education in kindergartens in different countries with diverging cultural backgrounds.

Similarity of Teachers' Pedagogical Practices in Early Childhood Science Education in China and America

Previous chapters have provided an examination of kindergarten in China and America. This part further discusses the similarities of teachers' practices in teaching children science in both kindergarten contexts across China and America.

Purpose of Early Childhood Science Education

Standards' Requirements

In terms of the early childhood science education, both countries have guidance/standards for kindergarten science education. Although the standards were different between China and America, the purpose for early childhood science education based on the standards were similar and emphasized cultivating children's inquiry capabilities and leading them to experience the joy of inquiry.

In China, according to the *Guide for 3- to 6-Year-Old Children's Learning and Development,* the core of early childhood science education is to stimulate interest in inquiry, experience the process of inquiry, and develop preliminary inquiry ability. As teachers, they need to be exhibit pedagogical approaches to guide children's discovery, protect their curiosity, make full use of natural and practical life opportunities, and guide children to discover, analyze, and solve problems. In terms of the science class in the kindergarten, instead of teaching children scientific knowledge, teachers pay more attention to fostering children's creativity, curiosity, and inquiry abilities (MOE, 2012).

According to this guide in China, there are three main purposes for kindergarten science education, including: letting the children have the opportunity to get close to nature, cultivating their interest in inquiry, letting them have a preliminary inquiry ability, and understand the surrounding things and phenomena in the process of inquiry. Based on these purposes, in terms of teachers, they need to provide children with interesting tools of inquiry, often leading them to get in touch with nature and stimulate their curiosity and desire to explore. In the process of exploration, teachers should guide the children to observe the things around them, support and encourage them to actively seek the answer to the question in the process of exploration, and guide the children to think in the process of exploration and make predictions based on their own experiences.

Furthermore, in America, the goal to develop the Next Generation Science Standards (NGSS) was to create research-based science standards, which could help teachers design science curriculum that could motivate student's interest in learning science. Moreover, in terms of this standards for kindergarten science education, it also emphasizes hands-on inquiry that expects children to ask questions, carry out investigations, analyze the data, and find solutions for the questions by themselves.

Based on these two standards, the requirement for early childhood science education in these two countries were similar in that each framework asks educators to pay attention to inquiry, including providing children with more structured activities to explore, gain hands-on experiences, and ask children to find and solve problems autonomously.

Content of Early Childhood Science Education Based on Standards

Other than the standards' requirements for early childhood science education in China and America, according to the Guide for 3- to 6-Year-Old Children's Learning and Development and Next Generation Science Standards (NGSS), the content for science education in kindergarten are also similar. Based on the guide in China, the children should know common animals and plants, and be able to discover the growth changes, appearance characteristics, habits and living environments of animals and plants. This also could yield diverging understandings about different weather. For instance, including the impact of different weather on their own life and through discovering the characteristics of different seasons and the impact on animals, plants, and people. Finally, they needed to understand some simple physical knowledge, such as buoyance of objects.

Moreover, through the NGSS Standards in America, its' content requirements for kindergarten science education mainly focus on the following three areas: weather, living and nonliving things, and the interaction of forces. For weather, it requires that children not only need to know which places are cold and which are warm through numbers, but that they also need to be able to describe the characteristics of different weather. For living and nonliving things, it mainly emphasizes animals and plants. As children, they need to know what factors are needed for animals and plants to be alive, and how to distinguish between living and nonliving things. Finally, children need to know the different effects of pulling and pushing forces in different directions.

Based on these two standards, this research revealed the teaching methods teachers used in teaching children science in these two kindergartens in China and America. It also described the activities or experiments conducted by teachers in these two kindergartens; the content that teachers needed to include in science class were similar in these two kindergartens, including weather, animals and plants, and simple physical knowledge.

Teachers' Beliefs in Early Childhood Science Education

According to the four teachers in the kindergartens in China and America, they all mentioned that as teachers, they were more like a facilitator. The teachers needed to guide children to discover, explore and find the results by themselves. One of the teachers from the kindergarten in China discussed: "The teacher is an observer, guide and companion. All we have to do is accompany them during the activity and observe them. Provide timely guidance when they needed. During the whole process, we need to observe what the children need and give them timely help and support." Comparatively, another teacher from the kindergarten in China also mentioned that: "For a problem, I will first let them find out what is going on, let them think and make hypothesis. Then at the end I will tell them the answer and do the experiment with them to get the result together. I think it will be better than if I tell them the result directly, the children will be more interested because they like to try and practice. If I told them the result directly, they probably wouldn't be interested." Based on the teachers' statements, this research deduced that as teachers, their beliefs about teaching children science were more student-centered.

