INVESTIGATING TEACHER-CHILD INTERACTIONS IN A NATURE-BASED AND NON-NATURE PRESCHOOL

By

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ABSTRACT

INVESTIGATING TEACHER-CHILD INTERACTIONS IN A NATURE-BASED AND NON-NATURE PRESCHOOL

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This dissertation was driven by a need to better understand how the growing movement of nature-based education, particularly nature-based preschools, compares to more conventional approaches. This dissertation analyzed videos of preschool teaching to describe nature-based teaching practices, particularly around the outdoors as a classroom and a place for science learning. An additional goal was to compare nature-based preschools with non-nature approaches in early childhood education. This was done through two research papers using explanatory mixed methods and case studies. Both papers explore the role of physical setting (i.e., Inside, Outside, Beyond) and social setting (i.e., large group, small group, free play, routines) on teachers' interactions within the two preschools.

The first paper takes a broad perspective exploring teacher language across both the nature-based and non-nature preschools—particularly related to the use of the outdoor space. The findings suggest that context, particularly the physical setting, influenced the frequency and quality of teachers' talk directed at children. For example, when indoors, teachers at the two schools generally used similar amounts and type of talk with children (i.e., primarily statements followed by questions/prompts). Additionally, this study found that the most extensive conversations (i.e., 7 or more turns) in both schools primarily involved one teacher with few children, were initiated by children, focused on concepts, were somehow connected to the physical environment, and primarily occurred in the outdoor play area. Observations of the two schools revealed differences in the frequency and length of talk when outdoors which may relate

to further differences in when in the class day outdoor time occurred, the number of classes in the outdoor play space at a given time, and the activity types which occurred. The findings from this work are important for guiding ways of richly extending the classroom in the outdoors for nature-based and non-nature based early childhood settings.

The second paper provides a detailed view of the nature-based approach by analyzing four extensive science-related interactions at the nature-based preschool. The findings suggest that the physical setting, particularly areas beyond the fence, afforded many opportunities for science sense-making, using a variety of science and engineering practices and cross-cutting concepts. This sense-making happened through direct experiences with a variety of phenomena, particularly life science, that children noticed themselves. Additionally, these experiences were often connected to previous experiences. The findings also suggest these longer-lasting interactions primarily occurred outside formal science lessons in small groups led by teachers who seemed relaxed and joyful. This work will be important for science educators in learning how an outdoor approach may support deep engagement in science through nature.

Findings from both papers indicate that outdoor experiences, particularly free choice experiences, can provide contextual supports for interactions that are not available indoors. This is especially true related to conceptual development such as science learning. The findings also highlight that the way in which outdoor time is structured and interacted with matters for how interactions take place (i.e., time, number of classes in a space, and activity type). Continued studies about the affordances of outdoor environments for learning and how teachers can leverage those affordances, in both conventional and nature-based schools, will ensure children's meaningful interactions with the world around them.

To My Parents
Who provided me a childhood full of nature adventures,
and have supported all the adventures I've embarked on since

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"Teach the children. We don't matter so much, but the children do. Show them daisies and the pale hepatica. Teach them the taste of sassafras and wintergreen. The lives of the blue sailors, mallow, sunbursts, the moccasin flowers. And the frisky ones—inkberry, lamb's-quarters, blueberries. And the aromatic ones—rosemary, oregano. Give them peppermint to put in their pockets as they go to school. Give them the fields and the woods and the possibility of the world salvaged from the lords of profit. Stand them in the stream, head them upstream, rejoice as they learn to love this green space they live in, its sticks and leaves and then the silent, beautiful blossoms. Attention is the beginning of devotion."
~Mary Oliver, Upstream

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CHAPTER 1: INTRODUCTION

All children deserve meaningful interactions and support in making sense of the natural world (UNICEF, 1989). Yet they often do not have rich opportunities to do so (Louv, 2005), particularly in formal education settings. A rapidly growing movement in education has emerged in response to this lack of opportunities—nature-based early childhood education (NbECE). Nature-based early childhood education (NbECE) is an approach which integrates the practices of two disciplines—early childhood and environmental education (Bailie, 2012; Larimore, 2011b). The program model at the heart of NbECE is nature-based preschools. In 2010, there were 12 nature-based preschools in the U.S. (Bailie, 2012). In 2017, there were more than 250 (North American Association for Environmental Education, 2017). In 2020, there were 585 (Natural Start Alliance, 2020). In a nature-based preschool, nature is integrated throughout the curriculum, indoors and outdoors, and children spend a minimum of 30% of the class day outside (Bailie, 2012; Larimore, 2011b).

The growth in numbers suggests these programs are attractive to educators and families. Yet, little is understood about the teaching practices within the nature-based approach, how these practices compare to more conventional approaches, and the impact those practices have on children. Is this growth warranted? Are the experiences children are getting any different or better than conventional preschools? Recognizing the need to advance the understanding and implementation of nature-based learning, a group of scholars recently published a coordinated research agenda (Jordan & Chawla, 2019). Among the recommendations were calls to explore the mechanism of influence of nature-based learning as well as the implications for policy and practice, including answering the question, “How does nature compare with other programs and approaches…in terms of its effectiveness in enhancing learning?” (Jordan & Chawla, 2019, p. 6).

These calls for research and the growth of the movement suggests that both educators and families believe that NbECE has positive effects on young children. For many, this movement responds to children's disconnect from the natural world in recent decades (Louv, 2005). While children increasingly spend time indoors and on their electronic devices, research continues to highlight the positive impacts of exposure to nature on children's physical, cognitive, and social-emotional development (Gill, 2014). One challenge, however, is the majority of these studies have been conducted for older children and are not specific to the instructional and pedagogical model of nature-based preschools. This leaves many unanswered questions about the impact this growing preschool approach has on teachers, and in turn, young children—particularly in comparison to more conventional approaches. In other words, there is growth in the number of nature-based preschools, but are these programs having the impact for which educators and families are hoping? There are few studies that have provided answers to these questions.

This dissertation addresses that need. It examines the interactions in a nature-based and non-nature preschool to compare teaching practices and to more fully describe nature-based teaching practices. To begin addressing that goal the dissertation builds on a research effort to examine child outcomes in nature-based preschools and compared with more conventional preschools. That study found comparable results between the two types of schools. In particular, it found that children had similar language and literacy skill development, specifically letter name and sound knowledge, and some executive function skills between the two types of settings (Sobel et al., 2017). What remained unclear from this work, however, was what teacher practices might have supported children in learning. In other words, why were those outcomes observed at these two different preschool settings? This question is a component of a question posed by the 2019 coordinated research agenda (Jordan & Chawla)—"How do interpersonal

dynamics among children, parents, friends, and teachers influence nature-based learning?" (p. 5). Answering these questions could improve implementation of NbECE as well as the preparation of new nature-based educators. This dissertation draws on data from the prior study to do just that—study the interpersonal interactions between teachers and children. Further, this dissertation highlights how nature-based educators can further leverage science teaching opportunities. Delving deeper into the teaching practices of the nature-based approach not only matters for the field of NbECE, but also for educators in more conventional programs. Understanding nature-based teaching practices can provide insight into easy ways for educators in more mainstream programs to integrate more meaningful experiences with nature into their daily practice.

One particular teacher practice that has a strong influence over a broad range of learning outcomes is teacher-child interactions including verbal and non-verbal interactions. This dissertation analyzes teacher-child interactions to determine how NbECE compares to more conventional early childhood approaches. Furthermore, the number and quality of these interactions are greatly influenced by setting and activity (Cabell, DeCoster, LoCasale-Crouch, Hamre, & Pianta, 2013; Chien et al., 2010; Turnbull, Anthony, Justice, & Bowles, 2009; Wasik & Jacobi-Vessels, 2017). Given nature-based preschools are structured around extensive time outdoors, these programs are rich with exposure to every-changing natural phenomena, implying inherent affordances for a variety of conversation from day-to-day. The teacher language used in teacher-child interactions might be focused on supporting social-emotional development, such as encouraging self-regulation, or a more cognitive focus such as scientific sensemaking around natural phenomena. Analyzing interactions in a nature-based preschool would help determine how teachers use or are influenced by the outdoors in their interactions with children.

The role the outdoor context plays in the frequency and quality of teacher-child interactions is still unknown. How, for example, does the frequency, diversity, and quality of language vary between a nature-based and non-nature preschool? How do non-verbal aspects of interactions vary between a nature-based and non-nature preschool? Further, the presence of affordances does not necessarily mean teachers are utilizing those opportunities in their language generally, and around science in particular. Are science-related interactions occurring? If so, what is the nature of these science-related interactions and how does it align with current approaches to science education?

Context, Conceptual, and Theoretical Framework

This dissertation is motivated by the interest in studying nature-based preschools, teacher-child interactions, and engaging children in figuring out the world—specifically the need to examine the teacher-child interactions in nature-based and non-nature preschools—both broadly and specifically related to science teaching.

Context: Nature-based preschools utilize a unique pedagogical approach

For all of human history the natural world has played a role in young children's development. As early childhood education began to formalize there became more explicit mention of using the natural world as part of teaching and learning in the early years. Early childhood theorists were explicit in their mention of nature as a tool for education. "Nature was considered an essential educational vehicle by Dewey, Froebel, Montessori, Steiner, and others" (Moore, 2014b, p. 213). For example, Friedrich Froebel is commonly referred to as the "father of kindergarten." The translation of the German term "kindergarten" means "children's garden" which combines both the human and natural elements. This notion was reflected in his methods

which included gardening, caring for animals, and daily walks around the countryside (Joyce, 2012; Weber, 1984).

While many early childhood theorists mentioned nature in their methods, the formalization of nature-based education as an approach began in earnest in the late 1960s. This involved two separate movements in different parts of the world—one in Europe and one in the United States. Over time, European models such as Skogsmulle in Sweden, Barnehage in Norway, and Udeskole in Demark began to emerge (Sobel, 2016; Warden, 2012, 2015). Similarly, preschools such as "I Ur och Skur", translated to Rain or Shine School, emerged in Sweden and "Waldkindergartens" or Woods Kindergartens in Germany also emerged. (Sobel, 2016; Warden, 2012, 2015). As the European movement was growing so was a movement in the United States within privately owned nature centers. In 1967, the New Canaan Nature Center in Connecticut opened the country's first nature-based preschool (Bailie, 2012; Larimore, 2011a; Natural Start Alliance, 2019). Just nine years later the Massachusetts Audubon also opened a preschool and in 1982 the Kalamazoo Nature Center also opened a preschool (Bailie, 2012; Larimore, 2011a). The emergence of these preschools led to the term "nature-center based preschools" (Bailie, 2010) though the language quickly shifted to remove the "center" and become "nature-based preschools" (Larimore, 2011a). From there, the movement was relatively slow to grow with 12 known nature-based preschools in the U.S. in 2010 (Bailie, 2012). However, the landscape quickly changed after 2010 with than 250 nature-based preschools in 2017 (North American Association for Environmental Education, 2017). In 2020, this has grown to 585 (Natural Start Alliance, 2020).

What joins these different models is a very similar pedagogical approach. In the United States, this pedagogical approach is referred to as nature-based early childhood education

(NbECE), though sometimes also called nature pedagogy (Warden, 2015) or nature-based pedagogy (Larimore, 2019). Reflecting the historic roots of preschools at nature centers, NbECE is described as the integration of two disciplines—early childhood education and environmental education (Bailie, 2010; Larimore, 2011a). As such, NbECE is theorized as having dual goals of whole-child development and environmental literacy (Bailie, 2012). That is, goals that value not only cognitive, but also social-emotional and physical development (Bishop-Josef & Zigler, 2011), along with children's connection to the natural world (Larimore, 2019). This approach includes any program model which provides young children, ages 0-8, extensive daily outdoor time, operates with nature as the curriculum's organizing concept (Larimore, 2016; Sobel, 2014), and the curriculum emerges from children's interest in seasonal events (Andrachuk et al., 2014; Kenny, 2013; Larimore, 2011a; Moore & Cosco, 2014; Sobel, 2016; Warden, 2012). Additionally, daily outdoor experiences and teacher-child interactions provide the foundation for learning which crosses the boundaries of the physical spaces *indoors*, *outdoors*, and in more wild spaces *beyond* the outdoor play space (Finch & Bailie, 2015; Warden, 2015). Of course these spaces vary based on factors such as climate, weather, and topography (Warden, 2015).

Today, under the broad umbrella of NbECE, there are a variety of program models throughout the world (e.g., nature-based preschools, forest preschools, forest kindergartens, nature kindergartens, bush kindergartens). Some of these variations among these models are based on cultural context, such as the term preschool versus kindergarten in different countries, but both typically meaning 3–5-year-olds. Other variations include the emphasis on time outdoors and the utilization of an indoor facility (Larimore, 2016; Natural Start Alliance, 2019). For this study I focus on nature-based preschools which, in addition to the pedagogical NbECE parameters listed above, are licensed preschools serving 3-5 year-olds and spend a minimum of

30% of the class day outside (Bailie, 2010; Green Hearts, 2014; Larimore, 2011a). Additionally, nature-based preschools include time spent beyond the designated play area, nature infused into the indoor spaces, and with nature as the driving theme of the curriculum (Bailie, 2010; Green Hearts, 2014; Larimore, 2011b, 2011a; Moore, 2014). As licensed preschools, nature-based preschools must adhere to any policies set forth by regulatory agencies (e.g., state Quality Rating Improvement Systems) as well as any relevant funding bodies (e.g., Head Start, state-funded PreK).

To provide a better sense for what nature-based preschools are like in the U.S., some descriptions are useful. According to the Natural Start Alliance (2020), there are 585 nature-based preschools in the U.S. While this is a nearly 25-fold increase in a decade, these preschools are not numerous enough to be equally available to all children (2017). Further, research in 2017 found these programs were serving predominantly White children (83%) and less than 5% of the students received special education or were dual language learners (North American Association for Environmental Education, 2017). Therefore, nature-based preschool children are currently not representative of the cultural and linguistic diversity of the United States. In part, this may be because the majority (64%) of the nature-based preschools in the U.S. do not offer full-day programs which creates a barrier for families who need full-day care.

While there is a current lack of racial and linguistic diversity among nature-based preschools, it remains an actively growing movement in the U.S. (North American Association for Environmental Education, 2017). Nature-based schools follow long traditions in other countries such as Finland, Scotland and others who have had similar schools and movements for decades (Sobel, 2014). Additionally, nature is available anywhere—even in urban spaces—and relatively inexpensive. As a growing movement in the US, a historical type of school across the

world, and because of accessibility and potential benefits, learning more about the nature-based approach will be helpful for informing broader applications of nature-based teaching and learning throughout the country and world.

Conceptual Framing: The Role of Teacher-Child Interactions in the Preschool Classroom

Teacher-child interactions are a common focus in research on early childhood teaching (e.g., McCartney, 1984; Turnbull et al., 2009), and generally accepted to be an important factor in child development (e.g., Hamre, Hatfield, Pianta, & Jamil, 2014; Hoff, 2006). Analysis of these interactions may look at how they develop vocabulary, support children's interest, ask open-ended questions, or pose cognitively challenging ideas (Whorrall & Cabell, 2016).

Teacher-child interactions are particularly influential on literacy development related to print concepts (Cabell et al., 2011; Guo, Kaderavek, Piasta, Justice, & McGinty, 2011), more complex syntax (Huttenlocher et al., 2002; Justice et al., 2013), and vocabulary (Cabell et al., 2011; Justice, Jiang, & Strasser, 2018). Increases in children's vocabulary has also been positively correlated to teachers' use of language that elicits and extends children's ideas (Cabell, Justice, McGinty, DeCoster, & Forston, 2015). The way teacher-child interactions are implemented, or the process quality, also has a positive effect on child outcomes (e.g., Ulferts, Wolf, & Anders, 2019). Despite the evidence on the benefits, quality interactions are rare in the preschool classroom (Dickinson et al., 2008; Winton & Buysse, 2005) and when they do occur rarely involve cognitively engaging conversations (Chen & de Groot, 2014).

Further, studies of teaching and learning in the early years indicate context strongly influences the number and quality of interactions teachers have with children. Teacher-child interactions are typically greater during teacher-led activities such as large or small group meetings (Cabell et al., 2013; Chen & de Groot Kim, 2014; Chien et al., 2010) and less frequent

during free play (Chen & de Groot, 2014; Winton & Buysse, 2005). In terms of quality of interactions, one study found preschool teachers use more statements rather than questioning in teacher-child interactions, and these interactions occurred primarily in the art area (Tu & Hsiao, 2008). Others have found the most cognitively challenging questions (i.e., open-ended questions) occur during shared reading time (Fuccillo, 2011; Massey et al., 2008) or science-focused activities (Fuccillo, 2011). Further the teacher-led science activities generate more cognitively engaging teacher-child interactions than other areas of cognitive development (e.g., math) (Cabell et al., 2013; Tu & Hsiao, 2008). Given the influence of context on interactions, it is important to explore the differences in interactions among these two preschools which vary in terms of social activities and physical setting as this is likely to be a meaningful mechanism or indicator of what might be occurring in these preschools.

Conceptual Framing: Science in the Early Years

Young children are innately curious about the world around them (Greenfield, 2017; National Research Council, 2007) and capable of learning science (Brenneman et al., 2009; Eshach & Fried, 2005; Greenfield, 2017; National Research Council, 2007; National Science Teachers Association, 2014). Experiences with science not only develop children's scientific literacy and engagement as adults (Eshach & Fried, 2005; Greenfield, 2017; National Research Council, 2007), but also develop skills in language and literacy (Brenneman, 2011; French, 2004), social-emotional realms (French, 2004), and domain general skills (Brenneman, 2011; Eshach & Fried, 2005; Greenfield, 2017) in the early years. Not only do science experiences support children's development, but children also have a right to make sense of the world around them (Larimore, 2020), particularly a right to develop a "respect for the natural environment" (UNICEF, 1989, p.9).

Despite these benefits of science learning, the reality is little time is spent on science in preschool (Piasta et al., 2014; Tu, 2006; Early et al., 2010). Opportunities for science learning in preschool is traced to assessment performance in science later on. Fewer opportunities are correlated with lower assessment scores and the differences between high and lower assessments scores often grow as children get older (Morgan et al., 2016). Preschools typically spend less instructional time on science than any other discipline (Early et al., 2010; Piasta et al., 2014; Tu, 2006). This lack of time may be due to teachers' confidence around science content and pedagogy (Garbett, 2003; Gerde et al., 2018) or due to emphasis on language and literacy instruction in the early years (Greenfield et al., 2009). Whatever the reason, it is the young children who miss out on meaningful experiences with science.

To make sense of the world around them, however, young children must have encounters with natural phenomena using a variety of science ideas (National Research Council, 2012b; National Science Teachers Association, 2014). This is not a new idea to early childhood education. For example, Maria Montessori (1912) said:

> The action of educative nature so understood is very practically accessible. Because, even if the vast stretch of ground and the large courtyard necessary for physical education are lacking, it will always be possible to find a few square yards of land that may be cultivated, or a little place where pigeons can make their nest, things sufficient for spiritual education. Even a pot of flowers at the window can, if necessary, fulfill the purpose. (pp. 160-161)

Montessori suggests even the smallest spaces can afford learning opportunities. It seems likely then that nature-based preschools, with ongoing experiences in the natural world, may be more likely to afford opportunities for meaningful science encounters. Thus, I hypothesized

nature-based preschools, with ongoing experiences in the natural world, are more likely to afford opportunities for encounters with natural phenomenon and therefore more opportunities for children to wonder about and make sense of the world around them.