Moreover, in their paradigms, they needed to give children more chances to observe, think, predict and find answers by themselves. And for teachers, they were more so facilitator that provided children with support and help when they needed it. For example, the teachers from the kindergarten in America also claimed that: "We are facilitators. We don't need to give them too much information, it's more about experiences. "It's tapping into their curiosity and helping them was sort of the process of asking questions and the tools to find answers. What's I care about is being able to ask questions, think critically, experiment, make hypothesizes. I think it's the idea about investigation, questioning and curiosity." According to both of the teachers from Chinese kindergartens and American kindergartens, their understandings of early childhood science education was all student-centered. In order to conduct science education in the kindergarten, instead of telling children the results or answers directly, teachers were facilitators who provided children with more opportunities to discover, investigate, ask questions, and find answers by themselves, have more hands-on experiences, and become interested in and curious about science.

In conclusion, based on the requirement and content of early childhood science education based on the Guide for 3- to 6-Year-Old Children's Learning and Development in China and Next Generation Science Standards (NGSS) in America, as well as, the teachers' beliefs and understandings of science education in the kindergarten, this research deciphered the purpose for conducting early childhood science education in these two countries were similar. First, in terms of science education in the kindergarten, the teachers needed to let children acquire the knowledge of weather, animals, plants, and simple physical concepts. In addition, as teachers, they needed to conduct science classes that could invite children more chances to discover, explore, and find results by themselves.

Differences of Teachers' Pedagogical Practices in Early Childhood Science Education in China and America

This section discusses the differences in early childhood science education in the two kindergartens in China and America, including the differences in curriculum designs, learning environment settings, and teachers' pedagogical practices.

Structure and Flexibility

The first major difference was that Chinese early childhood science education was more structured in terms of curriculum and teaching environment design. The American early childhood science education was more flexible, including greater levels of flexibility with curriculum and learning environments.

In terms of the curriculum used by teachers in the Chinese kindergarten, it was structured. There was a provided syllabus for teachers to use to sequence their instruction. In this kindergarten in China, there was also a prepared textbook named "Feifei rabbit" used by teachers to teach children science. For this textbook, it was designed by a company and picked by the kindergarten. In terms of this textbook, it would tell the teacher what content they should teach in the class, what they needed to prepare before the class, what activity/experiment they needed to carry out in the class and what questions they needed to ask the children to guide their learning. Moreover, there was also a video for this textbook that the teacher could play in the class and it explained the science knowledge the children need to know for that day's science class. Based on this textbook, the teachers have less chances to design what they want to teach or what activities/experiments they want to do in the class. During most of the science class time, the teacher followed the content from the textbook and followed the pacing provided to instruct children science step by step.

Compared with the curriculum in this Chinese kindergarten, the curriculum in the American kindergarten science class was more flexible. In the kindergarten in America, the teachers did not have a fixed schedule for the science class, and they designed the curriculum by themselves based on the NGSS standards and children's interests. In terms of the science curriculum in the class, it was more flexible. Although the NGSS standards included the content that the kindergarten teachers needed to follow while teaching children science, the curriculum, activities and experiment designs were left to the teachers' discretion. For science classes, topics were often generated randomly and suddenly. It might be a phenomenon, or a problem suddenly discovered by children. Teachers adjusted and designed their own teaching syllabus according to children's interests, curiosity, and lived experiences.

Other than the curriculum design, the learning environment created by teachers to carry out science classes, activities, and experiments were also differences between the Chinese kindergarten and theAmerican kindergarten. In terms of the Chinese kindergarten, the science class, activity and experiment were mainly conducted in the classroom, while in the American kindergarten, all of these were conducted in the classroom, outside the classroom, on the campus, and off-campus.

Based on these reason, the science class in the Chinese kindergarten was more structured while theAmerican kindergarten was more flexible. In the Chinese kindergarten, the teachers' curriculum, activities, and experiment designs were limited by the prepared syllabus and the environment. In the American kindergarten, the science activities and classes were conducted at times outside the classroom, such as in the botanical garden. The learning environment for children was more flexible and they could get closer to the nature and discover and explore by themselves. Moreover, for teachers, they could teach children science knowledge and conduct science activities by using what exists in nature, such as asking children to observe, discover, and explore the different plants in the botanical garden; therefore, the teachers' teaching could also be flexible based on different learning environments.

Teacher-centered and Student-centered

The second difference for science education in the kindergartens between China and America were teachers' pedagogical practices in teaching children science. Although the purpose for early childhood science education in these two countries were similar in that each context paid attention to inquiry and needed to give children more chances to explore and discover by themselves, there were differences in their practices. Based on this research, the pedagogical practice in the Chinese kindergarten were more teacher-centered while in the American kindergarten they were more student-centered.

According to the teachers' pedagogical practices in the Chinese kindergartens, although the teachers wanted to give children more chances to explore and have more hands-on experiences, due to the constraints of various factors, teachers' instructional methods were also limited in many cases. First, in the Chinese kindergarten, it always attached great importance to order and rules. For instance, the layout of the classroom typically positioned the teacher at the front and the children sat neatly at their table. During class, children also needed to maintain order and raise their hands to answer questions. These factors affected the teacher's methods of instructions during science classes. Because the children needed to sit neatly in front of the table, many scientific experiments were conducted more based on the teacher's demonstration and the children's observation. When the children wanted to express their ideas, many children would be reluctant to express their thoughts because they needed to raise their hands to get the teacher's approval first. Second, ensuring the safety of children was also very important in the Chinese kindergartens. For this reason, scientific activities and experiments were always carried out in the classroom. Therefore, the children rarely had the opportunity to go outside of the school, such as the botanical garden, planetarium, and other places to conduct scientific exploration.

Under this situation, the children always completed some simple science exploration activities under the guidance of their classroom teacher. Moreover, because none of the kindergarten teachers in China have a professional scientific background, most of the time their teaching was based on the existing textbook “Feifei rabbit” and they followed the guidance in the textbook sequentially. For this reason, the children rarely received opportunities to choose the scientific knowledge they wanted to learn or the scientific experiment they wanted to complete. More often, they learned the prepared scientific knowledge under the guidance of the textbook and the instruction from teachers.

In addition, in the kindergarten in America, although the content of science classes were required based on the NGSS standards which includes weather, living and nonliving things, and force and interaction, the curriculum, activities, and experiments design are in the hands of the teachers who have the right to decide what activities they wanted to conduct and what knowledge they wanted to cover in the class. For example, although the content required by the NGSS standards included living and nonliving things, the teachers could choose what kind of living and nonliving things they planned to include in the class. According to the topics covered in the science classes, most of the time they were created based on children’s interest. During the time the teacher found out most of the children were interested in the earthworm, the teacher designed the science class to talk about earthworm. Moreover, rather than telling children what the earthworm looked like and what the characteristics and living habits of earthworms directly, the teacher asked children to observe, discover, and explore by themselves first, and then the teacher gave them timely support and aid their explorations.

Based on this example, this research found the most important thing in the kindergarten in America was created student-centered science classes. The teachers did not have professional science backgrounds, but, there was not a scheduled syllabus for them to follow and the curriculum was designed by themselves. Moreover, most of time, the teacher designed curriculum based on children's interest. Second, in the process of science classes, the teachers tried their best to give children more chances to discover and explore, and then the children would have more hands-on experiences. What the teachers always said was "let's find out/investigate/discover together." As far as science classes were concerned, the teachers were more so facilitators to guide students as they discovered problems, asked questions, made hypotheses, conducted exploratory experiments, and found answers to questions with children together. Throughout the whole classes, they were student-centered, and the teachers gave children timely help and support during their explorations.

Results-oriented and Process-oriented

The final differences between the kindergartens in China and America in teaching children science was that the Chinese kindergarten showcased more attention to the results after children's learning, whereas the American kindergarten focused more on the learning process. Although the teachers in the Chinese kindergarten also attended to the process of exploration, the children needed to carry out purposeful exploration under the guidance of the teacher. At the end of the classes, they needed to master the knowledge points of this class and know the answers to the questions. Compared with the kindergarten in America, teachers emphasized the exploration process, such as how the children gleaned their results.