Theoretical Framework: Sociocultural Learning Theory

This study is framed by sociocultural learning theory (Vygotsky, 1978). This is to say, analysis in this study will be guided by the belief that young children learn through interactions with the world around them, which is influenced by social culture. Vygotsky argued the gap between children's current development and their potential development (i.e., zone of proximal development) can be closed through support from a knowledgeable and responsive adult or peer (Vygotsky, 1978). In this study, I will focus on the interactions among teachers and children (i.e., teacher-child interactions). The theoretical foundation for this study also incorporates the belief that adults can facilitate learning by eliciting and extending children's knowledge. This scaffolding of learning can be done through interactions which use varied vocabulary, support children's interest, ask open-ended questions, or pose cognitively challenging ideas (Whorrall & Cabell, 2016). This theoretical foundation also incorporates the belief that adults can serve as models for young children's cognitive and non-cognitive development. Through these interactions, which both facilitate and model, children construct knowledge of the world around them—paramount to whole-child development (i.e., physical, social-emotional, cognitive). In short, support from a responsive adult through teacher-child interactions can in turn support children's learning.

While sociocultural theory has been a mainstream view of early childhood education for some time (Copple & Bredekamp, 2009), science education has historically emphasized individual cognitive development related to science content knowledge (National Research

Council, 2007, 2012b). This approach assumes knowing science and becoming a scientist is rooted in rational thought. Science educators have paid little attention to non-cognitive aspects of science learning. In the past twenty years, however, science education has shifted towards recognizing the value and influence of children's prior experiences (National Research Council, 2007, 2012b), social interactions (Leach & Scott, 2003), identity (Calabrese Barton et al., 2013), culture (Nasir et al., 2006) and context (Leach & Scott, 2003) on science learning. This shift acknowledges teacher-child interactions not only support the scaffolding of children's knowledge about science, but also their initiation as agents within the broader discourse of the field of science.

In addition to interactions with adults and peers, sociocultural theory acknowledges the influence of the physical environment. Sociocultural theory contends the physical artifacts in the environment represent the beliefs and values of the surrounding culture (Leach & Scott, 2003; Miller, 2016). Put simply, sociocultural theory focuses on the "child-in-activity-in-cultural-context, rather than the child alone" (Miller, 2016, p. 207). Recognizing the influence of sociocultural theory on both early childhood and reform-based science education, in the present study, I pay particular attention to the interactions which occur between teachers and children (i.e., teacher-child interactions), while at the same time acknowledging the learning context.

This theoretical framework for understanding teaching and learning has been widely implemented in early childhood education (Copple & Bredekamp, 2009) and studies have found teacher-child interactions vary among social settings and activities (Cabell et al., 2013; Chien et al., 2010; Turnbull et al., 2009; Wasik & Jacobi-Vessels, 2017). One study, for example, found teacher-child interactions were more effective (i.e., responsive to children's comments or ideas) in a large group setting compared to free play or routine-based activities like meals (Cabell et al.,

2013). Given the importance of context in the sociocultural framework, I collected and analyzed data to reflect the social setting. Keeping in mind the importance of context in teacher-child interactions, and the fact physical environment is a critical component of the nature-based approach, the study also included physical setting as a lens for analysis. That is, the analysis captured if and in what ways teacher-child interactions occurred indoors, outdoors in a play area, or in an area beyond the fence.

Dissertation Approach

This dissertation analyzed videos of preschool teaching in order to describe nature-based teaching practices, particularly around the use of the outdoors as a classroom and a place for science learning, and how those practices compare to more conventional preschool teaching. The goal was to gather evidence in order to compare nature-based preschools with non-nature approaches in early childhood education. This work was guided by these overarching research questions:

1. What is the general nature of teacher-child interactions in two preschools—one nature-based, one non-nature?
    a. How does the frequency, diversity, and quality of the language in interactions compare?
    b. How might contextual factors (e.g., physical setting) play a role in these interactions?
    c. How do these interactions unfold?
2. How might one characterize extended interactions within a nature-based preschool setting?

a. Are science-related interactions occurring? If so, what is the nature of these science-related interactions and how do the interactions align with current approaches to science education?
b. How might the outdoor setting play a role in these interactions?

I address these research questions through two research papers using explanatory mixed methods and observational case studies. Using mixed methods provides a broad picture of teacher-child interactions, while also providing more depth through detailed case studies (Flyvbjerg, 2011). Each research paper, provided in Chapters 2 and 3, was designed as a stand-alone manuscript while also answering the overarching research questions of the dissertation.

The first paper takes a broad perspective exploring teacher language across both the nature-based and non-nature preschools—particularly related to the use of the outdoor space. That is, it describes the frequency and types of utterances teachers direct to children as well as the conversations that occur between teachers and children. The findings from this work are important for both nature-based and non-nature early childhood audiences related to ways to extend the classroom to outdoors. The second paper provides a detailed view of the nature-based approach by analyzing extended interactions of science moments at the nature-based preschool. Due to the depth in describing how early childhood science unfolds in this nature-based setting, this work will be particularly relevant to a science education audience. Both papers explore the role of physical setting (i.e., indoors, outdoors, beyond the play area) and social setting (i.e., large group, small group, free play, meals, routines) on teachers' interactions within the two preschools.

Table 1.1 provides a summary of the two papers, the broad dissertation questions the chapter addresses, the research questions of the manuscript specifically, and the methods used

for analysis. Chapter 5 of this dissertation provides a summary of the two manuscripts as it relates to the overall research questions. It also addresses the contributions of both studies for the development of theory, along with implications for the field.

Table 1.1
Summary of Two Papers Within the Dissertation

Chapter and Study Title	Overarching Research Question(s) Addressed	Study Research Questions	Method
Chapter 2: Moving Beyond Recess—Examining the Use of the Outdoors as an Extension of the Classroom at a Nature-based and Non-nature Preschool	RQ1	1. What similarities and differences might exist in teacher-child interactions between the nature-based and non-nature preschool (both inside and outside the classroom)? 2. How might teacher language and behavior leading up to, during, and after outdoor experiences generate possible insights for any variation in teacher-child interactions between school type and settings?	Sequential explanatory mixed-methods analysis of how a nature-based and non-nature preschool enacted vision of the outdoors as an extension of the classroom
Chapter 3: "I love nature!"—Teachers' Interactions with Children about Three-Dimensional Science in a Nature-based Preschool	RQ2	1. What science moments occur between teachers and children in a nature-based preschool? 2. How do these moments align with three-dimensional science teaching approaches? 3. How do these science moments unfold?	Observational study to determine affordances of nature for early science learning opportunities by examining science-related interactions in one nature-based preschool

CHAPTER 2: MOVING BEYOND RECESS—EXAMINING THE USE OF THE OUTDOORS AS AN EXTENSION OF THE CLASSROOM AT A NATURE-BASED AND NON-NATURE PRESCHOOL

Outdoor learning has been increasingly recognized as critical to young children's development (Gill, 2014; Louv, 2005). Children are more physically active outdoors, particularly in child care settings (Tandon et al., 2015). There is also growing evidence that outdoor learning supports children's social-emotional and cognitive development, as well as pro-environmental behaviors (Kuo & Jordan, 2019). As a result, some states are beginning to recommend the outdoors be utilized as a vital component of the preschool classroom (e.g., Michigan State Board of Education, 2013; State of Texas, 2014). That is, to go beyond focusing on physical development or "recess" and consider the outdoors as an extension of the classroom to support the whole child. Nature-based preschools fulfill this recommendation by centering outdoor experiences in the curriculum (Finch & Bailie, 2015; Larimore, 2016) and could be used as a model to help educators understand how to use the outdoors as a classroom in order to promote children's development.

Nature-based preschools are rapidly gaining popularity as a teaching approach. In 2010, there were 12 nature-based preschools in the U.S. (Bailie, 2012). In 2017, there were more than 250 (North American Association for Environmental Education, 2017), and in 2020, there were 585 (Natural Start Alliance, 2020). The growth in numbers suggests these nature-based preschools are attractive to educators and parents. Yet, little is understood about the teaching practices within the approach, how these practices compare to more conventional approaches, and the impact those practices have on children. Is this growth warranted? Are the experiences children are having, particularly in outdoor learning environments, any different than more mainstream approaches? Recognizing the need to advance the understanding and implementation of nature-based learning, a group of scholars recently published a coordinated research agenda

(Jordan & Chawla, 2019). Among the recommendations were calls to explore the mechanism of influence of nature-based learning as well as the implications for policy and practice. This included recommendations to answer the question, "How does nature compare with other programs and approaches…in terms of its effectiveness in enhancing learning?" (Jordan & Chawla, 2019, p. 6).

One mechanism of consideration to compare among preschool approaches is the frequency, type, and length of talk occurring between teachers and children. These interactions include the language teachers use and how they use that language, particularly in conversations with children (Whorrall & Cabell, 2016), to scaffold children's understanding of the world around them. Previous research has indicated the frequency and quality of teacher-child interactions are greatly influenced by context (Barnes, Grifenhagen, & Dickinson, 2019; Cabell et al., 2013; Chien et al., 2010; Turnbull et al., 2009; Wasik & Jacobi-Vessels, 2017). "Context" includes factors such as group size (Turnbull et al., 2009), social setting such as teacher-led large and small groups (Cabell et al., 2013; Chen & de Groot Kim, 2014; Chien et al., 2017) and free play (Chen & de Groot, 2014; Winton & Buysse, 2005). Context also includes the physical setting, curriculum used, and pedagogical philosophy of the school. Nature-based preschools, with extensive time outdoors, include different contextual factors which may result in differences in how teachers interact with children.

To begin studying how nature-based preschools compare with other forms of preschool experiences, this study looked at the interactions between teachers and children. In particular, it did so around outdoor experiences, which seems to be a potential area of difference. As such, this study compared and contrasted the teacher-child interactions leading up to, during, and after outdoor experiences as part of the class day at two high-quality preschools (per the state's quality

rating improvement system), one nature-based and one non-nature based. This explanatory mixed-methods study examined the similarities and differences between the two preschools around teacher's language and conversations in those contexts that may support children's cognitive concept development. Furthermore, this study examined the extent to which teachers' language varied among physical settings (i.e., inside, outside, beyond) and social settings (e.g., large group, free choice). This study describes what occurred at the two preschools and provides insights into why any variations might exist by using an explanatory mixed-method design (Flyvbjerg, 2011).

Preschool policy documents frame the outdoors as "an extension of the classroom"

State-level early childhood policy documents are beginning to reflect a growing awareness of the importance of outdoor time to children's overall health (e.g., Gill, 2014; Louv, 2005). In 2015, while only six states mentioned time required in, or the quality of, the outdoor learning environment in their Quality Rating Improvement System (Cooper, 2015), some of these states have gone even further than time requirements to suggest how the outdoor time should be used. In policy documents, such as licensing and early learning standards, states have positioned the outdoors as being a classroom learning environment. Texas, for example, changed the outdoor descriptor from "playground" to "outdoor learning environment" in its quality rating standards (Cooper, 2015). These standards go on to say, "Outdoor environment and activities are linked to and reinforce indoor learning" (State of Texas, 2014). Similarly, Michigan state child care licensing regulations declare, "The outdoor play area is considered an outdoor classroom and an extension of the learning environment" (State of Michigan, 2019, p. 18).

Extending the learning environment, or the classroom, to include the outdoors means no longer limiting the purpose of the outdoors to supporting children's physical development only.

The outdoor space is of course important for supporting active outdoor play. In fact, children are most active when they have child-led, free play (Tandon et al., 2015). However, extending the classroom outdoors also means addressing other developmental domains such as social-emotional and cognitive development. Both Texas and Michigan include recommendations for supporting social-emotional and cognitive development in the outdoor learning environments in their measures of quality (Michigan State Board of Education [MSBE], 2013; State of Texas, 2014). In its Early Childhood Standards of Quality for Prekindergarten, for example, Michigan says teaching and learning should "capitalize the opportunities the outdoor environment presents for learning about and from the natural world, exploration, language, literacy creativity, solitude (e.g., an area to observe food plants growing)" (MSBE, 2013, p. 131). Additionally, Michigan specifies the learning in these domains should be provided through a "variety of play opportunities throughout the day" (MSBE, 2013, p. 122) and the physical environment itself should support this learning. Specifically, Michigan indicates, the learning environment is a "physical representation of the curriculum that includes: relationships, human and social climate, teaching practices, and the space, materials, and equipment. Ideally, this includes both indoor and outdoor space" (MSBE, 2013, p. 146). Those same early learning standards also suggest that principles of responsive teaching should extend "from the indoor to the outdoor environment (e.g., adults are engaged with the children rather than simply "watching" them)" (MSBE, 2013, p. 131). All of this is to say, the outdoors is not simply for recess, or a break in learning, where teachers are monitoring behavior. Rather, the outdoors should support all developmental domains just as the indoor classroom space is intended to do. This means the teacher-child interactions that occur in the outdoor space should closely resemble the interactions that occur indoors.

Despite some of these shifts in policy recommendations, child care programs are providing little opportunity for physical activity outdoors (Reilly, 2010), let alone for development in other domains. A survey of Texas child care programs, for example, found less than half of the programs were meeting the licensing requirements for physical activity and time in the outdoor learning environments (Byrd-Williams et al., 2019). Furthermore, a previous study found teachers perceive a maintained playground to be more beneficial for learning than more natural outdoor settings (Ernst, 2014a). Another found preschool teachers' beliefs about the difficulty of using the outdoors for learning, along with their personal relationship to nature, directly related to their self-reports of how often they engaged children in outdoor activities (Ernst, 2014b). Thus, as some states begin to shift to conceptualizing the outdoors as another classroom, or learning environment, there is still a disconnect when it comes to implementing this idea in practice.

Teacher language plays a pivotal role in supporting learning

One measure of a space being used as a learning environment, or another classroom, is the way teachers and children interact with one another. While there are multiple types of physical and social interactions, the verbal exchanges between teachers and children (i.e., teacher-child interactions) play an important role in children's development (e.g., Hamre, Hatfield, Pianta, & Jamil, 2014; Hoff, 2006). Teachers play a pivotal role in these interactions by making choices to focus on developing language, supporting children's interest, asking open-ended questions, or posing cognitively challenging ideas (Wasik & Jacobi-Vessels, 2017; Whorrall & Cabell, 2016). These approaches, when implemented by a knowledgeable and responsive adult, help to narrow the gap between children's current development and their potential (Copple & Bredekamp, 2009; Vygotsky, 1978).

These teacher-child interactions are influential on children's development in a variety of domains including language, literacy, math, and science. For example, teacher language is particularly influential on literacy development related to print concepts (Cabell et al., 2011; Guo, Kaderavek, Piasta, Justice, & Mcginty, 2011), more complex syntax (Huttenlocher et al., 2002; Justice et al., 2013), and vocabulary (Cabell et al., 2011; Justice, Jiang, & Strasser, 2018). Increases in children's vocabulary has also been positively correlated to teachers' use of language that elicits and extends children's ideas (Cabell, Justice, McGinty, DeCoster, & Forston, 2015). In math, quality interactions related to math positively impacts children's math development (Ulferts et al., 2019). For the domain of science, one study found content-specific language was a positive predictor of children's conceptual learning (Studhalter et al., 2021)

Despite the evidence on the benefits, quality interactions are rare in the preschool classroom (Dickinson et al., 2008; Winton & Buysse, 2005) and when they do occur rarely involve cognitively engaging conversations (Chen & de Groot, 2014; Leuchter et al., 2020). Quality interactions refer to conversations that include intentional language and meaningful pauses (Cohrssen et al., 2014) to scaffold children's ideas (Cabell et al., 2015). In addition, studies of teaching and learning in the early years indicate context strongly influences the number and quality of interactions teachers have with children. Teacher-child interactions, for example, are typically more frequent during teacher-led activities such as large or small group meetings (Cabell et al., 2013; Chen & de Groot Kim, 2014; Chien et al., 2010) and less frequent during free play (Chen & de Groot, 2014; Winton & Buysse, 2005). One study found the greatest number of interactions between teachers and children occurred in the art area (Tu & Hsiao, 2008). In terms of quality of interactions, or what is being said, one study found preschool teachers use more statements, rather than questions in their interactions with children (Tu &

Hsiao, 2008). Others have found the most cognitively challenging questions (i.e., open-ended questions) occur during shared reading time (Fuccillo, 2011; Massey et al., 2008) or science-focused activities (Fuccillo, 2011). Though teacher-led science activities most often include close-ended questions (Hamel et al., 2020), the context of science activities generate more cognitively engaging teacher-child interactions than other areas of cognitive development such as math (Cabell et al., 2013; Tu & Hsiao, 2008). Further, science materials explicitly introduced to children increased children's engagement with science materials during free play (Nayfeld et al., 2011), suggesting the materials may also be an important contextual element for children's play and their interactions with teachers.

While time outdoors seems to be limited in preschools, when teachers and children *do* spend time outside, previous research suggests there may be more frequent and higher quality interactions which support children's growth beyond physical development. One study, for example, measured the quality of teacher talk using the CLASS PreK and found more time spent outside improved the teacher-child interactions that occurred outdoors (Tonge et al., 2018). Other studies have examined teacher talk in outdoor play areas specifically related to science (Gustavsson et al., 2016; Gustavsson & Pramling, 2014; H. Kloos et al., 2018). One of those studies found teachers were twice as likely to use spontaneous science-related language in a more natural play area than in a human-built one (Kloos et al., 2018). Thus, there is a need to more deeply explore the ways in which teachers do and can interact with children outdoors to embody the notion of the outdoors as an extension of the classroom.

Nature-based preschools utilize a unique pedagogical approach

Nature-based early childhood education (NbECE) is an approach to teaching preschool which positions the outdoors as core to teaching and learning by integrating two disciplines—

early childhood and environmental education (Bailie, 2010; Larimore, 2011a; Natural Start Alliance, 2019). This approach includes any program model which provides young children, ages 0-8, extensive daily outdoor time, operates with nature as the curriculum's organizing concept (Larimore, 2016; Sobel, 2014), and the curriculum emerges from children's interest in seasonal events (Andrachuk et al., 2014; Kenny, 2013; Larimore, 2011a; Moore & Cosco, 2014; Sobel, 2016; Warden, 2012). The daily outdoor experiences and teacher-child interactions provide the foundation for learning which crosses the boundaries of the physical spaces *indoors*, *outdoors*, and in more wild spaces *beyond* the fence of the outdoor play space (Warden, 2015).

Within the broad umbrella of NbECE are several program models. For this study I focus on nature-based preschools which, in addition to the pedagogical NbECE parameters listed above, serve 3-5 year-olds and spend a minimum of 30% of the class day outside (Bailie, 2010; Green Hearts, 2014; Larimore, 2011a). This includes time spent inside, outside in a fenced natural play area, and beyond the designated play area (Bailie, 2010; Green Hearts, 2014; Larimore, 2019; Warden, 2015). While each preschool is different, some half-day nature-based preschools start their day outside in a natural play area, explore the beyond the fence, and then return to the building. At this point the group often has another choice time, which may be inside or outside, followed by a small group time for a more focused activity, and a final group meeting. The daily outdoor experiences in these spaces and teacher-child interactions provide the foundation for learning which crosses the boundaries of the physical spaces of the Inside, Outside, and in less human-developed Beyond (Larimore, 2019; Warden, 2015). That is, at nature-based preschools the classroom is not limited to the inside space, but rather conceptualized to extend outside the building to include all three spaces for learning.

This sequential explanatory mixed-method study addressed how this vision of the outdoors as an extension of the classroom is being enacted at a high-quality nature-based preschool. It also examined how a more conventional high-quality preschool, which did not ascribe to the vision of using nature as core to the curriculum, used the outdoors for learning. This study focuses on teachers verbal interactions with children as one practice which might provide insights on what might be similar or different in the use of the outdoors as a classroom. This effort was guided by the following research questions:

1. What similarities and differences might exist in teacher-child interactions, particularly utterances and conversations supporting children's learning, between the nature-based and non-nature preschool (both inside and outside the classroom)?
2. How might teacher language and behavior leading up to, during, and after outdoor experiences generate possible insights for any variation in teacher-child interactions between school type and settings?