Although the main classroom discourse methods the teachers used in teaching children science in the kindergartens between China and America was IRF (Initiation, Response, & Feedback) turn, the purpose for teachers to initiate a conversation were different. In terms of the

Chinese kindergarten, this research found the teachers always asked “what” questions to initiate the conversation. Through asking “what” questions, the teachers wanted to extract accurate answers from children. For example, in the science class that talked about the form of water, the teacher asked children: “like water at very cold temperatures, like below 0 degree, what does it become?”. Based on this question, the teacher wanted to get the answer from the children who said “ice.” Moreover, the teacher continued asking children t “what will happen to the water if it is heated?”. For this question, the teacher’s goal was also to get the right answer form the children who said “water vapor.” Rather than asking “what” kinds of questions, the teachers in this Chinese kindergarten also asked “yes or no” questions or “choose an answer” questions in the science classes to let the children find the right answer, such as: “If you put a plastic foam block in the water, will it sink or float?” or “Does ice turn into water when heated?”. All of these questions’ purposes were to encourage the children to find the right answers and assess if they have understood what the teachers have taught in their class.

Further, for the science class in the American kindergarten, although the classroom discourse method the teachers used was also mainly IRF (Initiation, Response, & Feedback) turn, they focused more on the exploration process for children. During the science classes, the teachers always asked “why” or “how” questions to encourage children express their inquiry process. In terms of one of the science classes, the teacher did an experiment to let children explore how rain forms. Although this experiment was conducted by the teacher, during the experiment process, the teacher asked the children questions like: “Why would water be there?” and “How did the ice melt?”. This prompted students to ask, explore, and discover by themselves. For this experiment, if the teacher told the children how the rain formed directly or asked questions like: “Do you see the fog inside the bottle?”or “What do you see inside if I put the ice on the top of the bottle?," it would have limited children's thinking and exploration since the questions would have guided children to observe what the teacher wanted them to find first.

Moreover, the teachers also asked "what" questions in the science classes, but the purpose for asking these questions was not to seek for the answers or results. What the teachers wanted to do by asking "what" questions was to encourage children to share their experiences or what they were interested in as related to the class. For the science class that talked about weather, the teacher asked the children: "What type of weather have you experienced or know about?". The teacher's goal was to ask this question to access students' prior knowledge about types of weather the children. The teacher focused more on information exchange with students by inviting them into an expressive process. The teacher continued asking follow up questions to encourage children share as much as they knew about the weather.

Furthermore, the kindergartens in both China and America all included painting when teaching children science, but their purpose for using painting was different. In the Chinese kindergarten, the teachers always used painting in the end of the classes to check if the children mastered the knowledge they talked about in the class. For example, after the science class about buoyance, the teacher asked the children to draw the buoyancy and mark the direction of the buoyancy that could help children check the teaching result for today's science class. On the other hand, the teachers in the American kindergarten always used painting in the beginning of the science classes to let the children draw what they have known for pertained to that day's topic. For example, in the beginning of the science class talking about weather, first, the teacher asked children to draw a type of weather and try their best to draw as much as they knew about this type of weather. When the children completed their drawings, the teacher asked children to share and explain their drawings to the class. In this process, the teacher encouraged and guided the children to think and share more about the weather. What the teacher paid more attention to was the sharing and exploring processes.

Collectively, although the teachers in the kindergartens between China and America were all attentive to the inquiry process in the science classes, the teachers in the Chinese kindergarten focused more on the results of learning. Rather than giving children chances to explore, in the end of the class, the teachers needed to let the children understand and master the key knowledge points for that day's class based on the syllabus. The children also needed to solve the problems or find the answers to the questions on the syllabus. Therefore, the early childhood science education in this Chinese kindergarten was more result-oriented whereas the American kindergarten was more process-oriented.

Discussion

In terms of the science education in these two kindergartens in China and America, all of their purposes were providing children with more opportunities to explore and have more hands-on experiences. They all emphasized inquiry by children themselves rather than telling students the answers directly by teachers. In the science class in this Chinese kindergarten, despite the requirements by the *Guide for 3- to 6-Year-Old Children's Learning and Development* framework and the teachers' beliefs towards science education, the kindergarten emphasized stimulating children's interests in inquiry, experiencing the processes of inquiry, and developing preliminary inquiry abilities. However, there were still differences in the implementation processes. Because of the structured syllabus, structured and limited learning environment, the teachers' pedagogical practice in teaching children science were still more teacher-centered and result-oriented.

Compared with the science education in the American kindergarten, based on the flexible syllabus and diverse learning environment, the science classes in this American kindergarten were more student-centered and afforded children more chances to observe, discover and explore by themselves. Under this situation, the goal of early childhood science education and the implementation in teaching children science in this kindergarten in America were almost the same.

According to sociocultural theory, cultural characteristics in different contexts impacts the learning environment setup and the teaching approaches, and then it also could influence the design of curriculum and classroom activities (Vygotsky, 1981). In terms of an open culture, the learning environment in this cultural context is more flexible and the teachers' instruction is more democratic with increased levels of communication and interaction. On the other hand, the learning environment could be more structured, and the teachers' teaching is more teacher-centered in a relatively conservative cultural context. For this research, the result showed that in terms of science education in the kindergarten, the curriculum and teaching environment design in the Chinese kindergarten was more structured whereas it was more flexible in America. And for teachers' pedagogical practice in teaching children science, it was more teacher-centered in China while it was more children-centered in America.

Based on Engeström (1987)'s model of an activity system, human activity would be affected by subject, object, tools and means, rules, community, and division of labor. The result of this research explored the teachers (subject) applied different curriculum, pedagogies and classroom discourse methods (tools and means) in teaching children science in these two countries. The teachers' pedagogical practices and activities they designed could also be influenced by different preschool policies and cultural characteristics in China and America.

In conclusion, although the purpose and requirement of early childhood education in China and America were similar, given their different social and cultural contexts, the implementation of teaching children science in these two kindergartens varied.

Limitations and Future Research

By doing the research in the kindergartens in both China and America, this study found the factors that affected science education in these two kindergartens, teachers' pedagogical practices, and classroom discourse in teaching children science in these two kindergartens. However, this study has limitations regarding its' focus and methodologies.

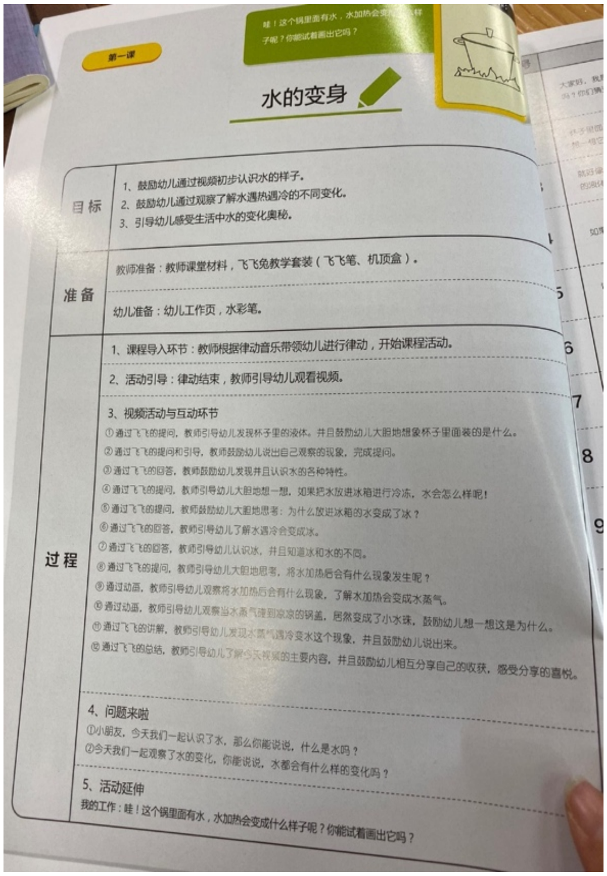
This study mainly focused on teachers' practices in early childhood science education, without paying attention to children's learning under different teaching pedagogies. In order to do the research about teachers' pedagogical practices in teaching children science, future research needs to also focus on children's reaction to different teaching pedagogies, including whether the children like this teaching pedagogy, whether the children have learned scientific knowledge in the whole teaching process or activity process, and the children's evaluation of the teacher's pedagogy. Since this is a comparison study, in order to deeply know how the different teaching pedagogies would affect children's learning about science knowledge, future research needs to focus on children's achievement under different teaching pedagogy. Furthermore, longitudinal studies are also needed to see if these different teaching pedagogies would affect those children's long-time science learning and science interest, even for their choices of science-related majors in the college or science-related careers in the future.