Methods

The goal of this sequential explanatory mixed-methods study (Creswell, 2014; Tashakkori & Taddlie, 1998) was to compare and contrast teacher-child interactions leading up to, during, and after outdoor experiences as part of the preschool class day. This study particularly examined teachers' use of questions and conversations among schools (i.e., nature-based and non-nature preschool), social setting (e.g., large group, free choice), and physical settings (i.e., inside, outside, beyond). In addition, the study explored how teachers in different program models frame the outdoors in their language and behaviors leading up to, during, and after outdoor experiences. First, analysis was conducted to identify patterns in questioning and the presence of conversations which allowed for a more purposeful sampling for the qualitative

analysis (Creswell & Plano Clark, 2003). Additional qualitative analysis of the video recordings provided more depth, and possible explanations, to the quantitative findings through rich detailed descriptions of what occurred in the two preschools (Creswell, 2014).

Setting & Participants

This study included two preschools in suburban areas in the Upper Midwest—one of which called itself a nature-based preschool. Both preschools were considered high-quality per the state's quality rating improvement. The non-nature preschool was also National Association for the Education of Young Children (NAEYC) accredited and operated as a laboratory school for the preparation of future teachers. These two programs were selected, as part of a larger study, due to similar program quality as well as similar demographics within the preschools. Both served only children ages 3- to 5-years old. The data for the present study was part of a larger study in which children were assessed and families were asked to identify their race and the mother's education level. Demographics of those participating in the child assessment indicated that at the children at both schools were predominantly White. At the nature-based preschool 90.2% of the children were White/Caucasian, 2.4% identified as American Indian/Alaskan, 3.7% as Asian/Pacific Islander, and 3.7% as other. At the non-nature preschool 67.2% of the children identified as White/Caucasian, 12.1% as Asian/Pacific Islander, 3.4% as Black/African American, 3.4% as American Indian/Alaskan, 1.7% Hispanic/Latino, and 12.1% as other. At both preschools, the majority of mothers reported completing an undergraduate degree or higher. At the nature-based preschools 1.2% of the mothers reported completing high school, 17.1% reported completing some college, 46.3% reported completing an undergraduate degree, and 32.9% reported completing graduate/professional school. At the non-nature preschool 6.9% of the mothers reported completing some high school, 1.7% reported completing high school,

10.3% reported competing some college, 31% reported completing an undergraduate degree, and 48.3% reported completing graduate/professional school.

Combined there were six classrooms in this study serving preschool-aged children. Five of the six classrooms were half-day programs (i.e., 3 hours) and one in the non-nature setting was a full-day program (i.e., 6 hours). Each classroom ranged in session length from 2-4 days per week. Both programs had at least three adults in the classroom with a maximum of 20 children ranging in age from three to five years old. Video of the two primary teachers in each of the six classrooms was collected and analyzed. Four of the teachers at the nature-based preschool were female and two were male. Five of the six had a Bachelor's degree, one had a Child Development Associates, and one had also earned a Master's degree beyond the Bachelor's. All the teachers at the non-nature preschool were female. Of the two teachers recorded at the non-nature preschool, three were mentor teachers with Master's degrees and three were student teachers working to earn their Bachelor's degree.

In addition to the self-described nature-based approach, the nature-based preschool used Creative Curriculum® as its curriculum and Teaching Strategies Gold® for child-level assessment. The non-nature preschool varied in curriculum by classroom with one using the Reggio-Emilia approach, one the Project Approach, and one High Scope®. The indoor spaces looked similar at both schools with designated and labeled learning areas and materials such as blocks, dramatic play, art, and reading and writing.

The nature-based preschool was located in a mix of eastern hardwood and pine forest with a small neighboring year-round pond, a river, and temporary wet areas in the woods during the springtime (i.e., vernal pools). The topography surrounding the school was mostly flat with a few small inclines and a large drop-off from the woods to the river's edge. The nature-based

preschool had three different outdoor play areas with a mix of vegetation, loose parts, a few human-built structures for group gathering, but no climbing structures. The non-nature preschool organization had two program sites. The first site included two play areas with extensive tree cover. One included traditional climbing equipment and the other, certified as an outdoor classroom by Nature Explore®, had an open plan with a few shrubs along the edges. The second site included one large open play area with little tree cover, a mix of traditional climbing equipment, and some loose parts play (e.g., mud kitchen). Both preschools used tricycles, but these were not used in all the play areas.

Data Collection

Video data of two teachers (i.e., lead and primary assistant) were collected in each of the six classrooms at two timepoints in the second half of the school year (i.e., late January/early February, and late March/early April). These timepoints were selected to observe teacher-child interactions once classroom routines and behavior management were well-established. Thus, the observations would be more likely to illustrate the most cognitively rich teacher-child interactions. Observations were scheduled at the teachers' convenience and on days when they were following their typical classroom schedule. For all six classrooms data collection lasted three hours, which for five of six classrooms was the entirety of the class session. Video at the non-nature preschool was recorded using stationary cameras and wireless microphones. Due to contextual factors at the nature-based preschool (e.g., trees blocking sight lines), teachers were equipped with wearable cameras during these two time points.

Table 2.1
Definitions for Setting Descriptors

Code	Description
Physical Setting	
Inside	Inside the school building (e.g., classroom, gym)
Outside	Fenced outdoor playground area
Beyond	Any space outdoors that is outside the fenced playground area
Social Setting	
Free choice	Children able to select what and where they would like to play or learn
Large group	Organized whole-class or large-group activity involving 7 or more children
Small group	Organized activity involving 6 or fewer children
Routines	Changing from one setting to another or performed routine classroom procedures (e.g., toileting, standing in line, waiting for materials to be passed out, meals)

Identification of representative video segments

Drawing on previous teacher-child interaction research (e.g., Cabell et al., 2013; De Rivera, Girolametto, Greenberg, & Weitzman, 2005; Massey et al., 2008), the current study used a representative video segment approach to make claims about overall quality of cognitive engagement. These representative segments were identified using a 25-minute observation cycle protocol (i.e., 15 minutes of observation, 10 minutes of no coding) until the three-hour observation was complete. Each segment was then coded in terms of its primary social setting (e.g., Large Group) and physical setting (e.g., Inside) as described in Table 2.1. If a segment spanned multiple social or physical settings, the entire segment was coded based on where the majority of the segment occurred. For example, if a segment was inside for 5 minutes and outside for 10 minutes it was coded as "outside." For both timepoints and schools there were a total of 117 segments identified across Timepoint 1 (n = 57) and Timepoint 2 (n = 60). Given the emphasis of this study was on outdoor time, indoor analysis was limited to one timepoint to provide a baseline for comparison among the types of interactions between the two schools (i.e., Nature-based and Non-nature). Since there were no segments at Timepoint 2 that occurred Inside at the Nature-based preschool, Timepoint 1 was selected for cross-school analysis (i.e.,

comparing Nature-based and Non-nature). This eliminated 26 segments from the Non-nature preschool at Timepoint 2 (Table 2.2), which all occurred indoors and were spread across multiple social settings (Table 2.2). However, since the primary focus of this study was the use of the outdoor settings the four Non-nature segments that occurred Outside at Timepoint 2 were retained for comparison among the schools in relation to conversations. These adjustments resulted in a total of 91 segments included in analysis.

Table 2.2
Number of video segment by Timepoint, Setting, & Preschool

Video Segments by Physical Setting

		Nature	Non-Nature	Total
Timepoint 1	**Physical setting**	**33**	**24**	**57**
	Inside	17	22	39
	Outside	14	2	16
	Beyond	2	0	2
Timepoint 2		**30**	**30**	**60**
	Inside	0	26[a]	26
	Outside	19	4	25
	Beyond	11	0	10
Total		**63**	**54**	**117**

Video Segments by Social Setting

		Nature	Non-Nature	Total
Timepoint 1	**Social setting**	**33**	**24**	**57**
	Free choice	17	10	27
	Large group	8	5	13
	Routines	2	3	5
	Small group	6	6	12
Timepoint 2		**30**	**30**	**60**
	Free choice	16	19[b]	35
	Large group	10	3[b]	13
	Routines	2	5[b]	7
	Small group	2	3[b]	5
Total		**63**	**54**	**117**

a. These 26 segments were not included in analysis

b. Of the Non-Nature at Timepoint 2, 4 segments occurred outside during Free choice. The other segments at the Non-Nature, Timepoint 2 were not coded.

Analysis of Frequency and Content of Teacher-to-Teacher Talk

The 91 representative video segments were then analyzed based on type of utterance, conversations, and the interplay of questions and conversations. These segments yielded 16,354 utterances spoken by teachers. Of those utterances, 235 were unintelligible and thus eliminated from analysis of type of utterances, leaving 16,119 utterances for analysis of challenging questions. However, given that length of conversation was based on turns between teachers and children the unintelligible utterances were kept in the conversation analysis to indicate the number of turns.

Table 2.3
Definitions for type of utterance codes

Code	Description	Examples
Concept Development		
Question/Prompt	Teacher language intended to generate a verbal response related to concepts. This includes both **closed-ended and open-ended questions OR statements to elicit information** from the child.	• What was this called? • Are you okay? • Tell me more • Tell me where you played today
Statement	Statements that maintain conversation, manage behavior, provide directives, or provide information. This includes statements repeating the children's words only if the teacher also adds another idea.	• Five more minutes • Sit down. • That tool is called a hammer. • Look how they're eating. • C: 8 T: There are 8 children, just like 8 planets in our solar system
Other Child-Directed Utterance		
General Reflection	Repeats the child's statements &/or corrects the grammar (without adding to the idea)	• Child: It's purple. Teacher: It's purple. • Child: It hurted me. Teacher: Oh, it hurt you?
Singing/Reading	Language directly from a text or song when the teacher is singing or reading aloud.	
Greeting	Greeting a child hello or goodbye	• Good morning • Hi, [Name] • Bye, have a good day
Other Utterances		
Teacher-to-Teacher Talk	Any teacher language to another teacher or adult (not a child)	

Frequency and Use of Type of Utterance

The utterances within the video segments were coded for teacher's use of questions and statements in their language. Initial codes of teacher utterances drew on previous work related to questioning (Massey et al., 2008) and extension and expansion of children's ideas (Cabell et al., 2015; De Rivera et al., 2005; Girolametto & Weitzman, 2002). The coding system was iteratively revised with the goal of achieving a Krippendorff's alpha greater than .80, with the minimally acceptable alpha for drawing tentative conclusions being $\alpha \geq .667$ (Krippendorff, 2004) between two raters. The result was a coding system with six different codes. The codes included Singing/Reading, General Reflection, Greeting, Question/Prompt, Statement, and Teacher-to-Teacher Talk (Table 2.3). To code for more cognitive engagement, utterances that were intended to elicit a response from the child were coded as Question/Prompt. Statements of observation or information were coded as Statements. For example, if a teacher said, "Why did that happen?" or "Tell me more about that" the utterance was coded as Question/Prompt. If, however, the teacher said, "That is really tall" the utterance was coded as Statement. Singing/Reading were any utterances that came directly from the text or song. General Reflection was coded when a teacher repeated a child's statement. Saying hello or goodbye to a child was coded as Greeting. The final code, Teacher-to-Teacher Talk, was used if teachers were speaking, but to another adult in the room rather than a child.

Krippendorff's alpha was used to assess inter-rater reliability across 12 transcripts, which yielded a sample size of 1,780 teacher utterances. For the two raters, the Krippendorff's alpha ranged from .72-.97 with 95% confidence interval ranges of .65-1.00—reflecting high reliability. Pearson chi-square analyses were then conducted to examine the degree of relationship between

categorical variables identified based on previous research on teacher-child interactions (e.g., social setting) and those of particular focus in this study (e.g., physical setting).

Table 2.4
Definitions for conversation codes

Code	Description
Conversation	A conversation is a teacher-child exchange with a minimum of two turns on a particular topic, with a turn being a change in the speaker, semantically linked content. Exchanges could be with the same child or multiple children on the same topic. Turn count is based on the teacher utterance.
Brief conversation	2-3 turns on a topic
Moderate conversation	4-6 turns on a topic
Long conversation	7-9 turns on a topic
Extensive conversation	10+ turns on a topic

Note: Reading a story was not a conversation unless there were two or more turns without reading text.

Frequency and Length of Conversations

The representative video segments were also used to capture the frequency of conversations. Leveraging the work of Cabell et al. (2015) and De Rivera et al. (2005), conversations were defined as an exchange between a teacher and child(ren) with a minimum of two turns on a topic. A turn was defined as a change in speaker. For example, if a teacher spoke two utterances without a child speaking that was coded as one turn. Whereas if a child spoke on the same topic between the two teacher utterances, that was coded as two turns. The conversation exchanges could be with the same child or multiple children, but only if the exchanges were semantically related. Reading a story was not counted as a conversation unless there were two or more turns without reading the text. If for example, a teacher paused to ask the children to predict what will happen next, the child responded, and then a teacher asked a follow-up question, that would be counted as a conversation. The turns in conversation were then aggregated to identify brief, moderate, long and extensive conversations (Table 2.4). The

categories of brief and moderate were based on categories used in previous preschool research (Cabell et al., 2015). This previous research was used along with a scatter plot histogram to identify the logical breakdowns of the Long and Extensive conversation categories (i.e., 7-9 and 10+ respectively).

As with the use of questions and statements, Krippendorff's alpha was used to assess interrater reliability across 12 transcripts. While there were 1,780 teacher utterances in this sample, there were 584 and 525 utterances identified by each of the two coders. When determining agreement on the presence or absence of a conversation, the maximum bounds of the conversation were captured. That is, the earliest and latest utterance in a conversation by each coder was used for determining reliability about the two raters. This analysis resulted in a 95% confidence interval of .66-.73 and alpha of .69—slightly better than the lowest conceivable limit of $\alpha \geq .667$ (Krippendorff, 2004). I then conducted Pearson chi-square analyses to identify differences in the proportions of varying lengths of conversations across preschool type, social setting, and physical setting. Due to the small sample size, and violations of assumptions as a result, significance in differences in proportions could not, however, be calculated at the Non-nature preschool. Thus, only frequencies, means, and ranges in turns of conversations were calculated for the Non-nature preschool. These descriptive statistics were also calculated for the Nature-based preschool.

Content of Conversations

Finally, I analyzed the types of utterances teachers were saying during conversations. That is, I compared what teachers were saying (e.g., statements) across the different lengths of conversations (e.g., brief). Given the focus of this analysis was to assess interactions which supported cognitive development, Teacher-to-Teacher Talk was eliminated from the analysis.

Since Singing/Reading, Greeting, and General Reflection were not cognitively focused, but still directed at children, these were collapsed into the new variable "Other Interactions." I conducted Pearson chi-square analyses for the Nature-based preschool at both Timepoints and the Non-nature preschool at Timepoint 1, to identify differences in the proportions of utterance types across varying lengths of conversations.

Analysis of Interaction Differences

To address the question "How might teacher language and behavior leading up to, during, and after outdoor experiences generate possible insights for any variation in teacher-child interactions between schools and settings?" I qualitatively analyzed the video recordings. This provided context and potential explanations for the differences in teachers' type of talk and use of conversations when interacting with children. In particular, I returned to the video and associated transcripts to holistically view classroom interactions, particularly related to the outdoors. To do so, I used an interpretive, ethnographic approach (Emerson et al., 2011) and multiple rounds of exploratory observational coding (Saldaña, 2016) around interactions related to the outdoors. While I began the coding process with some predetermined codes using a provisional coding approach (Saldaña, 2016) including the location and activity type, I primarily implemented a holistic approach to allow new codes to emerge (Miles et al., 2014). For example, part of my provisional coding process (Saldaña, 2016) was the structure of the class day. Yet a more holistic approach allowed me to explore teacher-child interactions beyond the structure of each class to understand the processes within those parts of the day. I then took a broader view to draw cross-case conclusions (Creswell & Poth, 2018; Yin, 2018) around the framing and engagement leading up to, during, and after outdoor experiences.

Given the focus of the current study was to examine teacher-child interactions as a measure of the outdoors as an extension of the classroom, I selected the most extensive conversations (Creswell & Plano Clark, 2003; Tashakkori & Taddlie, 1998) for additional microanalysis. I then used a similar combination of provisional and holistic coding approach as described above to characterize longest of all of the conversations. I began analysis of these longest conversations with an eye to the number of teachers and children involved and who initiated the conversation, while also allowing new codes to emerge. This more detailed analysis helped to further explain why and how these atypically long conversations were occurring.

Findings

To address research question "what were variations in the number of teacher utterances spoken, the type of utterances used, and conversations between teachers and children and why might they have occurred?" I analyzed the discourse and behavior surrounding those interactions. The analysis revealed differences in how the two schools conceptualized the purpose of outdoor spaces, as evidenced by differences in the time and timing of outdoor time, along with variations in how the schools used the outdoor spaces. These findings are summarized in Table 2.5 and explained in more detail in each section below. The analysis also revealed the impact of contextual factors, such as the social setting of Free Choice and the physical environment, on the longest lasting conversations.

Table 2.5
Summary of findings related to the use of the outdoors

	Nature-based	Non-Nature
Time	≥ 1.5 hours outdoors (Outside & Beyond)	< 30 minutes Outside
Structure	1 class at a time in outdoor play area	2+ classes in outdoor play area
	Started the day Outside	Ended the day Outside
	All social settings occurred Outside (though Small Group only observed once)	Only conducted Free Choice when Outside
	Only conducted Large Group & Routines in the Beyond	N/A (No visits Beyond)
Teacher-to-Teacher Talk	Most frequent in the Beyond	Most frequent Outside
Other	---	1 teacher turned off mic & went indoors at both timepoints; 1 took off mic before going outside

Frequency of Teacher-Child Interactions in the Different Physical and Social Settings

At Timepoint 1, when both classes were Inside part of the class day, Nature-Based teachers spoke twice as many utterances compared to the Non-Nature-based preschool (6,560 versus 3,659 or a difference of 2,901 utterances in Table 2.6).

Table 2.6
Number (Percentage) of Utterances by Physical Setting and Preschool at Timepoint 1

	Nature	Non-Nature
	n **(%)**	n **(%)**
Inside	3559 **(54.30)**	3386 **(92.50)**
Outside	2676 **(40.80)**	272 **(7.50)**
Beyond	325 **(5.00)**	N/A
Column Total	6560 **(100.00)**	3659 **(100.00)**

To determine if this was typical for the nature-based preschool, I compared these numbers with those of Timepoint 2. At this second timepoint, when the Nature-based classes were entirely outdoors, they spoke fewer utterances or 5,422 utterances, which is 1,138 less than

Timepoint 1 (Table A.1). This suggests variability in talk from timepoint to timepoint. In order to compare the two schools with different numbers of utterances, I focus on the proportions (i.e., percentages) of talk, rather than the numbers.

Figure 2.1

Typical Class Schedule at the Nature and Non-Nature Preschools

Nature			Non-Nature	
Activity	Location[a]		Activity	Location
Free Choice/Arrival	Outside		Free Choice/Arrival	Inside
Group Meeting	Outside		Group Meeting	Inside
Hike to Beyond	Beyond		Free Choice/Snack	Inside
Snack	Inside or Outside	3 hours	Small Group	Inside
Free Choice	Inside or Outside		Free Choice	Outside[b]
Small Group	Inside or Outside			
Group Meeting	Inside or Outside			

Note. The time for each portion of the day and the transitions between portions of the day varied among classes.
[a] One Nature class conducted a "backwards" day during the Timepoint 1 observation.
[b] One Non-Nature class held this Free Choice in the gymnasium during the Timepoint 1 observation.

Utterances Spoken Reflect Variations in Time Spent Inside, Outside and Beyond

Further analysis indicates that the proportion of utterances in locations (i.e., inside, outside, and beyond) aligned with where the preschools spent their class time throughout the day (Figure 2.1). For example, when Inside was included in the class day (i.e., Timepoint 1), both schools spoke more Inside than any other location (Table 2.6). The largest proportion of utterances were spoken Inside (Nature, 54.30%; Non-nature, 92.50%), the next largest proportion Outside (Nature, 40.80%; Non-nature, 7.50%) and then the Beyond (Nature, 5.00%) for the Nature-Based Preschool.