In addition, since this research only chose two kindergartens in China and America, the results were limited and could not represent the early childhood science education situation more fully in these two countries. Moreover, since these two kindergartens were all research-based and focus on early childhood science education, they could not represent most of the commonplace kindergartens in these two countries. For this reason, future research needs to include more kindergartens to include both research-based and comonplace kindergartens to study the early childhood science education in China and America more comprehensively.

Collectively, this study only focused on four teachers from these two kindergartens to conduct research about their teaching pedagogical practices in teaching children science and their understanding of early childhood science education; it was still limited. For future research, more kindergarten teachers with different backgrounds need to also be included in the research.

APPENDICES

Appendix 1: One of the Class Syllabuses from Feifei Rabbit



哇！这个锅里面有水，水加热会变成什么样子呢？你能试着画出它吗？

第一课

水的变身

目标	1、鼓励幼儿通过视频初步认识水的样子。 2、鼓励幼儿通过观察了解水遇热遇冷的不同变化。 3、引导幼儿感受生活中水的变化奥秘。
准备	教师准备：教师课堂材料，飞飞兔教学套装（飞飞笔、机顶盒）。
	幼儿准备：幼儿工作页，水彩笔。
过程	1、课程导入环节：教师根据律动音乐带领幼儿进行律动，开始课程活动。
	2、活动引导：律动结束，教师引导幼儿观看视频。
	3、视频活动与互动环节 ①通过飞飞的提问，教师引导幼儿发现杯子里的液体。并且鼓励幼儿大胆地想象杯子里面装的是什么。 ②通过飞飞的提问和引导，教师鼓励幼儿说出自己观察的现象，完成提问。 ③通过飞飞的回答，教师鼓励幼儿发现并且认识水的各种特性。 ④通过飞飞的提问，教师引导幼儿大胆地想一想，如果把水放进冰箱进行冷冻，水会怎么样呢！ ⑤通过飞飞的提问，教师鼓励幼儿大胆地思考：为什么放进冰箱的水变成了冰？ ⑥通过飞飞的回答，教师引导幼儿了解水遇冷会变成冰。 ⑦通过飞飞的回答，教师引导幼儿认识冰，并且知道冰和水的不同。 ⑧通过飞飞的提问，教师引导幼儿大胆地思考，将水加热后会有什么现象发生呢？ ⑨通过动画，教师引导幼儿观察将水加热后会有什么现象，了解水加热会变成水蒸气。 ⑩通过动画，教师引导幼儿观察当水蒸气碰到凉凉的锅盖，居然变成了小水珠，鼓励幼儿想一想这是为什么。 ⑪通过飞飞的讲解，教师引导幼儿发现水蒸气遇冷变水这个现象，并且鼓励幼儿说出来。 ⑫通过飞飞的总结，教师引导幼儿了解今天视频的主要内容，并且鼓励幼儿相互分享自己的收获，感受分享的喜悦。
	4、问题来啦 ①小朋友，今天我们一起认识了水，那么你能说说，什么是水吗？ ②今天我们一起观察了水的变化，你能说说，水都会有什么样的变化吗？
	5、活动延伸 我的工作：哇！这个锅里面有水，水加热会变成什么样子呢？你能试着画出它吗？

Change of Water

Object	1. Encourage kids to know the water appearance through video preliminarily. 2. Encourage kids to know the different changes of water when it is heated and cold by observation. 3. Guide kids to feel the change mystery of water in life.
Preparation	Teacher preparation: Teaching materials; FeiFei rabbit teaching set (FeiFei pen, set top box).
	Kids preparation: Kids exercise book, water color pen.
Process	Introduction: The teacher leads the kids to move with the rhythm music, starting the class activities.
	Activity guidance: After the rhythm activity, the teacher guides kids to watch the video.
	Video activity and interaction ①Based on Feifei's question, the teacher guides kids to find the liquid in a cup, and encourages them to guess what it is in the cup. ②Based on Feifei's question and introduction, the teacher encourages kids to say the phenomenon observed and answer the question. ③Based on Feifei's answer, the teacher encourages kids to recognize various properties of water. ④Based on Feifei's question, the teacher guides kids to think boldly if water is put in the refrigerator for freezing, what the water will be! ⑤Based on Feifei's question, the teacher encourages kids to think boldly: Why does the water in refrigerator turn into ice? ⑥Based on Feifei's answer, the teacher guides kids to know that water turns into ice when it is cold. ⑦Based on Feifei's answer, the teacher guides kids to know the ice and the differences between ice and water. ⑧Based on Feifei's question, the teacher guides kids to think boldly what will happen if water is heated. ⑨Based on animation, the teacher guides kids to observe the phenomenon after water is heated, knowing that water turns to vapor after heated. ⑩Based on animation, the teacher guides kids to observe that vapor turns to small ice beads when touching the cool pot cover. ⑪Based on Feifei's interpretation, the teacher guides kids to find the phenomenon of vapor turning into water when it is cold, and encourages kids to speak out. ⑫Based on Feifei's conclusion, the teacher guides kids to know the main content of today's video, and encourages kids to share their gains with each other, enjoying the feeling of share.
	4. Questions ①Hi, kids, today we recognize the water together, then can you tell what is water? ②Today we observe the changes of water together, then can you tell what changes does water has?
	5. Activity extension My task: Wow! There is water in this pot. What will the water turn to when it is heated? Can you try to draw it?

Syllabus: Chinese Version

Syllabus: English Version

Appendix 2: Classroom Observation Sheet

Date：	Class：	Teacher:		
Time	Event	Observation		Interpretation
		Teacher	Students	
Summary				

Appendix 3: Interview Questions for Teachers

Interview Protocol

Thanks for your time to participate in my research. I am a PhD student study at the Graduate School of Education and Information Studies in UCLA.

The purpose for this study is to know preschool teachers' understanding of science education and also to explore the appropriate pedagogy for preschool teachers to help children learn science concepts and knowledge. The interview today is to help people know the important of preschool science education and nothing about the evaluation of you. You may feel free to say whatever you want during the interview. And if there are some questions you don't know how to answer or you do not want to answer, you may just say "I don't want to talk it".

Before we begin our interview, I will ask your permission to record today's interview and also ask your permission to take notes during our conversation. And in addition, to protect your personal information, I will use pseudonym in my further research. And do you have any other questions before we start?

Questions

Background history

1. Could you tell me about your background (age, degree, major, position in school)? How long have you been a preschool teacher?
2. How do you become a preschool teacher? The meaning of teaching?
3. What subjects are you good at?
4. Do you have any science related hobbies?

5. What kind of training (including pre-service training and in-service training) do you have received with your field?
6. What challenges and concerns do you have met in your teaching career?

Understanding of science education

7. What is your understanding of “science education” in preschool? What is the meaning of early childhood science education to you, to your students, to your school and to your community?
8. Do you think “science education” is necessary and important in preschool? Why or why not?
9. What is the most recent science related activities you do in the classroom?
10. Why do you think it is a science related activity?
11. What do you do during the activity and what do you think your role in this activity?
12. For this activity, do children do some hands-on experiments or activities?
13. How often do you do this activity?
14. What do you think about the current early childhood science education in the US/China and what are the opportunities for improvement?

Experience of teaching science

15. What aspects of your job are the most challenging, and how do you overcome them?
16. Science can be a challenging subject for some learners. How do you make your lessons engaging and fun for children and also relevant to their lives?
17. What is a typical day like for you?
18. What aspects of teaching science did you enjoy the most and the least?
19. Is there something else you want to add?

Thanks for your time to participate!

Appendix 4: Video-Cued Interview Questions for Teachers

1. Why do you conduct this activity and what is your purpose/objective?
2. What result you expect to achieve after doing this activity?
3. What role do you think you played in this activity?
4. Why do you ask children this question during the activity?
5. Why do you say this word/phrase during the activity?
6. How do you evaluate children's performance at the activity? Is it the same as you expected?
7. Do you think there is still room for improvement in the design of this activity? If so, how would you improve it next time you start such an activity?
8. How do you evaluate your conservation with children during the activity? And do you think that you still have any shortcomings in communicating with children? If so, how would you like to improve it at your next activity?

Thanks for your time to participate!

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