Analysis of the daily class structures helps explain these differences by revealing variations in amount of time spent outside and when that outdoor time occurred. The Nature-based preschool spent a much greater proportion of their day outside of the building (i.e., Outside and Beyond) than the Non-nature preschool. In fact, the Non-nature preschool spent little time

outdoors at either timepoint (ranging from 24-29 minutes), and the time they did spend outdoors was entirely Outside as they never left the fenced play area to use Beyond spaces. Further, at Timepoint 1, one of the three classes did not go outdoors, but rather visited the gymnasium during the portion of the day normally allocated for outdoor play and spent 20 minutes there.

In contrast, at the Nature-based preschool, the classes spent much more time outside of the building which included visiting the Beyond each day. The Nature-based preschool did not, however, entirely avoid the indoor space. During Timepoint 1, all three nature-based classes spent and even amount of time Inside and outside the of building. That is, all three spent approximately 1.5 hours Inside and 1.5 hours outside of the building in a combination of Outside and Beyond. While the Nature-based preschool used all three spaces at Timepoint 1, none of the classes went Inside the building at Timepoint 2, but rather spent the entire 3-hour class in the Outside and Beyond.

These variations in time spent outdoors may be connected to when in their day the two preschools went outside. The Non-nature preschool's outside time occurred at the end of the day, which may have eliminated the teachers' ability to extend the time for outdoor play. In contrast, the Nature-based preschool began their day Outside and included Inside time (if any) at the end of the day[1].

Another relevant finding related to understanding how the two preschools use the outdoors for learning relates to how the teachers treated the Outside, as indicated by their use of the microphones for this study. Specifically, when teachers at the Non-nature preschool chose to take off their microphones seemed to indicate what they thought would be interesting for

[1] One Nature-based classroom conducted a special "backwards" day during the Timepoint 1 observation. On this day the class started Inside and finished Outside. This class still spent half of their day outdoors.

researchers to record. Most of the teachers wore the microphones until the end of the class time. However, during outdoor play at both timepoints, one teacher at Non-nature went back Inside while the children were Outside. Both times she helped children transition to the outdoors, then turned off her microphone, and went back Inside. In another moment as the Non-nature class was beginning to transition from the Inside to the Outside, Teacher A removed her microphone, turned it off, and placed it on the classroom counter. She continued helping the class transition by cleaning up, zipping children's jackets, and gathering everyone at the door until Teacher B noticed the microphone on the counter. Teacher B then said, "Oh, you know, she's [the researcher] going to tape you even outside. So, you can keep your thing on. She's going to record you even outside because she goes outside too. Teacher A responded, "Oh, okay" and put the microphone back on. Since the researcher recording did not ask Teacher A why she removed the microphone, it is impossible to know for sure the motivation to remove the microphone. However, it seems reasonable to surmise that, on some level, the teacher did not believe a researcher would be interested in observing the Outside time.

Table 2.7
Number (Percentage) of Utterances by Social Setting and Preschool at Timepoint 1

	Nature	**Non-Nature**
	n (%)	n (%)
Free choice	3291_a (50.50)	1402_b (38.30)
Large group	1534_a (23.40)	843_a (23.00)
Small group	1247_a (19.00)	946_b (25.90)
Routines	488_a (7.40)	467_b (12.80)
Column Total	6560 (100.00)	3658 (100.00)

Pearson x^2(3) = 194.496a, p < .001

Each subscript letter denotes a subset of Preschool categories whose column proportions do not differ significantly from each other at the 0.05 level.

Utterances Spoken by Social Setting Reflect How the Outdoor Spaces Were Used

To address the research question about how the social setting might have impacted the number of utterances, analysis revealed that both programs spoke the most during Free Choice and the least during Routines (Table 2.7). However, there were differences in the ranking of the two social settings in the middle. Further, there were differences in the percentages in talk among these social settings—even when the rank (i.e., most or least frequent) was the same. During Free Choice, Nature-based teachers spoke significantly more (50.50%) than Non-nature (38.30%), (X^2 (2, N = 10218) = 194.496, p < .001). Yet the reverse occurred at the least frequent setting of Routines where the Non-nature (12.80%) had a greater proportion spoken than Nature-based (7.40%). This suggests similar patterns in talk based on social setting, but in varying amounts of talk between the two schools.

I compared these findings to talk at the Nature-based preschool at Timepoint 2 and saw similar patterns, with the majority of talk during Free Choice and then Large Group. However, at the second timepoint the gap in talk between Large Group and Small group was even wider with significantly more talk during Large Group than Small Group, X^2 (3, N = 11982) = 544.136, p < .001. In other words, when the Nature-based preschool was outdoors the entire day they engaged in even more talk during Large Group than Small Group, compared to when they were Inside[2].

One explanation for these variations in the amount of talk by social setting is how the two schools used the outdoors (Table A.2). The first notable difference in how the spaces were used was the activities (i.e., social setting) used in the variation locations. At both schools, Free Choice was the dominant social setting for talk as well as the dominant portion of the day.

[2] When the Nature-based classes were entirely outdoors (i.e., Timepoint 2), 35.70% of the utterances were spoken during Large Group and 5.90% during Small Group. Yet, when they were Inside, the talk during Large Group was 23.40% and Small Group was 19.00% of their total talk.

Further, when Outside, the Non-nature preschool only engaged in Free Choice. While Free Choice was also a primary social setting at the Nature-based preschool, all social settings were observed Outside at the Nature-based preschool. That is, the Nature-based preschool also held snack (i.e., Routine), Large Group, and Small Group[3] gatherings Outside. In the Beyond the primary social setting was Large Group, and one of the classes was also observed having a snack, a Routine, in the Beyond[4]. In summary, a deeper look at the Nature-based preschool shows teachers were rarely engaging in Small Group activities. Thus, it is not surprising the Nature-based teachers spoke more during Large Group than Non-nature teachers, as it reflects where they spent more of their class day.

A second notable difference in how the Outside space was used at the two schools was the number of classes, and thus number of children and adults, in a single fenced play area. The Nature-based preschool had the same number of children indoors as outdoors, whereas the Non-nature preschool had multiple classes sharing the same Outside space[5]. That is, teachers and children that were not playing and learning together Inside were suddenly together when Outside. This may have impacted teachers' ability to interact with children. For example, while the teacher to child ratio technically stays the same, the teacher was interacting with up to 20 children he/she does not normally interact with Inside, making it harder to connect to the interests and skills or a particular child. This also means teachers were working with twice as many colleagues Outside than Inside. In contrast to this combined approach, at the Nature-based preschool each classroom had their own outdoor play area each day, similar to a designated

[3] Among all three Nature-based classrooms at both timepoints, Small Group was only observed Inside once and Outside once. In both cases these Small Groups occurred at the end of the class day.
[4] Neither Small Group nor was Free Choice were observed in the Beyond.
[5] This same sharing of space occurred when the one Non-nature classroom went to the gym.

indoor classroom space[6]. This use of space will be particularly relevant when I discuss Teacher-to-Teacher talk in the next section.

One final notable difference between the social settings at the two preschools relates to the structure of Large Group. Both schools spoke approximately 23% of their utterances during Large Group. However, the structure of Large Group itself was very different between these two preschools. In this study, Large Group was defined as an organized whole-class or large-group activity involving seven or more children. At the Non-nature preschool, these whole-group activities occurred inside with all of the children and adults sitting in a large clump on an area rug. This was expected as it is the common approach to large group meetings in preschool classrooms.

In contrast, many of the Large Group meetings at the Nature-based preschool were conducted by physically moving from one location to another and they lasted much longer than the Non-nature large group activities—particularly when they occurred in the Beyond. In the outdoor play area (i.e., Outside), the Large Groups involved all of the teachers and children in the class sitting in a circle and having a shared conversation. This was similar to what was observed Inside at the Non-nature preschool. However, when the Nature-based preschool classes left the fenced play area to the Beyond, the group was together in an organized activity, but primarily walking to a destination of some sort with a brief whole-group conversation. Further, in the Outside play area the Large Group averaged 9.5 minutes in length. However, these whole group times were much longer when they occurred in the Beyond. For example, one group traveled to a wetland area where they looked for aquatic insects. The group spent nine minutes

[6] The classrooms did, however, rotate which outdoor play areas they used over time. For example, Classroom 1 used a different play area at Timepoint 1 than at Timepoint 2, but at both times they were the only class using that space.

walking to the wetland, where they sat in a clump, not a circle, and received brief reminders on how to use the equipment (e.g., “So when I use my dipper in the water, I'm going to go like this. I’m not going to smack the water.”). The group then looked for aquatic organisms for 20 minutes before walking back to the building, which took about five minutes. Thus, the entire Large Group lasted 34.5 minutes. In another example, a Nature-based preschool class went to the Beyond in search of tracks in the snow. They walked in a loop through the woods for 12 minutes in search of animal tracks (e.g., “Hey, let’s go see if we can find some more up here”) before returning back to the preschool building. So, while Large Group was common in both outdoor spaces (i.e., Outside and Beyond) at the Nature-based preschool, they differed in structure and function.

These differences in how the two preschools structure Large Group activities may help explain why there was more talk at the Nature-based preschool during Large Group at Timepoint 2, when the class was entirely outdoors, than Timepoint 1.

Table 2.8
Number (Percentage) of Utterances by Type and Preschool at Timepoint 1

	Nature	Non-Nature
	n (%)	n (%)
Question/prompt	1112_a (17.00)	487_b (13.30)
Statement	4226_a (64.40)	2331_a (63.70)
General Reflection	430_a (6.60)	217_a (5.90)
Singing/reading	232_a (3.50)	197_b (5.40)
Greeting	56_a (0.90)	38_a (1.00)
Teacher-to-Teacher Talk	504_a (7.70)	388_b (10.60)
Column Total	6560 (100.00)	3658 (100.00)

Pearson x^2(5) = 64.473a, p < .001.
Each subscript letter denotes a subset of Timepoint categories whose column proportions do not differ significantly from each other at the 0.05 level.

Similar Kinds of Talk in Varying Amounts Between Schools and Settings

In addition to identifying frequency of teacher talk and the physical and social setting for that talk, another goal of this study was to explore the focus of that talk. In particular, I wanted to address research question one by examining to what extent teachers used cognitively challenging talk with statements and questions in each preschool. Across both the Nature-based and Non-nature preschools, Statements were spoken in the largest proportion. This included a range of utterances like "Let's sit down," "I wonder what lives in those holes," and "Oh, I love that book." Statements were followed in frequency by Question/Prompt, Teacher-to-Teacher Talk, General Reflection, Singing/reading and finally Greeting (Table 2.8).

Analysis indicates an identical rank order of types of talk, and similar proportion of most utterance types. Nonetheless, the percentage of Questions/Prompt, Singing/reading and Teacher-to-Teacher utterances varied significantly between the two schools, X^2 (5, N = 10218) = 64.473, $p < .001$. Question/Prompt was the second most common utterance type used at both schools but was used in a greater proportion at the Nature-based preschool (17.00%) than Non-nature (13.30%). These utterances included such things as "What could I do to help you?" and "Tell me about owls." Singing/reading was the fourth most frequent utterance type at both schools, but children at the Non-nature were read or sung to significantly more (5.40%) than the Nature-based (3.50%) preschool. While not directed to children, Teacher-to-Teacher Talk, or interactions among teachers, occurred in greater proportion at Non-nature (10.60%) than Nature-based (7.70%). Some of this variation in talk may be due to the fact the Non-nature preschool is a laboratory preschool, so teachers are often coaching and supporting each other. However, more nuance in this Teacher-to-Teacher talk is discussed below.

Variations in Number of Questions/Prompts, Singing/Reading, and Teacher-to-Teacher Talk by Physical Setting

The variations in these three utterance types (i.e., Question/Prompt, Singing/reading, and Teacher-to-Teacher Talk) were particularly evident based on physical setting at each individual preschool and when comparing preschools. At the Non-nature preschool, Question/Prompt utterances and Singing/reading were both spoken more often Inside, with no singing or reading occurring Outside at all (Table A.3). Yet, with Teacher-to-Teacher Talk the opposite was true. There was a significantly greater proportion of Teacher-to-Teacher Talk spoken Outside (22.80%) at the Non-nature preschool than Inside (9.60%), $\boldsymbol{X}^2$ (5, N = 3658) = 66.742, $p < .001$. In comparison, Teacher-to-Teacher Talk at the Nature-based setting occurred in the greatest proportion Beyond (12.30%), then Inside (10.10%), and finally Outside (7.4%). One possible explanation for the greater Teacher-to-Teacher Talk at the Non-nature preschool, as was mentioned earlier, is the impact of shared outdoor play space. By sharing an outdoor play space, the teachers were working with twice as many colleagues Outside than Inside as well as additional children. This might require more communication among the adults related to logistics, behaviors, and so forth.

Analyzing just the Nature-based preschool at both timepoints, suggests differences in the type of talk teachers used based on the physical setting (Table 2.9). In fact, between the two timepoints, there were significant differences in all utterance types, with the exception of General Reflections, X^2 (15, N = 11982) = 166.750, $p < .001$. This was particularly true for the concept development utterances of Statements and Question/Prompts. Statements were the most common utterance spoken at the Nature-based preschool. However, significantly more Statements were spoken Inside (65.00%) and Beyond (66.60%) than Outside (60.50%). Analysis

of Question/Prompt utterances also revealed differences between the Outside and Beyond but paints a slightly different picture. The greatest proportion of Question/Prompt utterances occurred Outside (20.40%), which was significantly more than Inside (16.90%), and both were significantly greater proportions than the Beyond (14.50%), X^2 (10, N = 11982) = 236.476a, p < .001. In other words, teachers used statements most often Inside and Beyond, whereas they used questions and prompts most often Outside and least often in the Beyond. This suggests differences in the type of talk teachers are using in these different locations.

Table 2.9

Number (Percentage) of Utterances by Question/Prompt and Setting at the Nature Preschool Only

Utterances by Timepoint

	Nature Timepoint 1	Nature Timepoint 2	Row Total
	n (%)	n (%)	n (%)
Question/prompt	1112b (17.00)	1055a (19.50)	2167 (18.10)
Statement	4226b (64.40)	3339a (61.60)	7565 (63.10)
General Reflection	430a (6.60)	364a (6.70)	794 (6.60)
Singing/reading	232b (3.50)	41a (0.80)	273 (2.30)
Greeting	56b (0.90)	18a (0.30)	74 (0.60)
Teacher-to-Teacher Talk	504b (7.70)	605a (11.20)	1109 (9.30)
Column Total	6560 (100.00)	5422 (100.00)	11982 (100.00)

Pearson x^2(5) = 166.750a, p <0.01

Utterances by Physical Setting

	Inside	Outside	Beyond	Row Total
	n (%)	n (%)	n (%)	n (%)
Question/prompt	602b (16.90)	1194c (20.40)	371a (14.50)	2167 (18.10)
Statement	2314a (65.00)	3544b (60.50)	1707a (66.60)	7565 (63.10)
General Reflection	241b (6.80)	425b (7.30)	128a (5.00)	794 (6.60)
Singing/reading	21b (0.60)	214c (3.70)	38a (1.50)	273 (2.30)
Greeting	20b (0.60)	52b (0.90)	2a (0.10)	74 (0.60)
Teacher-to-Teacher Talk	361b (10.10)	432c (7.40)	316a (12.30)	1109 (9.30)
Column Total	3559 (100.00)	5861 (100.00)	2562 (100.00)	11982 (100.00)

Pearson x^2(10) = 236.476a, p <0.01

Utterances by Social Setting

	Free Choice	Large Group	Routines	Small Group	Row Total
	n (%)	n (%)	n (%)	n (%)	n (%)
Question/prompt	1309a (21.60)	505b, c (14.60)	108c (12.30)	245b (15.60)	2167 (18.10)
Statement	3671a (60.50)	2269b (65.40)	511a (58.00)	1114c (71.00)	7565 (63.10)
General Reflection	511a (8.40)	188b (5.40)	23c (2.60)	72b (4.60)	794 (6.60)
Singing/reading	107a (1.80)	150b (4.30)	4c (0.50)	12c (0.80)	273 (2.30)
Greeting	60a (1.00)	7b (0.20)	5a, b (0.60)	2b (0.10)	74 (0.60)
Teacher-to-Teacher Talk	407a (6.70)	349b (10.10)	230c (26.10)	123a (7.80)	1109 (9.30)
Column Total	6065 (100.00)	3468 (100.00)	881 (100.00)	1568 (100.00)	11982 (100.00)

Pearson x^2(15) = 631.101a, p <0.01

Each subscript letter denotes a subset of Timepoint categories whose column proportions do not differ significantly from each other at the 0.05 level.

Variations in Utterances Spoken Based on Social Setting

As has been noted, the rank order of the proportion of types of utterances for each preschool were identical, with Statements being the most frequent utterance type at both schools. However, there were differences in when in the class day (i.e., social setting) the different utterances were used.

The largest proportions of Statements were used during teacher-led activities at both preschools—though different activities. At the Non-nature preschool these Statements occurred most frequently during Large Group (72%; Table A.3). Whereas at the Nature-based preschool the Statements occurred most frequently during Small Group (71.00%; Table 2.9). The use of questions and prompts at the two schools were very different regarding the social setting. The largest proportions at the Non-nature preschool were spoken during Routines (16.50%), which was the least frequent social setting (Table A.2). Further, question/prompts during Routines were used significantly more than the second most common activity time—Large Group (12.70%). This varied from the Nature-based preschool where questions were spoken in largest amount during Free Choice (21.60%) and significantly more than Small Group (15.60%) which was the second largest proportion. Questions and prompts in both of these social settings at the Nature-based preschool occurred significantly more than all other social settings, $\boldsymbol{X}^2$ (15, N = 11982) = 631.101, $p < .001$. That is, Non-nature teachers asked more questions during routines such as snack, dressing to go outside, and whole-group activities, whereas Nature-based teachers asked more questions during Free Choice. This is important when we consider question/prompt utterances are most likely to support concept development and both preschools spent most of their day in Free Choice and Large Group.

While not specific to concept development, there were differences in Teacher-to-Teacher talk which may give insights into the use of the outdoor settings. Teacher-to-Teacher talk at the Non-nature preschool occurred most often during Free Choice (13.90%) and Routines (10.90%). Similarly, at the Nature-based preschool, Teacher-to-Teacher talk occurred most frequently during Routines (26.10%). In contrast to the Non-nature preschool, Teacher-to-Teacher talk was observed the least during Free Choice at the Nature-based preschool (6.70%).

Table 2.10

Number (Percentage) of Conversation Length at Non-Nature Preschool, Timepoint 1 by Physical Setting and Social Setting

Conversations by Physical Setting

	Conversation Length						
	Brief (2-3 turns)	**Moderate (4-6 turns)**	**Long (7-9 turns)**	**Extensive (10+ turns)**	**Row Total**		
	N (%)	N (%)	N (%)	N (%)	N (%)	M (SD)	Range
Inside	91a (72.80)	23a (18.40)	5a (4.00)	6a (4.80)	125 (100.00)	3.34 (2.45)	2-14
Outside	7a (77.80)	1a (11.10)	1a (11.10)	0a (0.00)	9 (100.00)	3.11 (2.15)	2-8
Column Total	98 (73.10)	24 (17.90)	6 (4.50)	6 (4.50)	134 (100.00)	3.32 (2.42)	2-14

Conversations by Social Setting

	Conversation Length						
	Brief (2-3 turns)	**Moderate (4-6 turns)**	**Long (7-9 turns)**	**Extensive (10+ turns)**	**Row Total**		
	N (%)	N (%)	N (%)	N (%)	N (%)	M (SD)	Range
Free choice	47 (74.60)	11 (17.50)	3 (4.80)	2 (3.20)	63 (100.00)	3.16 (2.15)	2-12
Large group	16 (76.20)	2 (9.50)	1 (4.80)	2 (9.50)	21 (100.00)	3.57 (2.99)	2-12
Routines	18 (75.00)	4 (16.70)	1 (4.20)	1 (4.20)	24 (100.00)	3.29 (2.69)	2-14
Small group	17 (65.40)	7 (26.90)	1 (3.80)	1 (3.80)	26 (100.00)	3.54 (2.39)	2-13
Column Total	98 (73.10)	24 (17.90)	6 (4.50)	6 (4.50)	134 (100.00)	3.32 (2.42)	2-14

Table 2.11

Number (Percentage) of Conversation Length at the Nature Preschool by Timepoint, Physical Setting, and Social Setting

Conversations by Timepoint

	Conversation Length				Row Total		
	Brief (2-3 turns)	**Moderate (4-6 turns)**	**Long (7-9 turns)**	**Extensive (10+ turns)**			
	N (%)	N (%)	N (%)	N (%)	N (%)	M (SD)	Range
Timepoint 1	79a (48.50)	46a (28.20)	12a (7.40)	26b (16.00)	163 (100.00)	6.03 (7.11)	2-49
Timepoint 2	134a (57.00)	66a (28.10)	19a (8.10)	16a (6.80)	235 (100.00)	4.46 (4.23)	2-31
Column Total	213 (53.50)	112 (28.10)	31 (7.80)	42 (10.60)	398 (100.00)	5.11 (5.64)	2-49

Pearson x^2(3) = 9.004a, p = 0.029.

Conversations by Physical Setting

	Conversation Length				Row Total		
	Brief (2-3 turns)	**Moderate (4-6 turns)**	**Long (7-9 turns)**	**Extensive (10+ turns)**			
	N (%)	N (%)	N (%)	N (%)	N (%)	M (SD)	Range
Inside	51a, b (51.50)	32a (32.30)	6a (6.10)	10a (10.10)	99 (100.00)	4.79 (4.41)	2-49
Outside	109b (50.50)	63a (29.20)	19a (8.80)	25a (11.60)	216 (100.00)	5.38 (5.87)	2-31
Beyond	53a (63.90)	17a (20.50)	6a (7.20)	7a (8.40)	83 (100.00)	4.77 (6.30)	2-49
Column Total	213 (53.50)	112 (28.10)	31 (7.80)	42 (10.60)	398 (100.00)	5.11 (5.64)	2-49

Pearson x^2(6) = 5.815a, p = 0.444.

Conversations by Social Setting

	Conversation Length				Row Total		
	Brief (2-3 turns)	**Moderate (4-6 turns)**	**Long (7-9 turns)**	**Extensive (10+ turns)**			
	N (%)	N (%)	N (%)	N (%)	N (%)	M (SD)	Range
Free choice	124a (48.80)	80a (31.50)	20a (7.90)	30a (11.80)	254 (100.00)	5.43 (5.84)	2-49
Large group	52a, b (59.80)	19a (21.80)	5a (5.70)	11a (12.60)	87 (100.00)	5.09 (6.38)	2-49
Routines	12a, b (60.00)	5a (25.00)	3a (15.00)	0a (0.00)	20 (100.00)	3.75 (2.05)	2-8
Small group	25b (67.60)	8a (21.60)	3a (8.10)	1a (2.70)	37 (100.00)	3.62 (2.69)	2-15
Column Total	213 (53.50)	112 (28.10)	31 (7.80)	42 (10.60)	398 (100.00)	5.11 (5.64)	2-49

Pearson x^2(6) = 12.899a, p = 0.167.

Each subscript letter denotes a subset of Context categories whose column proportions do not differ significantly from each other at the 0.05 level.

Frequency and Quality of Conversations in Different Physical and Social Settings

Frequency and Length of Conversations

Of the utterances spoken by teachers in this study, 33.6% of those utterances were spoken during conversations, or moments where there were two or more turns on the same topic. At Timepoint 1, there was a similar number of conversations at Nature-based ($N = 163$) and Non-nature ($N = 134$) and in both schools the majority of these conversations were Brief and occurred during Free Choice (Tables 2.10 and 2.11). However, there were variations in the longer conversations (i.e., Long and Extensive) and where conversations occurred—with most of these longer conversations primarily during Free Choice and primarily Inside at the Non-nature in contrast to Outside at the Nature-based preschool.

Physical Setting. In order to compare conversations with as few setting differences as possible, I conducted an analysis of only Inside conversations at both schools at Timepoint 1 (Table A.4). Inside the building, Brief Conversations, with 2-3 turns, were the most common type of conversation and made up more than half of the conversations at both the Nature-based (51.50%) and Non-nature (72.80%) schools. Similarly, Moderate conversations were the second most common conversation length at both schools. However, for both Brief and Moderate conversations, the Non-nature program used a greater proportion than the Nature-based preschool, X^2 (3, $N = 224$) = 181.551, $p < .012$. In contrast to Brief and Moderate conversations, Long and Extensive conversations were relatively rare Inside. These longer conversations represented less than 10% of all conversations and were spoken in relatively similar proportions in both schools. However, where things diverged among the two preschools was the mean range in turns of conversations. Inside at the Nature-based preschool conversations ranged from 2-31 turns with a mean of 4.79 ($SD = 4.41$) turns. In contrast, the Non-nature preschool had a slightly

lower mean of 3.34 (*SD* = 2.45) and a smaller range with 14 as the maximum number of turns in a conversation. In other words, when Extensive turns (i.e., 10 or more turns) occurred Inside, they were longer at Nature-based preschool (i.e., more turns) than at the Non-nature preschool.

Conversations that occurred Outside among the two schools showed an even greater contrast. While at the Non-nature preschool 125 conversations occurred Inside at Timepoint 1, only nine conversations occurred Outside. Further, these nine outdoor conversations had a maximum of 8 turns (i.e., Long conversation) compared to a maximum of 14 turns Inside (Table 2.10). That is, none of the Outside conversations were Extensive, one was Long, and the rest were Brief or Moderate. In order to provide a deeper view of outdoor conversations at the Non-nature preschool, I also analyzed conversations Outside at Timepoint 2. At this later spring timepoint there were 19 conversations, 10 more than the previous timepoint. The majority of these 19 conversations, as with the previous timepoint, were Brief or Moderate. However, at this second timepoint there were also two Extensive conversations—lasting 14 and 17 turns each. In other words, there were more frequent and slightly longer conversations Outside at Timepoint 2 at the Non-nature preschool than Timepoint 1, but still relatively few. At the Nature-based preschool, however, there were 57 conversations outside of the building, including both timepoints, 26 of which were Extensive.

In addition to longer conversations occurring at the Nature-based preschool, particularly outside of the building, there were also notable differences between the Outside and Beyond settings at the Nature-based preschool. At the Nature-based preschool there were significantly more Brief conversations Outside than any other conversation length or physical setting, X^2 (6, N = 398) = 5.815, p = .444. While there were no statistical differences in the other conversation lengths based on physical setting, the more involved conversations (i.e., Long and Extensive)

primarily occurred Outside. However, the range of turns was slightly higher in the Inside and Beyond, both 2-49, than the Outside (2-31).

Social Settings. At both schools, the bulk of conversations were short (i.e., Brief or Moderate) and occurred during teacher-led activities. In contrast, the longest conversations (i.e., Long and Extensive) were rare and mostly occurred during Free Choice and Large Group. Further, conversations during Free Choice averaged more turns at the Nature-based preschool (M = 5.43, SD = 5.84) and had a wider range (i.e., 2-49) than the Non-nature preschool (M = 3.16, SD = 2.15, Range: 2-12). More specifically, the greatest proportion of Brief Conversations occurred during Large Group at the Non-nature preschool (76.20%) and Small Group (67.60%) at the Nature-based preschool. Regarding Moderate conversations, Small Group (26.90%) was the greatest proportion at Non-nature, whereas Free choice was greatest proportion at Nature-based (31.50%). At both schools, Long and Extensive conversations occurred in the greatest proportions during Free Choice and Large Group (Tables 2.10 and 2.11). Extensive conversations made up 3.2% of the conversations during Free Choice at the Non-nature preschool compared to 11.80% at the Nature-based School. At the Non-nature preschool, as expected based on the structure of the day discussed above, all Outside conversations occurred during Free Choice.

Content of Conversations

The final quantitative analysis focused on the types of utterances spoken within conversations. Given the focus of this study is use of the outdoors as an extension of the classroom, the analysis focused specifically on Questions/prompts, Statements, and Other child-directed interactions. Following the pattern of utterances overall (i.e., outside of or during conversations), teachers at both schools primarily spoke Statements during conversations,

followed by Questions/prompts (Table A.5 and Table A.6). These proportion patterns were consistent across all conversations at both schools. That is, at both schools, within all of the conversations, the greatest proportion of utterances were Statements, followed by Questions/prompts, and finally Other Child-Directed interactions. The only place where these proportions varied significantly from each other was at the Non-nature preschool where Statements occurred more often during Long Conversations (74.30%) than Moderate (61.90%) and Brief Conversations (63.20%), X^2 (6, N = 1084) = 10.470, p = .106. In other words, the types of utterances within conversations did not vary from the types of utterances spoken outside of conversations (i.e., less than 2 turns).

Contextual Factors/Characterizations Influencing Conversation Length

At both schools Extensive Conversations were rare compared to other conversation lengths. There were 42 extensive conversations at the Nature-based preschool across both timepoints and only eight at the Non-nature School, two of which occurred Outside at Timepoint 2 and thus are not reflected in Table 2.9. These 50 conversations account for 11% of all of the conversations in the present study (N = 551). These Extensive conversations mostly occurred during Free Choice or Large Group, though at the Non-nature preschool one Extensive conversation occurred during Routines and another during Small Group. Further, at the Non-nature preschool these extensive conversations primarily occurred Inside whereas at the Nature-based preschool they primarily occurred Outside. To help explain these differences, I provide additional information about the contextual factors of the eight longest Extensive conversations at each school. This included all of the Extensive conversations at the Non-nature preschool and about 20% of the Extensive conversations at the Nature-based preschool. This analysis revealed

patterns related to the number of children involved, length of time, focus of the talk, and how conversations emerged and ended.

Longest Conversations in Free Choice with Few Children. Free Choice was by far the dominant setting for Extensive conversations overall and particularly the longest conversations. Free Choice is a child-led time where children can select the activities and places in the classroom they would like to play. A deeper examination of the longest conversations revealed how these conversations unfolded during Free Choice time.

The Free Choice conversations all involved one teacher with a maximum of five children, though most involved fewer than three children. For example, at the Non-nature preschool seven of the eight conversations involved 1-2 children. Similarly, at the Nature-based preschool six of the eight conversations involved fewer than three children. This low ratio of teachers to students during Free Choice, mostly 1:3 teacher child ratio, and the more relaxed pace of Free Choice may have allowed for longer interactions. Not only did these interactions involve more than 10 turns in conversation, but they also lasted from two minutes and 23 seconds (2:23) to seven minutes and three seconds (7:03).

Longest Extensive Conversations Mostly Focused on Concepts. The longest conversations at the two schools not only varied in social setting and elapsed time, but also varied with respect to the focus, or subject, of the conversation. The longest conversations at both schools fell into three broad subjects: management, conflict resolution, and concepts. Management conversations focused on directing children's behavior, such as cleaning up after choice time, and tending to personal care issues such as toileting. Conflict resolution conversations, while related to children's behavior, involved teachers facilitating conversation between at least two children to solve their conflict. For example, in one of the longest

conversations a teacher noticed a child was upset and said to the second child, “I want you to look at [Name]’s face. How do you think he’s feeling?” The three proceeded to talk through their feelings, the problem that caused those feelings, and how they could solve their problem. The most common of these extensive conversations were concept related. That is, the teachers and children were talking about something outside of their personal needs and related to the world around them. This included, for example, conversations on letter sounds while writing, exploring for worms, imaginative problem-solving, and recounting stories of things they’ve experienced.

At the Non-nature preschool four of the eight longest conversations were concept related, two conflict resolution and one conversation focused on toileting. Yet at the Nature-based preschool, only one of the eight conversations involved conflict resolution and the rest focused on concept development.

Concept-related Conversations Initiated by Children and Connected to the Physical Environment. While Extensive conversations were rare Outside at the Non-nature preschool, two of the four concept-related conversations at the Non-nature preschool occurred Outside. At the Nature-based preschool, all seven of the concept-related conversations occurred Outside. Yet, whether Inside or Outside, all of the concept-related conversations were initiated by the children and the physical environment contributed in some way to how the conversations came about. In some cases, the conversations were initially started by the children, but an interruption from another adult or child drew the teacher’s attention away before the teacher returned to the initial prompt. For example, one child said, “I can climb this tree” and then the teacher, before he could respond, answered another teacher’s question. The teacher then turned back to the child and said, “How are we going to get up there?” Thus, whether the teachers responded to the children

immediately or after a brief interruption, all of the concept-related conversations were initiated by children.

Further, each of these child-initiated conversations seemed to be prompted by the physical environment in some way—both Inside and Outside. This included objects that sparked personal interest, opportunities for writing, and opportunities for exploration. For example, Inside at the Non-nature preschool one conversation started by a child asking about a photo of the teacher and her family that was hanging on the wall. The teacher started with "I heard you calling my name in pretend play. Is there something that I can help you with?" and then the children said, "Yeah" and pointed to the photo leading into a conversation. Similarly, Inside at the Nature-based preschool one conversation was sparked when a child handed the teacher a book about pond life from the shelf and they noticed a photo of a goose inside. The group then told stories about when they'd recently seen geese and other animals.

Additionally, writing opportunities sparked extensive conversations both Inside and Outside. For example, at the Non-nature preschool, one child had created a puppet Inside and wanted help writing "Snowflake"—the puppet's name. A literacy activity Outside at the Nature-based preschool involved moveable wooden letters. A child initiated this conversation saying, "Do the ABCs. A, B. Let's do the ABCs." Finally, the physical environment seemed to provide opportunities for child-led exploration. For example, Outside at the Non-nature preschool both concept-related conversations related to searching for worms. A child mentioned finding worms and then, after a brief interruption, the teacher said, "Let's go find some worms. I'll show you where they all hide. I found a bunch yesterday. I got this bucket for them too." This was similar to two of the longest conversations at the Nature-based preschool where they also searched for worms and went exploring for squirrels.

In addition to the materials in the physical environment sparking conversation, whether Inside or Outside, almost all of the longest conversations occurred away from the rest of the group. Further, in all of these long conversations the teachers were either roaming the classroom space and called over by a child or the teacher was already sitting at the same level as the child and typically side-by-side with the child rather than face-to-face.

It should also be noted, the conversations focused on management and conflict resolution ended when the problem was solved. In contrast, the concept-related conversations ended when another child or teacher interrupted. For example, one conversation ended when a child joined a group and asked, "What are we playing?" In another case a child elsewhere in the classroom called out "Stop it!" which drew the teacher's attention away. In yet another example it was a different teacher announcing "Five more minutes until cleanup time" that interrupted the conversation.

Table 2.12
Distribution of the Eight Longest Extensive Conversations by Preschool and Teacher

	T1[a]	T2	T3	T4	T5	T6	Row Sub Totals
Nature	4	2	1	1	0	0	8
Non-Nature[b]	3	3	1	1	0	0	8
Column Total	7	5	2	2	0	0	16

a. T stands for "teacher" in this row
b. These counts do NOT include Inside conversations at the Non-Nature preschool at Timepoint 2.

Not All Teachers Engaged in Extensive Conversations. Most of this study examined the teachers at each school as a group. Yet, one final aspect of the eight longest conversations worth noting is that not all of the individual teachers engaged in Extensive conversations (Table 2.12). When looking specifically at the longest eight conversations at both schools, four of the six teachers at each school engaged in Extensive conversations. Two of the six at each school did not have Extensive conversations at all. Among the teachers that did have Extensive

conversations at Non-nature preschool, two engaged in three Extensive conversations and the other two teachers engaged in one Extensive each. Similarly, at the Nature-based preschool one teacher engaged in four out of the eight longest conversations; one teacher engaged in two conversations; and two teachers in one conversation each.

Discussion and Implications

This study analyzed teacher talk as an indicator of the ways in which nature-based and non-nature preschool teachers use the outdoors as an extension of the classroom. The findings of this explanatory mixed-methods approach contribute several insights to the field. First, analysis of the frequency and types of utterances revealed the physical setting (i.e., Inside, Outside, Beyond) and social settings (e.g., Free Choice, Large Group) seemed related to and potentially influence the frequency and quality of teacher's talk. Second, teachers at the Nature-based and Non-nature preschool had different ways of utilizing the outdoors in relation to activities, time, timing, and logistics which help explain the relationship between the physical and social setting and the types of talk. The Non-nature preschool used the Outside for brief Free Choice time, whereas the Nature-based preschool spent extensive time outdoors, including the entire class day at the second timepoint. Third, there were differences in how the Nature-based preschool used the spaces outside of the building (i.e., Outside and Beyond). While the Non-nature preschool never left the fenced play area to enter the Beyond, the Nature-based preschool used this space for both Large Group and Routines, though not Free Choice. Each of these findings have implications for future research and practice related to the use of the outdoors as a classroom space in both nature-based and more conventional settings.

Comparable Interactions When in Comparable Settings

Overall, the Nature-based preschool teachers spoke more utterances than the Non-nature preschool. However, the patterns at both preschools were similar when indoors in terms of type of talk and how long teachers interacted with children. That is, when the setting was the same (i.e., Inside), the interactions were generally the same at both schools. For example, when indoor time was included in the day, teachers at both schools spoke most frequently inside. Further, when indoors, all of the teachers in this study used mostly statements followed by questions/prompts. These patterns of talk in the present study confirms previous work which has suggested preschool teachers generally use statements more than questions and ask few cognitively challenging questions (Massey et al., 2008; Tu & Hsiao, 2008) — particularly during conversations (Chen & de Groot, 2014; Leuchter et al., 2020). This suggests that when indoors the teachers were interacting similarly to each other and preschool teachers from previous studies of indoor settings.

Looking more closely at these indoor interactions in terms of social setting, the findings of the current study highlight the importance of context as identified in previous studies (Cabell et al., 2013; Chen & de Groot Kim, 2014; Chien et al., 2010; Winton & Buysse, 2005). Teachers in both the Nature-based and Non-nature preschools spoke the least during routines such as meals which is also consistent with previous studies (Cabell et al., 2013; Chen & de Groot, 2014). While routines were the least frequent time for talk, talk was observed most often during Free Choice—more than observed during teacher-led activities (i.e., Large Group and Small Group). Further, at the first timepoint the Nature-based teachers spoke significantly more during Free Choice than Non-nature teachers. It was this timepoint when the nature classes had free choice both inside and outside in the play area. These findings contradict previous studies which

have found teacher-child interactions to be more frequent during teacher-led activities than during free play (Cabell et al., 2013; Chen & de Groot, 2014; Chien et al., 2010). Yet these findings align with at least one study which found higher quality interactions when children were able to freely choose their play—including moving freely between indoor and outdoor settings (Tonge et al., 2018). These mixed results among studies are intriguing considering the nature-based preschool in the current study spent most of their free choice time outdoors. These variations could exist for a variety of reasons. One possibility to explore further is how the physical environment lends itself to more interaction during outdoor play.

Conversations, or a string of utterances involving turns in talk between teachers and children, were another dimension of talk that varied based on context in the current study. At both schools, most of the conversations were short (i.e., 6 or fewer turns) and occurred during teacher-led activities. The longer conversations (i.e., Long and Extensive) were observed most often during Free Choice. Extensive questions, or those which lasted 10 or more turns, made up 11% of all conversations in the current study. This aligns with previous work which found preschool teachers conversations with children averaged five turns and only 10% were more than 10 turns (Cabell et al., 2015). In-depth analysis of the longest conversations showed these conversations were primarily initiated by children, suggesting that when teachers follow the children's lead, conversations were longer. This idea aligns with the work of Cabell and colleagues (2015) who found teachers who engaged in more child-initiated conversations had more multi-turn conversations.

Patterns of Talk: The Intersection of Physical and Social Setting Likely Influences Teacher Talk

Taken together, the findings in the current study suggest that, when indoors, the two schools generally had similar quality of teacher-child interactions, which is not surprising given both are considered high-quality programs per the state's Quality Rating Improvement System. However, when we take into consideration the intersection of social settings with the physical setting, there were differences in the frequency and quality of talk, including conversations, between the schools. These differences also varied slightly from previous research of preschool teachers in more conventional settings.

In the present study, for both schools and regardless of whether it was inside or outside, statements occurred most often during teacher-led activities with slight differences on which teacher-led setting was most frequent (i.e., Large Group or Small Group). Additionally, questions/prompts were more frequent during Routines and Large Group at the Non-nature preschool. While the use of questions/prompts in the present study would need more interpretation related to the children involved and types of questions, the basic finding aligns with previous studies which found open-ended questions to be most frequent during teacher-led activities such as science (Fuccillo, 2011) and reading time (Fuccillo, 2011; Massey et al., 2008). In contrast to these previous findings, in the current study Nature-based teachers asked more questions during Free Choice. One explanation for these differences is the fact that prior research (e.g., Fuccillo, 2011) only examined teacher-led activities. Another reasonable explanation, since the nature-based preschool spent most of their free play time outdoors, is that the physical environment influenced how often and in what ways teachers interacted with children. Regardless of the explanation, the findings of the current study suggest there are further

opportunities for teacher-child interactions involving questions during Free Choice—particularly when outside.

The second difference in the patterns of talk was the type of talk (e.g., questions/prompt, statement) was the same whether or not it occurred during a conversation. However, given the importance of concept development and interactions, it's important to consider how teachers engage in the most extensive interactions. The current findings also showed the longer conversations primarily involved one teacher with few children, were initiated by children, focused on concepts, and were somehow connected to the physical environment.

Of the eight longest conversations at both schools, it is particularly useful to look at those related to concept development in some way because one of the goals of this study was related to the outdoors as an extension of the classroom. That is, conversations that move beyond management of behavior to sense-making of the world. Of these long, concept-related conversations, almost all at the Nature-based preschool and two of the four at the Non-nature preschool occurred in the outdoor play area. This is consistent with one previous study which observed higher-quality interactions when the class spent more time outdoors (Tonge et al., 2018). Further, it is important to note the two outdoor conversations at the Non-nature preschool occurred in their natural play area rather than the more human-built playground, suggesting a more natural space may afford more concept-related conversations. This particular idea was studied by Kloos and colleagues (2018) who found teachers used twice as much science-related language in more natural play areas as they did in human-built ones. The current findings, along with these previous studies, suggests the outdoor environment may support more meaningful, concept-related interactions.

The similarities of talk inside and differences outside highlight the potential of all preschools to use the outdoors as a more meaningful learning environment. That is, the teachers were not fundamentally different in how they engaged with children. Rather the engagement changed based on their location. This implies the need for professional development specific to facilitating longer, child-initiated conversations in relation to outdoor settings. One previous study found, for example, that professional development increased the length of conversations as well as the frequency of child-initiated conversations (Cabell et al., 2015). Given the unique context of outdoor settings, it may also be useful to include specific strategies for referencing and connecting to the physical environment in these conversations. All preschools, even those that do not identify as nature-based, have outdoor play spaces and interaction strategies that could provide more equitable opportunities for connections with nature.

Differences in How Schools Used the Outdoors: Not All Outdoor Experiences Are Equal

Where teachers talked most frequently reflected where they spend their day. In this study, the Non-nature preschool spent little time outdoors (i.e., less than 30 minutes), whereas the Nature-based preschool spent at least half of their day outdoors, with time divided between the fenced play area and areas beyond the fence. This time spent outdoors aligns with previous research which has found child care programs provide little time for physical activity outdoors (Reilly, 2010) and the majority provide less than is required for licensing (Byrd-Williams et al., 2019). In contrast, the Nature-based preschool spent half of their day outdoors at the first timepoint and all of their day outdoors at the second timepoint. This outdoor time included time in both the Outside and Beyond. While different from the Non-nature program, this aligns with timeframes included in nature-based preschools definitions of a minimum of 30% of the day outdoors (Bailie, 2010; Green Hearts, 2014; Larimore, 2011a) and time outdoors inside and

beyond the boundaries of the fenced play area (Larimore, 2019; Warden, 2015). Not only did the two preschools spend different amounts of time outside, the two schools used that outdoor time very differently with the Non-Nature preschool only using the outdoors for Free Choice and the Nature-based preschool using the outdoors for both free play and teacher-led activities. Further, the Nature-based preschool used the fenced play area differently than the areas beyond the boundaries of the fence. Taken together, this suggests simply being outside of the building is not what distinguishes these two schools. What distinguishes these two schools is *how* they use the spaces outside of the building.

First, the two preschools had different times for when in the class day outdoor time occurred. The Nature-based preschool began their day outdoors whereas the Non-nature preschool ended their day outside. Having the outside time at the end of the class day may have contributed to shorter outdoor time at the Non-nature preschool because over the course of three hours timing of activities gets shifted and the end of the day gets cut short. This end-of-the-day scheduling may also explain why the Nature-based preschool only held one Small Group when they were outside—they were scheduled for the end of the day and thus were cut short or cut out completely.

Another difference in how the two schools used the outdoors was the structure of who was using the space at any given time. At the Nature-based preschool the outdoor play space was designated for one class at a time. However, at the Non-nature preschool the outdoor space was shared between multiple classes. Thus, the teachers were interacting with at least 20 children they had not been interacting with indoors. While over time teachers would get to know the children in the other classes, this takes a long time when they're interacting less than 30 minutes each day. As other research has found, relationships are a foundational component of quality

teacher-child interactions (e.g., Pianta et al., 2003). Additionally, without knowledge of an individual child, it is difficult for a teacher to "link to and reinforce indoor learning" like the State of Texas (2014) recommended in their quality rating standards related to outdoor learning environments. Sharing the outdoor classroom space also results in multiple teachers working together who were not working together indoors. This may help explain why nearly one quarter of the Teacher-to-Teacher talk at the Non-nature preschool occurred Outside, as they need to attend to more logistics. Further, the shared space may mean fewer opportunities for extensive conversations. The current findings suggest the longest conversations involved one teacher and very few children who were interacting in quiet spaces away from other groups. This not only has implications for the sharing of space, but also for the size and structure of the outdoor learning environment. For example, previous research has suggested natural play areas include spaces for children to interact with peers and teachers in small groups (Moore, 2014).

A third difference in how the two schools used the outdoor learning space was the activities that occurred there. At the Non-nature preschool, Free Choice was the only activity that occurred outside. However, at the Nature-based preschool all social settings occurred in the outdoor play area. That is, they utilized the outdoor space to implement the same components of the day as they had inside. Though, as was mentioned, Small Group only occurred once outside at the Nature-based preschool. This use of the outdoor space for a variety of learning activities is an embodiment of policy guidance for using the outdoors as a learning environment. For example, Michigan specifically says "the outdoor play area is considered an outdoor classroom and an extension of the learning environment" (State of Michigan, 2019, p.18).

These contrasts in how the outdoors was used at the two schools may reflect differing views on the purpose of outdoor time. While the present study did not ask teachers directly, the

additional talk between teachers may be an indicator of their perceptions on the purpose of outdoor play. That is, the teachers may have perceived that their role in outdoor play was to supervise, similar to recess, rather than interact with children. This runs counter to the MSBE recommendation that "adults are engaged with the children rather than 'watching' them" (2013, p. 131). Another possible indicator on the views of the purpose of the outdoors is the teacher who removed her microphone before outdoor class time. Again, while we cannot say for sure, this action may suggest the teacher did not imagine the researcher would find value in recording the outdoor portion of the class day. Previous research has suggested these differences in use may be connected to teachers' knowledge of the benefits of nature-based experiences, their personal connection to nature, and their perceived difficulty in using natural settings (Torquati & Ernst, 2013).

The similarities of talk inside and differences outside highlight the potential of all preschools, whether nature-based or not, to use the outdoors as a more meaningful learning environment. That is, the teachers in the two schools were not vastly different in their approaches to interactions with children. The differences instead were around the use of the outdoors as a learning space. This suggests it may only require a few strategies or shifts in thinking for all preschool teachers to increase the frequency and quality of talk outdoors. These shifts could provide more equitable opportunities for children's outdoor experiences.

That raises the question of the best way to support teachers in engaging in meaningful interactions outdoors. One study suggested it is important to focus on helping teachers remove barriers they may face rather than focusing on changing beliefs about the value of outdoor learning (Ernst, 2014b). The current study has identified at least two possible barriers—having outdoor activities at the end of the day and sharing the outdoor space. Further, for all teachers,

whether nature-based or not, the current study also suggests a need for strategies and activity ideas outside that relate to all developmental domains. For example, in this study the nature-based preschool teachers did little singing or reading outdoors. Specific strategies to intentionally integrate these activities might be useful for all teachers—no matter the type of preschool.

Aligning Activities in the Beyond with the Vision

Another difference in how spaces outside the building were used was the differing ways the Nature-based preschool used the Outside and Beyond. First, while all social setting occurred in the outside play area at the Nature-based preschool, only Large Group and Routine occurred in the space beyond the fence. That is, Free Choice never occurred beyond the boundaries of the fence. During this Beyond time, the Large Group activities often involved walking a fair distance and thus the whole-group activity lasted longer than when conducted in the play area or indoors. The routines all involved stopping to have snack as a group.

This structure of the Beyond activities seemed to influence how teachers talked in comparison to the Outside. For example, the teachers talked to each other more when they were in the Beyond than any other location (i.e., Inside or Outside). Further, they used statements most often and used questions least often in the Beyond. This reflects the fact that overall Nature-based teachers asked more questions during Free Choice. Similarly, the longest conversations at the nature-based school occurred during Free Choice. Yet, Free Choice did not occur in the Beyond. While these whole-group experiences beyond the fence still include brief times for exploration and some conversations between teachers and children, this study has shown more free play allowed for longer conversations. Further, not having long periods of time for exploration runs counter to the purpose of the beyond as theorized by nature-based educators. Scholars have argued nature-based preschools have dual goals of whole development and

connection to the natural world (Finch & Bailie, 2015; Larimore, 2016). They have further argued that outdoor experiences particularly support this connection with nature. For example, Finch and Bailie (2015) posed that there are two strategies for providing "frequent, unstructured time exploring nature" which include free play in a natural play space and group hikes in natural habitats. Others have suggested one purpose of time in the Beyond is to connect children with something bigger than themselves (Larimore, 2019; Warden, 2015, 2019a). Warden also suggests that in addition to a physical location the Beyond metaphorically represents "the unobservable, the undefined web of in betweenness that stretches across the observable and unobservable aspects of our lives" (2019, p. 34).

These findings suggest a need to better support nature-based teachers in reflecting on how they use the spaces within and outside the fenced play area, and how those does/doesn't align with the intended purposes. For example, it may be useful for nature-based programs to spend less time travelling and more time at a particular destination and then allow extensive free play at that destination. It may also be useful to better support nature-based teachers in organizing their day to include a variety of social settings without having to eliminate activities due to time constraints (e.g., small group). These findings can also be informative to non-nature schools. While a school might not have a nature focus, they might walk to a local park for an afternoon. The current findings suggest allowing for extended free play in one particular place may better support quality interactions. Thus, the school might schedule the outing to reduce travel time and maximize free play at the destination.

Limitations and Future Directions

One strength of this study was that it examined the teacher-child interactions at two high-quality preschool programs based on the state's Quality Rating Improvement System. However,

the findings identified in this study may not reflect the language of nature-based preschool teachers nationwide nor preschool teachers more broadly as this study observed classrooms in two particular schools. Therefore, while this study provides some insights into teacher-child interactions as an extension of the classroom, future studies could study these interactions in additional settings. Future studies could also study types of utterances and conversations in more nuanced ways.

Further research could analyze this work in greater detail, examining ways the outdoors may support learning in a variety of domains, and also how features of the outdoor environment itself influence the interactions and learning. With respect to teacher-child interactions, this study provided a broad exploratory view of the frequency and quality of teacher language as a baseline for what is occurring and possible in outdoor learning environments. This included teachers at the two schools being grouped together for analysis. While at least one study found no difference in child-directed talk among lead and assistant preschool teachers (Gest et al., 2006), the current study showed differences in individual teachers' engagement in conversation. This suggests there is more to understand about the frequency and quality of talk by individual teachers and the role individual teachers' and children's identities play. Thus, it would be useful if future work examined in more detail the types of questions and statements individual teachers were using. For example, others have studied types of questioning, such as open- or close-ended questions (Fuccillo, 2011; Massey et al., 2008), in non-nature settings. How do those types of questions unfold in nature-based settings and what influence do individual teachers and children have on those interactions? Additionally, if would be useful to identify the content and purpose of statements used by different teachers in their interactions with children in outdoor spaces. That level of detail would be useful in identifying the particular focus of interactions at both nature-

based and non-nature settings. For example, in the current study the nature-based teachers asked questions most frequently during Free Choice whereas the non-nature teachers asked more questions during Routines. Are the same kinds of questions being asked in these different settings? At the Non-nature preschool, classes shared an outdoor space. Are the statements used in this situation primarily directive related to children's behavior or are the statements reflecting teacher observations and thoughts about the world around them?

It would also be useful to examine the use of different types of conversations, and questions within those conversations, in more detail. The current study found the lengthiest conversations occurred outdoors and were related to concept development, but were they science-related as one previous study (Kloos et al., 2018) suggested might be the case? What non-verbal interactions are occurring during conversations to support this concept development? Further, it has been theorized that outdoor learning should be linked to the learning occurring indoors (Larimore, 2019; State of Texas, 2014; Warden, 2015). To what extent are concept-related conversations building on or referring to experiences in other spaces? How do these conversations build over time? In the current study a turn in conversation was counted when any child responded on the same topic but focusing on individual children in conversation might be particularly useful in examining concept development over time. Such work related to conversations would help to answer questions about how teachers are leveraging the physical environment to support children's learning. Further, while the present study examined individual teachers, it would be useful to examine which children were involved in these longer conversations. That is, did many or most children engage with teachers in an extended way or were the longer interactions outdoors limited to a few individual children?

Future work examining the physical environment itself and how the differences in the environment support teacher-child interactions would be useful. Previous studies have found different interaction in different parts of the classroom such as the art area (Tu & Hsiao, 2008). Though this study did note more details about the physical environment in the qualitative analysis of the extensive conversation, it primarily considered the Inside, Outside, and Beyond as three large spaces. That is, I did not capture micro-spaces within those three areas. For example, conversations were captured Outside, but this study did not distinguish if the conversation occurred on a built climbing structure, at a mud kitchen, or in a garden. It would also be helpful to identify what equipment and materials are in those spaces. Capturing more detail about the physical environment would help to identify the features particularly useful in supporting the outdoors as a learning environment and connect to previous work in this area (Kahn et al., 2017). Knowing more about these features would provide more meaningful outdoor experiences for children in rural, suburban, and urban settings.

Finally, this study, with a focus on language interactions, provides some insights on the role of the outdoors as a space for children's development beyond simply physical development. There is also a need, however, to consider how the outdoors may support learning in ways other than talk and in a variety of developmental domains. Future work should examine in more detail cognitive and physical development as this study and others have begun (e.g., Fjortoft et al., 2009; Skibbe et al., 2017), but also the role of the outdoor classroom for social-emotional development. Additionally, it would be useful to study interactions beyond just verbal language to include embodied interactions. For example, previous studies have examined pauses in conversation (Cohrssen et al., 2014). It would be useful to examine how teachers use silence during or outside of conversations and how that silence might support children's cognitive

development, but also their aesthetic development. It would also be useful to examine how interactions are embodied. For example, how does a teacher crouching to a child's level extend a conversation about the insects they are observing?

Conclusion

The findings of this study, identified through mixed methods analysis of teachers' talk at a nature-based and non-nature-based preschool, indicate the physical setting and the activities occurring in those locations (e.g., Free Choice, Large Group) may influence the frequency and quality of teacher's talk. However, simply being outside of the building does not necessarily support more frequent and higher-quality teacher-child interactions. Rather, what matters is how the outdoor spaces are used. The various activities, time, timing, and logistics all influence how the outdoor spaces are used as an extension of the classroom—particularly with respect to the frequency and quality of talk. These factors not only influence how the outdoor play areas are used, but also the spaces beyond the fence. These findings have implications for those preschools that do not identify as nature-based, as well as those that do such as the structure and use of spaces beyond the fence to allow for free play. The current findings provide possibilities for removing the barriers keeping teachers from using the outdoors as learning environment for children's whole development. This in turn may allow for more children from a variety of backgrounds and in a variety of program types to experience the outdoors as an extension of their preschool classroom.

While this study provides insights teacher-child interactions as an extension of the classroom, it would be useful for future studies to examine in greater detail both verbal and non-verbal aspects of teacher-child interactions, and the role the features of the outdoor environment play in these interactions. Moving forward, nature-based and other early childhood educators

should continue to identify the teaching practices that shift the outdoors from a place solely for recess to a place purposefully used for learning in all developmental domains. Doing so will help all children, regardless of the school they attend, experience the many benefits to physical, social-emotional, and cognitive development the natural world provides.

CHAPTER 3: "I LOVE NATURE!"—TEACHERS' INTERACTIONS WITH CHILDREN ABOUT THREE-DIMENSIONAL SCIENCE IN A NATURE-BASED PRESCHOOL

Nature-based preschools are a growing phenomenon in preschool education in the United States. The number of nature-based preschools has grown from 12 nature-based preschools in 2010 to more than 585 in 2020 (Bailie, 2012; Natural Start Alliance, 2020). Nature-based preschools, with extensive time outdoors and surrounded by natural phenomena, have the potential to promote science in ways not observed in conventional preschool classrooms. This is particularly critical given the importance of science experiences for young children's development (e.g., National Research Council, 2007) and also how infrequently they have opportunities to engage with science (Early et al., 2010; Piasta et al., 2014; Tu, 2006).

The overall approach in nature-based preschools is integration of nature throughout the curriculum, spending at least one-third of the class day outside (Bailie, 2010; Larimore, 2011a). This outdoor time is divided between time in a fenced play area and areas beyond the fence (Larimore, 2019; Warden, 2015). With this extensive time outdoors and a stated curricular desire to connect with nature, it seems nature-based preschools have the potential to promote science learning in ways not observed in more conventional preschool classrooms.

While the physical environment of nature-based preschools may provide inherent affordances for science learning, simply being based "in" nature does not, however, guarantee teachers are supporting children in making sense of the natural world in a scientific way. Yes, context and content seem to influence the types of teacher-child interactions that occur in a preschool classroom (Cabell et al., 2013; Chen & de Groot, 2014; Tu, 2006; Wasik & Jacobi-Vessels, 2017). However, previous studies in conventional preschool classrooms have shown preschool classrooms generally have many science-related materials available, but don't often use those materials (Fleer, Gomes, & March, 2014; Tu, 2006; Vitiello et al., 2018). Of course, in

primarily indoor settings the science phenomena are selected and introduced by the teachers. Whereas outdoors, the natural world is providing the science-related phenomena. Thus, we are left to wonder the impact the context, particularly the physical environment, may have on science interactions when so much class time is spent surrounded by natural phenomena rather than teacher-provided materials.

To better understand the affordances of nature-based settings and how those settings might impact the interactions and outcomes of learning, this study observed the teaching practice at one nature-based preschool to better understand what science interactions were occurring, in what ways those interactions connected to three-dimensional approaches to science teaching, and how the episodes unfolded. Understanding how science teaching is being leveraged in this preschool, and the affordances and constraints of this context, will inform teaching practice to maximize science learning for young children in both nature-based and more conventional preschools. Learning more about the affordances and constraints of nature-based preschool settings and related instruction is important to further inform K-12 science teaching and learning, particularly using three-dimensional approaches.

Science in the Early Years

Young children are innately curious about the world around them (Eshach & Fried, 2005; Greenfield, 2017; Greenfield et al., 2009; Katz, 2010; National Research Council, 2007) and capable of learning science (Brenneman et al., 2009; Eshach & Fried, 2005; Greenfield, 2017; Inagaki, 1992; National Research Council, 2007; National Science Teachers Association, 2014). This includes learning practices needed for the doing of science (Fusaro & Smith, 2018; Samarapungavan et al., 2015; van der Graaf et al., 2018) and the language used in science (Akerson et al., 2011; Eshach & Fried, 2005; van der Graaf et al., 2018). However, learning

science also includes the development of dispositions and feelings such as curiosity (Brenneman et al., 2009; Greenfield, 2017; Jirout & Klahr, 2012), motivation (Mantzicopoulos et al., 2008; Oppermann et al., 2019), and positive attitudes toward science (Eshach & Fried, 2005; Gomes & Fleer, 2019; Mantzicopoulos et al., 2013; Oppermann et al., 2017).

Opportunities for experiences with science not only develop children's scientific literacy and engagement as adults (Eshach & Fried, 2005; Greenfield, 2017; Inagaki, 1992; National Research Council, 2007), but also develop skills in the here and now. Science, for example, develops young children's language and literacy (Brenneman, 2011; French, 2004), social-emotional (French, 2004), and domain general skills (Brenneman, 2011; Eshach & Fried, 2005; Greenfield, 2017). Additionally, it is important to remember children have a right to make sense of the world around them (Larimore, 2020), including the right to develop a "respect for the natural environment" (UNICEF, 1989, p.9)—in the present moment.

All states now have preschool early learning standards which include science (Greenfield et al., 2009; Kloos, Maltbie, Brown, & Carr, 2018)—indicating a value of science learning in the early years. These early learning standards generally emphasize content knowledge and process skills such as observing and predicting (Greenfield et al., 2009). In contrast, at the K-12 level science education has shifted to emphasizing integration of content and skills into three-dimensional science teaching including science practices, disciplinary core ideas, and crosscutting concepts (National Research Council, 2012b).

While preschool is different than K-12 settings, the three-dimensional approach aligns with the way young children inherently make sense of the world (National Science Teachers Association, 2014). The underlying philosophy of three-dimensional science is to shift children from knowing or learning about science to "figuring out" science (Schwarz, Passmore, & Reiser,

2017, p. 12). This approach, as outlined in *A K-12 Framework for Science Education* (National Research Council, 2012b) and Next Generation Science Standards (NGSS Lead States, 2013), focuses on science practices, disciplinary core ideas, and crosscutting concepts rooted in phenomena (National Research Council, 2012b). Science and engineering practices, of which there are eight described in the *Framework*, integrate both knowledge and skill to describe the doing of science (e.g., "asking questions and defining problems" and "planning and carrying out investigations"). Disciplinary core ideas are the science concepts rooted in life, earth, and physical science content. The third dimension, crosscutting concepts, are science ideas that help children connect different disciplinary core ideas. "Structure and function" and "patterns" are two examples out of the seven crosscutting concepts described in the *Framework*. Finally, it is important to note that these three dimensions are rooted in exposure to phenomena. Phenomena are events in the world that children are trying to make sense of or "figure out" (i.e., what, how, and why something occurs) or understand in order to design a solution (i.e., engineering) (Schwarz et al., 2017). All this is to say, in order to make sense of the world around them young children must have authentic encounters with natural phenomena in a variety of disciplinary ideas (National Research Council, 2012b; National Science Teachers Association, 2014) while engaging in the *doing* of science (i.e., science and engineering practices).

Despite the many benefits of science learning and inclusion of science in learning standards, the reality is little time is spent on science in preschool (Piasta et al., 2014; Tu, 2006; Early et al., 2010). While this lack of science leads to gaps in science achievement beginning as early as kindergarten, and for which children rarely catch up (Morgan et al., 2016), it also deprives children of opportunities to make sense of their world. Preschools typically spend less instructional time on science than any other discipline (Early et al., 2010; Piasta et al., 2014; Tu,

2006). This lack of time may be due to teachers' limited knowledge about science content and pedagogy (Garbett, 2003; Gerde, Pierce, Lee, & Van Egeren, 2018; Kallery & Psillos, 2001; Pendergast, Lieberman-Betz, & Vail, 2015; Tu, 2006) or due to emphasis on language and literacy instruction in the early years (Greenfield et al., 2009).

Teacher-child interactions are critical to science learning because they can elicit and extend children's ideas. Interactions may focus on vocabulary, supporting children's interest, asking open-ended questions, or posing cognitively challenging ideas (Whorrall & Cabell, 2016). These conversations allow for and support ongoing sense-making. For example, one study found teacher's use of content-specific science language was a positive predictor of children's sense-making around science concepts (Studhalter et al., 2021). And yet, not only is time on science rare, quality interactions are also infrequent in the preschool classroom (Dickinson et al., 2008; Winton & Buysse, 2005). Further, these interactions rarely involve cognitively engaging conversations (Chen & de Groot, 2014)—in any domain, let alone science.

There is evidence that both context and content influence if and how teachers and children interact in preschool classrooms. While most studies around teacher-child interactions in preschool have been outside the domain of science, there is clear indication that context strongly influences the number of interactions teachers have with children (Cabell et al., 2013; Chien et al., 2010; Turnbull et al., 2009; Wasik & Jacobi-Vessels, 2017). Group size, for example, appears to have a moderate effect on the number of teacher-child interactions (Turnbull et al., 2009). Further, these interactions are typically greater during teacher-led activities such as large or small group meetings (Cabell et al., 2013; Chen & de Groot Kim, 2014; Chien et al., 2017). Teacher-child interactions are less frequent during free play (Chen & de Groot, 2014; Winton & Buysse, 2005).

In addition to context, the content of conversations seems to influence teacher-child interactions. That is, the materials available in a particular space influence the interactions. Preschool teachers interact with children more in the art area than other areas of the classroom (Tu & Hsiao, 2008). The language, particularly questions, used in those classroom areas also varies based on the location. Teachers, for example, ask more cognitively challenging questions during shared reading time (Massey et al., 2008). Teachers also encourage more reasoning in the dramatic play area and more measuring and counting in the block area (Tu & Hsiao, 2008). Specifically related to science, there is evidence that teacher-led preschool science activities generate more cognitively engaging interactions than other areas of cognitive development (e.g., math) (Cabell et al., 2013; Tu & Hsiao, 2008). Previous studies have indicated the presence of science-related materials in the preschool classroom, but little utilization of those materials (Fleer, Gomes, & March, 2014; Tu, 2006; Vitiello et al., 2018) In fact, one study observed 47 teacher-led science lessons and never observed a child using a science tool such as a hand lens, balance, or microscope (Vitiello et al., 2018). The use of these tools seem to depend heavily on the teachers attitude about science (Fleer et al., 2014).

Taken together, these studies suggest the context and content may play an important role in the types of interactions teachers and children have around science ideas.

Nature-based Preschools

Nature-based preschools, with ongoing experiences in the natural world, may be more likely to afford opportunities for encounters with and interactions related to natural phenomena. Nature-based early childhood education (NbECE) is an umbrella term describing the integration of two disciplines—early childhood and environmental education (Bailie, 2010; Larimore, 2011a; Natural Start Alliance, 2019). This study focuses on one model within the NbECE

umbrella—nature-based preschools. Nature-based preschools serve 3-5 year-olds and spend a minimum of 30% of the class day outside (Bailie, 2010; Green Hearts, 2014; Larimore, 2011a). Additionally, nature-based preschools include time spent beyond the designated play area, nature infused into the indoor spaces, and with nature as the driving theme of the curriculum (Bailie, 2010; Green Hearts, 2014; Larimore, 2011b, 2011a; Moore, 2014). That is, nature is integrated into learning indoors, outdoors, and "beyond" (Larimore, 2018; Warden, 2015). As such, the curriculum emerges from children's interest in seasonal events (Andrachuk et al., 2014; Kenny, 2013; Larimore, 2011a; Moore & Cosco, 2014; Sobel, 2016; Warden, 2012). Nature-based preschools are primarily distinguished from more conventional preschools based on the amount of time outdoors and the use of nature as the organizing concept of the daily curriculum.

Given the extensive time outdoors, it seems reasonable to expect the physical environment will have more affordances for engagement with natural phenomena. Teachers may be able to engage learners in phenomena-based science in more frequent and meaningful ways by placing the planning burden on nature. That is, in nature perhaps the intensive work of providing an ideal context and content for science learning is lifted because the natural world has provided it. This in turn may allow the teachers to focus on rich interactions with children around the phenomena. However, while there may be the potential, what remains unknown is if and how science interactions are occurring in nature-based preschools. This current study is a first step toward providing insights into science teaching in this unique preschool setting and approach.

Two recent studies indicate the potential of nature-based contexts as supporting science-related language in promising ways. The first examined preschool teachers' science-related language during field trips to rural and urban natural play areas. This study found teachers were twice as likely to use science-related language in the rural play area with natural ecosystems

(Kloos et al., 2018). This suggests the more natural environment *does* provide unique affordances for science teaching. The programs in the study were not, however, implementing a nature-based preschool approach, but rather visiting these natural play areas periodically. The second study exploring science in a Swedish preschool analyzed teachers' approach to conversations around natural phenomena with preschool-aged children. The preschool was more aligned with the U.S. "forest preschool" model in that teachers and children were outside the entire school day. This study described three broad ways teachers interacted with children around science. This included opening up conversations to recognize variation, building on previous experiences with phenomena, and using a playful, make-believe approach (Gustavsson & Pramling, 2014). While these studies had similar goals to the present one in terms of conversation around science in preschool, both studies indicate the need for a deeper exploration of science teaching in programs using the nature-based pedagogical approach every day.

In order to determine affordances of nature-based preschool for science learning opportunities, this observational study looked, in depth, at interactions in one nature-based preschool. The study was driven by the following research questions:

1. What science moments occur between teachers and children in a nature-based preschool?
2. How do these moments align with three-dimensional science teaching approaches?
3. How do these science moments unfold?

Methods

This observational multiple-case study (Yin, 2018) focused on determining what kinds of science interactions between teachers and children might occur within a nature-based setting. This included describing, interpreting, and explaining how those moments of interaction unfold and in

what ways they align with three-dimensional science teaching approaches. Thus, this study focused analysis on observing and analyzing a subset of the moments among three lead teachers which lasted the longest and involved extensive discourse related to science. Another goal of analysis was to describe how these interactions varied across various settings and activities. In other words, the intent was to describe the best-case scenarios in this setting related to three-dimensional science. In the end, four moments happened to be among two teachers. The science moments were analyzed using an interpretive, ethnographic approach (Emerson et al., 2011). After analysis, these moments were referred to as "episodes" due to the length of time of each.

Setting & Participants

The data for this study were obtained from a nature-based preschool in a suburban community in the upper Midwest serving more than 130 children throughout the school year in three different classrooms. The school was a high-quality program as indicated by being rated five starts, the highest rating, as part of the state's official Quality Rating Improvement System (QRIS). The preschool was located in a mix of eastern hardwood and pine forest and the surrounding property included a small year-round pond, a river, and temporary wet areas in the woods during the springtime (i.e., vernal pools). The three classrooms in this study were all half-day programs (i.e., 3 hours), ranging in session length from 2-4 days per week. Each classroom had three teachers in the classroom with a maximum of 18 children who ranged in age from three to five years old. Children were funded through tuition, private scholarships, or local and state public funding including this state's Great Start Readiness Program for at-risk 4-year-olds. The present study was part of a larger study in which children's demographic data were collected. The majority of the children in the preschool were White/Caucasian (90.2%) and the majority of mothers reported earning an undergraduate degree or higher (79.2%).

The typical schedule for these half-day classrooms was to start the day outside in a natural play area. After spending 45 minutes to 1-hour in free play, the class gathered for a brief large group meeting before exploring a wilder space (i.e., natural) beyond the fence of the play area (i.e., "beyond"). The exploration beyond the play area included a variety of activities ranging from searching for missing letters teachers have placed in the forest to visiting the pond to look for frogs. After the hike, the class returned to the preschool building where children transitioned to snack time—indoors or outdoors depending on the day. This was followed by an hour of choice time where they could choose among the activities available, a small group time for a more focused activity, and a final large group meeting. The location of these activities varied among the timepoints in the study. The indoor space looked similar to conventional preschool spaces with designated learning areas and materials, but also included materials reflective of the natural world (i.e., natural materials in the art area, nature-themed storybooks, nature as decoration).

The goal of the study was to capture best-case science moments, whether during teacher-led activities or free choice. Thus, assuming the lead teacher was more likely to lead teacher-led activities (e.g., whole group meetings), I focused on analyzing video data from the lead teacher in each classroom. After analyzing for these moments across all three classrooms, which is described in more detail below, the most extensive moments occurred with two teachers —Brad and Nicole (pseudonyms). Brad, a White male, had a Bachelor of Science in science and 10 years of preschool teaching experience all at this nature-based preschool. Nicole, a White female, had a Child Development Associates with 11 years of preschool teaching experience—five of those years at this nature-based preschool.

Data Collection

I collected video data of teacher practices at three time-points and for the entirety of the class session (i.e., 3 hours). The first time-point was in October, the second in late January/early February, and the final collection in late March/early April. I scheduled the recording at the teachers' convenience and avoided sessions which included special activities which varied from the typical classroom schedule.

At the October timepoint video was recorded using stationary cameras and wireless microphones. To more accurately capture the lived experiences of teachers and children in the classroom, teachers were equipped with wearable cameras for subsequent data collection (i.e., winter and spring). This approach allowed teachers to move more freely through the indoor classroom, outdoor play area, and the woods beyond the fence than with the stationary camera and microphone system.

Data Analysis

To analyze the video recordings of science teaching I developed and iteratively refined an exploratory observational coding scheme (Saldaña, 2016). This included leveraging existing tools related to K-12 three-dimensional science teaching practices (e.g., A Framework for K-12 Science Education), as well as early childhood education practices more broadly. Given the goal to highlight science teaching, I defined a science moment as a teacher-child interaction, initiated by student or teacher, which connects to three-dimensional science discourse in some way (e.g., disciplinary core ideas, science and engineering practices, crosscutting concepts, nature of science, identity). Using these provisional codes, I reviewed the fall, winter, and spring teaching episodes of each lead teacher to find examples of science moments. This deductive approach to

video analysis (Derry, 2007; Jewitt, 2012) identified 32 science moments within 18 hours of video.

Given the exploratory nature of this study around science in nature-based settings, the goal was to illustrate the best-case interactions. Some qualitative methodologists recommend limiting cross-case analysis so as not to dilute the comparisons, but also to include enough cases to identify meaningful perspectives (Miles et al., 2014; Yin, 2018). Specific numbers of cases for comparison range greatly, but 4 or 5 cases is a common recommendation (Creswell & Poth, 2018; Miles et al., 2014). Thus, to allow for more thorough analysis, I identified four of the 32 possible moments. The four selected were the longest lasting moments (i.e., multiple turns in conversation) with the greatest presence of provisional coding about science (i.e., related to three-dimensional science discourse in some way). Again, with the intent that these four would provide insights into best-case scenarios. The iterative, interpretive data analysis process (Emerson et al., 2011) led to the realization these moments were complex—involving multiple turns and three out of the four lasting more than 15 minutes. Thus, "episodes" seemed a more appropriate term than "moments."

Given that nature-based preschool programs offer different physical settings than more conventional programs, it was essential to identify where the episodes occurred in terms of physical setting (i.e., inside, outside, or beyond). Doing so was consistent with previous work by early childhood education scholars who identified differences in teacher-child interactions among setting and activity (Cabell et al., 2013; Chien et al., 2010; Turnbull et al., 2009; Wasik & Jacobi-Vessels, 2017).

The four episodes were then micro-analyzed using a holistic coding approach to look beyond the initial provisional codes (Miles et al., 2014). This allowed for analysis to capture not

only the words teachers were speaking related to science, but also non-verbal elements of interactions such as crouching, whistling, or handling objects themselves. After I analyzed each case, I took a more macro view to draw cross-case conclusions (Creswell & Poth, 2018; Yin, 2018) about how three-dimensional science was being used by teachers in and across the four best-case-scenarios in this particular nature-based preschool.

The Four Science Episodes

Here I will briefly describe each episode to provide overall context, and then further explore in Findings the contextual factors as relevant to this study.

Episode 1: Animal Coats

The first episode, led by Brad and 22 minutes long, primarily focused on how animals adapt for winter. The episode began in a pine forest where Brad stood in front of the entire class of children that were sitting on wooden benches in a semi-circle outside the fenced play area in the "beyond." Brad opened the lesson by saying "Winter's coming. It's gettin' cold." and then asking, "What happens in the winter?" Brad continued asking the children about what they wear in winter (e.g., **"Do wild animals wear coats?")** and then asked the children if wild animals wear clothes and how they keep warm. After this brief conversation, Brad proceeded to wrap himself in a wolf pelt, smile, rub his face on the fur and suggest to the group, "Ohhhh…here if you're brave enough, you can even feel it on your cheek." He then walked several furs around the group encouraging them to look and touch at the pelts—calling attention to changes in fur thickness, texture, and so forth. After formally presenting the furs to each child, Brad encouraged the children to come up to the wooden table and explore on their own.

After several minutes of exploring the furs, the episode shifted to pretending to be animals getting warm and finding shelter when Brad said, "Imagine you were an animal, a wild

animal…an animal that lives in the woods." He then wrapped the wolf pelt around himself and walked towards the woods and directed the children with, "Come with me. Bring some fur. You're gonna need it. Winter's coming." For their play the class used "shelters" that had been previously built out of long, sturdy sticks leaned against a tree. They proceeded to drape the furs over the shelter or wrap themselves in the furs. After a few minutes of this play the group then shifted into a game of predator/prey relationships.

This shift to the predator/prey game happened after four children had started running around in the woods. As though inspired by their play, Brad, with the fur of a red fox casually tossed over his right shoulder, called out "I'm gonna get them. Here comes the fox!" Brad yips like a fox as he runs toward the four children. Preston announces he is a tiger, to which Brad responds, "Oh no, you're a predator. Oh no, run…gotta get to my shelter! The predators are coming!" This game lasted approximately seven minutes before Brad called out to the entire class and directed them back to where the fur lesson began with, "Animals! Back to the benches!"

Episode 2: Bird

This 17-minute episode, led by teacher Nicole, centered around an ongoing investigation of a dead woodpecker. During the previous class meeting, five days prior, the children found a dead yellow-bellied sapsucker—a specific species of woodpecker. They drew pictures of the dead bird and then decided to put it in the woods in front of a motion-censored trail camera to see if anything would eat it. On the day of this science episode Nicole took a group of six children to walk into the nearby pine forest to visit a spot where they had placed the dead bird in front of a motion-censor camera (i.e., "trail camera"). The goal was to walk to retrieve the data card, and then view the images back at the preschool building (e.g., "We're checking on the bird.

Remember?") As they walked on the mostly sunny early-April day toward the camera one child called out, "Found the camera!" Nicole acknowledged the child's statement and yet was also concerned about the group's proximity to the river (about 50 feet away). She said, "Remember guys this is the river. We need to keep our bodies safe." While bringing the group back to the task at hand a child called out, "Nicole!" as Nicole simultaneously made the same observation, "Where's the bird? Where did it go?...Hmm, wait a minute! Look it! I see a sign!"

Nicole then gathered the children around the bird remains, presented a large notebook on the ground to document their investigation, and asked, **"What happened to our bird?"** While writing in the notebook about what happened to their dead bird one of the children pointed toward the river and said, "Somethings floating in there." After asking the group what was floating, and one child announced it was the island, Nicole clarified, "The island is floating? Oh, the island is back isn't it?" Nicole then prompted the group to return to documenting their observations (i.e., "Chloe, Gabe, bring that feather over here. Let's make sure that feather's from our bird.").

After the group had returned to discussing the bird, one of the children interrupted the group, holding out her hand with something inside. Nicole asks the girl what she found to which Chloe answers, "A bug snail." After some brief exchanges about the bug snail and a bit more about the bird investigation the group slowly made their way back to the building. As they walked, the group had a variety of conversations including one about a squirrel in the area. Nicole posed to the group, "I wonder if the squirrel ate our bird. What do you think?"

Episode 3: Love

The third episode in this study was brief, lasting just under three minutes, and occurred while Nicole and a group of five children were making their way back to the indoor classroom after

time in the "beyond" looking for animal tracks. It was a late February winter day and Nicole was casually following and conversing with one child while periodically stopping to check on the other children following behind. Cloaked in their winter clothing and boots for comfort the children were in no rush as they moved across the snowy ground. Despite the cold temperatures, the sun was pouring through the open red pine forest and glistening off the recent dusting of snow. As she walked Nicole casually said, "Man, I hear those birds. Singing in the sunshine." Moments later she added, "Wow!" as the sounds of the birds continued ringing through the forest.

As though understanding Nicole's moment of reverence about the bird singing, a child stopped, craned his neck to look up at the sky, and matter-of-factly said, "It's nature." Nicole immediately affirmed and added, "It is nature. **I love nature!**" The child turned back toward the building and as he started walking quietly said, "I love nature too." In response to the conversation about a love for nature, and perhaps a commentary on the long Michigan winter, one of the children about 20 feet away, casually added, "I love it when it's summer." This comment led to a discussion about what favorite activities in different seasons (e.g., "Oh, fun. I love fishing. Have you ever gone ice fishing?").

After the discussion about seasons Nicole returned her focus back to the singing bird, mimicking the bird's call by whistling herself. She had a brief exchange with one child about the bird singing (e.g., "What do you hear in the sky?," "I wonder what that bird is saying?") as they reached the school door and the episode came to an end.

Episode 4: Squirrel

This 20-minute episode, "Let's go get the squirrel!," taught by Brad was a series of moments around multiple phenomena, but all connected by the idea of finding a squirrel. The

episode began while Brad and three children were huddled around a maple sap bucket in the outdoor play area during morning arrival time. It was an overcast, damp early March day with no snow on the ground. One of the children suddenly noticed a squirrel outside the fence and called out "Let's go get the squirrel!" Following the children's interest Brad observed and then proposed, "Oh I see him. Should we go get closer?" When the group affirmed Brad said, **"Let's go get the squirrel!"** The result was Brad and the group casually wandering around the small pond right outside the play area, which was mostly covered in ice with a bit of open water at the shoreline, surrounded by a pine forest.

While beginning their search for the squirrel one of the children noticed a crow and said, "No, we're hunting for the crows." Brad embracing this shift, asked "Where is that crow?" and then began mimicking the crow with "Caw, caw, caw." This triggered two of the boys to call as well—each with their own cadence of what they heard rather than the stereotypical "caw, caw" call. After a few exchanges about the crow the group returned to search for the squirrel and a child bent down to pick a tree bud up off the ground and asked, "What is that?" Brad and the children had several exchanges about the bud (e.g., "Where are they coming from?" "Did you see this? Look at this part. Do you know what that is?") before once again returning to search for the squirrel.

The next stop on their slow meander around the pond was when a child suddenly stopped, pointed, and then gently rubbed his gloved hand over a mossy log which prompted Brad to also crouch down, touch the moss and inquire, "What is that?" As with the bud moment there were multiple exchanges about the moss (e.g., "see the green? And then look at these coming out of the moss.") before once again returning to search for the squirrel.

As they continued, they discussed a nearby vernal pool (i.e., temporary spring wetland), a pile of animal scat, and a piece of birch bark they found on the ground. Towards the end of the episode they briefly discussed a tree that had fallen down, returned to talking about bird calls, and as they rounded the final bend of the pond a child who noticed ice on the ground simply announced, "Ice!"

Findings

The analysis of the four-lasting science episodes reveals clear connections to science learning. Analysis of the teacher-child interactions, including both verbal and non-verbal components, revealed the physical setting, particularly areas beyond the fence, seemed to afford more opportunities for longer-lasting science teaching and learning. Further, in these interactions the teachers implemented a Framework-aligned "figuring out" approach to science. Analysis of the contextual elements surrounding the interactions revealed these moments occurred outside formal science lessons in small groups. Below, I provide evidence from the cases to address the research questions.

Research Question #1: What Teacher-Child Interactions Occur Around Three-Dimensional Science in a Nature-Based Preschool?

The four episodes included the presence of multiple natural phenomena with a range of engagement with those phenomena, interactions around three-dimensional science (i.e., content, science practices, crosscutting concepts), and extensive use of science-related language in context.

Presence of Naturally Occurring Phenomena that Children Themselves Noticed

One of the primary findings around the science interactions in a nature-based preschool was the high frequency of interactions with natural phenomena. That is, any natural occurrence

that could be observed in the physical environment and/or specific conversation around a natural phenomenon not observable at the moment. The conversation did not, however, require a clear verbal connection to the science practices or crosscutting concepts. All four episodes included exposure to multiple phenomena (Table 3.1). How these phenomena were brought forward in interactions varied greatly—from core to a focused discussion to conversation connector to being acknowledged in a cursory way.

In-depth exploration of phenomena was rare in the episodes. In fact, the only episode that explored the same phenomenon throughout was *Animal Coats* with ongoing conversation and play regarding animal adaptations for different seasons. In this episode, Brad opened the lesson by saying, "Yeah, are you feeling it too? There's a chill in the air. Do you feel that chill? Yeah, it's getting a little colder out and I see a lot of you are adapting. What are you wearing?" This opening statement directed the children's attention to the phenomenon of how animals adapt for winter, which Brad then explored in a teacher-led activity of touching different animal furs. Brad continued to emphasize the phenomenon of seasons as the group shifted to pretending to be animals using shelters when he said, "So winter's coming. It's gettin' cold. And what happens in the winter?...This happened the other day…it snowed. Oh, we got to stay warm for the snow." This play soon shifted to a predator/prey relationship game and the seasons phenomenon was abandoned.

More common than in-depth exploration of the same phenomenon was the use of phenomena as a connector or a touchpoint throughout the episode. These connectors spontaneously emerged in the moment. That is, the teacher did not pre-plan engagement with the phenomenon. This was particularly evident in *Squirrel* and *Bird* episodes. The 20-minute *Squirrel* episode, for example, was a series of moments related to 10 different phenomena (Table

3.1), and yet the movement of the group through the forest and the conversations that ensued were all connected by the idea of finding a squirrel. The episode started by a child seeing a squirrel and then calling out “Let’s go get the squirrel!” and then throughout the episode both Brad (e.g., “Alright, did we lose the squirrel?”, “Wait...ope, I thought I heard the squirrel”) and the children (e.g., “Let's go look for that squirrel,” “Are we going to look for the squirrel?”) came back to finding the squirrel. At one point a child even referenced the squirrel when exploring the phenomenon of moss. When Brad bent down to touch moss on a log one child said, “I think the squirrel made this” and another countered with “That’s not the squirrel” before the conversation went to the texture of the moss and the log. The *Bird* episode had a similar connector of the dead bird. In this episode, however, it was primarily Nicole who returned to the phenomenon with comments like, “Right now we're checking on the bird. Remember?” and “Where's the bird?” as they walk to where they’d placed the dead bird in front of the motion-sensor camera.

The most common presence of phenomena in these episodes was cursory engagement. That is, in all four episodes, and on multiple occasions, the teacher and children acknowledged the phenomenon in some way but did not spend a great deal of time exploring or discussing it. In *Animal Coats*, for example, a child noticed during pretend play that a leaf was falling from the sky. Brad repeated the observation clarifying, “A leaf was falling down?” The group then shifted into a game of predator/prey relationships and neither the child nor Brad seemed to acknowledge the leaf falling any further. Similarly, in *Bird* one child pointed to the island in the river and said, “Something’s floating in there.” Later in that same episode one child noticed “a bug snail” which Nicole acknowledged with, “A bug snail. Wow! Where'd you find that at?” The child then pointed out she’d also found a nut, and that was the end of the conversation on both of those

phenomena. The *Love* episode was quite short, but also included a more cursory discussion of phenomena when Nicole brought the group's attention to the phenomenon of birds singing with, "Man, I hear those birds. Singing in the sunshine."

The episode most packed with brief, somewhat cursory acknowledgement of phenomena was *Squirrel.* As they ventured around the pond, they experienced birds calling at the beginning of the episode (e.g., "Where is that crow? Caw, caw, caw") and again at the end of the episode as Brad whistled like a bird. There was also mention of the phenomenon of liquid when a child stepped into the melting edge of the pond and Brad said, "You gotta have rubber boots to go in liquid." Shortly after, the group experienced tree buds when one of the children picked up a bud that had fallen onto the ground. Then they discussed moss on a log (e.g., "This is called moss. It's a type of plant."), a vernal pool (e.g., "Oh! There's a lot of water. That's a big vernal pool."), birch bark on the ground (e.g., "Yeah, I found some but it's peeling off of this tree."), and animal scat (e.g., "Look at all that scat."). Towards the end of the episode, the small group briefly discussed a tree that had fallen down, returned to talking about bird calls, and as they rounded the final bend around the pond a child noticed ice on the ground and simply announced, "Ice!" In summary, while this episode was full of a variety of phenomena, in most cases very little time or conversation was spent exploring them. Instead, there was acknowledgement, a brief observation, and then the group moved on.

In addition to the depth of engagement with phenomena it is important to note two other commonalities among these four episodes. First, engagement with phenomena almost always spontaneously emerged out of a child or teacher's observation in the moment. The only exception were the teacher-led phenomena in *Animal Coats* and *Bird* where the teachers had a clear plan to discuss animals preparing for winter and the dead bird investigation respectively.

Yet the other 17 instances of phenomenon described in Table 3.1 all emerged as a result of children and teachers noticing and commenting on the world around them. In fact, a second commonality around engagement with phenomena was where the teachers and children were engaging with phenomena.

In all four episodes, including those with a more teacher-led component, the exposure to multiple phenomena occurred in the space beyond the fenced play area provided. This space, with little to no management by humans, generally provided tangible phenomena the children could experience through their senses. *Squirrel*, for example, included 10 phenomena which the teacher and children experienced through sight (e.g., squirrel), sound (e.g., birds calling), and touch (e.g., mossy log). Though the other three episodes also included sensory-based experiences with phenomena (e.g., hearing birds, seeing an island, watching a leaf fall), there were interactions around phenomena that did not include a tangible component. Instead, the setting provided relevant context for conversation. The conversation around seasons, for example, occurred when children were feeling the cool air on their cheeks and the crunch of snow under their feet. While it's hard to tangibly experience multiple seasons at a given time, they were physically feeling winter in contrast to their discussion about summer. The phenomenon least rooted in the physical environment was in the first episode, *Animal Coats,* where Brad provided the furs to serve as the phenomenon. These furs supported conversation about how animals prepare for winter and then served as a prop for the predator/prey game. While not directly related to phenomena, the physical environment did influence their play. For example, one boy, pointing to a fort structure, said frankly, "Squirrel house." Brad acknowledged the idea and returned back to play with, "This is the squirrel house? Has anyone seen the fox house?"

Table 3.1

Presence of Phenomena in the Four Episodes

Episode 1: Animal coats	Episode 2: Bird	Episode 3: Love	Episode 4: Squirrel
Seasons *"Winter's coming. It's gettin' cold. And what happens in the winter?"* **Animal adaptation for winter** *"Do wild animals wear coats?"* **Leaf falling** *"A leaf was falling down?"* **Predator/prey relationships** *"Oh, no, you're a predator."*	**Dead bird** *"What happened to our bird?"* **Island in the river** *"The island is floating? Oh, the island is back isn't it!"* **Bug snail** *"A bug snail. Wow!"*	**Birds and how they communicate** *"Man, I hear those birds. Singing in the sunshine."* **Seasons** *"You love it when it's summer."*	**Squirrel** *"Let's go get the squirrel. Alright."* **Birds calling** *"Where is that crow? Caw, caw, caw"* *"What sounds?"* *(whistles like bird)* **Liquid in pond** *"You gotta have rubber boots to go in liquid."* **Tree bud** *"That holds the buds."* **Moss on the log** *"This is called moss. It's a type of plant."* **Vernal pool** *"Oh! There's a lot of water. That's a big vernal pool."* **Birch bark on the ground** *"Yeah, I found some but it's peeling off of this tree."* **Scat** *"Look at all that scat."* **Fallen tree** *Child says, "Hey, this tree fell down."* **Ice on the ground** *Child says, "Ice!"*

Presence of Three-Dimensional Science

Disciplinary Core Ideas. While each episode included multiple phenomena, there were only four different disciplinary core ideas (DCIs) among all episodes (Table 3.2). Yet, despite the limited number of DCIs there was a range of full-sensory engagement around these core ideas with differing depth of exploration within DCIs.

The DCIs of Physical Science and Earth Systems were present in the four episodes, yet most of the emphasis was on Life Science. There was one Physical Science DCI (i.e., matter and its interactions) mentioned in the episodes and it was a brief utterance by Brad—"You gotta have

rubber boots to go in liquid." There was also only one Earth System's DCI among the episodes, but with two different foci. The first focus was weather variations (e.g., "This happened the other day…it snowed"). The second was about water in rivers when the group viewed the island in the river which had reappeared after the flood waters receded during the *Bird* episode (i.e., "The island is floating? Oh, the island is back isn't it!"). This included Life Science 1 (i.e., From Molecules to Organisms: Structure and Processes) and Life Science 2 (i.e., Ecosystems: Interactions, Energy & Dynamics). The Framework describes the From Molecules to Organisms DCI as including understanding that "…all organisms can be characterized by common aspects of their structure and functioning" (National Research Council, 2012, p.143). All four episodes in this study included discussion of structures and/or functions of structures (e.g., "Let's make sure that feather's from our bird" and "That holds the buds"). In contrast, the second Life Science DCI which focuses on ecosystems, was included in all episodes with the exception of *Love*. In other words, while the number of DCIs was limited, even within Life Sciences, there was a range of examples within those DCIs (Table 3.2).

Similar to phenomena in the episodes, there was a wide range of depth of engagement with these core ideas. For example, in *Animal Coats* the group touched and discussed animal furs explicitly for seven minutes as a whole group highlighting animal structures and functions. Most, however, were more cursory. Focusing on the LS1: From Molecules to Organisms: Structures & Processes as an example, the other episodes included language related to the DCI, but it was not explicitly addressed with the children as to how or why that was related to structure and function. In *Bird* Nicole said, "Let's make sure that feather's from our bird" and in *Love* she said, "I wonder what that bird is saying." She didn't, however, make any comments about reasons she

thought birds may have feathers (e.g., to help them fly, to keep them warm) or about the role of a bird's call (e.g., to communicate with birds of the same species).

While the number of DCIs covered was limited and there was no explicit mention of connection to these DCIs, there was full sensory engagement around these core ideas. Unlike typical classroom experiences, the DCIs involved in these episodes involved children directly experiencing the phenomena foundational to each DCI. For example, children heard, and even mimicked with their own voices, a wide range of bird calls. They experienced decomposition first-hand by touching a rotting log and having it crumble under their hands. Thus, while the number of DCIs addressed was limited in these episodes the experiences children were having with them were richer and more tangible than they likely would have experienced in a more conventional classroom setting.

Table 3.2

Disciplinary Core Ideas Present in the Four Episodes

	Episode 1: Animal coats	Episode 2: Bird	Episode 3: Love	Episode 4: Squirrel
LS1: From Molecules to Organisms: Structures & Processes "…all organisms can be characterized by common aspects of their structure and functioning." (Framework, p. 143)	Animal furs	*"Let's make sure that feathers from our bird."*	*"I wonder what that bird is saying."*	Squirrel noticing *"The crows. Ok."* *"Chickadees Gabe says."* *"That holds the buds."* *"See the green."* *"How's it feel?"* Characteristics of bark Animal scat
LS2: Ecosystems: Interactions, Energy & Dynamics "Ecosystems are complex, interactive systems that include both biological communities (biotic) and physical components (abiotic) of the environment." (Framework, p. 150)	*"The predators are coming."* *"Wait, what if I go in the shelter. Will that keep me safe?"*	*"You think something ate it."*	---	Vernal pools *"The log is starting to break apart. It's starting to turn into dirt. It's decomposing."* Fallen tree
ESS2: Earth's Systems "Weather is the combination of sunlight, wind, snow or rain, and temperature in a particular region at a particular time" (Framework, p. 188) "Water is found in the ocean, rivers, lakes, and ponds" (Framework, p. 184)	*"What's if it's so cold…what happens, what would happen in the rain if it was so cold?"* *"This happened the other day…it snowed."*	Island in the river	*"…you do ice fishing in the wintertime, so it's kinda chilly."*	---
PS1: Matter & Its Interactions "Different kinds of matter exist, and many of them can be either solid or liquid…" (Framework, p. 108)	---	---	---	*"You gotta have rubber boots to go in liquid."*

Science and Engineering Practices. Five out of the eight science and engineering practices (SEPs) were used in the four episodes (Appendix B). The most frequent was "analyzing and interpreting data" which was present at least once in all four episodes. This SEP at the kindergarten level suggests students "Record information (observations, thoughts, ideas)" (National Research Council, 2012, p.57). In *Animal Coats*, for example, Brad tried to elicit children's ideas by asking, "Is there anything different about this one?" Similarly, Nicole noted her own observation during Love when she said, "Man, I hear those birds. Singing in the sunshine." Three of the SEPs observed in this study were present in two of the four episodes (i.e., Asking questions, planning and conducting an investigation, and constructing explanations and designing solutions). For example, planning and conducting an investigation occurred in both *Squirrel* (e.g., "See the green. And then look at these coming out of the moss.") and *Bird* (e.g., "Where's the trail cam?"). One SEP, developing and using models, was present in one episode when Nicole asked the children to "…write down or draw a picture of what happened" to the dead bird they were investigating.

While there were many SEPs used in these episodes, the teachers did not use explicit language to inform the children they were engaged with a particular science practice. In other words, the teachers focused on engaging in the practice rather than attempting a metacognitive description of what they were doing. During the *Bird* episode, for example, the teacher encouraged the children to write down or draw their ideas of what happened but did not use explicit SEP language such as "Let's make a causal model to explain what happened." Similarly, in analyzing and interpreting data the teachers verbalized their observations, thoughts, or ideas without using practice-specific terms such as "let's gather data." The closest to explicit language was phrases like, "I hear…" or "I see…" For example, in *Love* the teacher said ""Man, I hear

those birds. Singing in the sunshine." and in *Bird* the teachers said "Hmm, wait a minute! Look it! I see a sign!"

Crosscutting Concepts. The wide variety of experiences with phenomena because of the physical environment meant more exposure to a wide range of crosscutting concepts (CCCs), though they were not necessarily explicitly discussed as being CCCs. Thus, teachers and children may not have realized they were engaging with crosscutting concepts.

The Framework (National Research Council, 2012) describes seven crosscutting concepts (CCCs) for K-12 grades. Five of those were present in this preschool study (Table 3.3). Patterns was the most frequent CCC appearing in all four episodes. For example, both Episodes 3 and 4 involved repeated bird calling or conversation about the bird calls. In these cases, they were building patterns as they had experiences with phenomena over time, locations, and bird species. Structure and function was the second most frequent CCC present in two of the four episodes (i.e., *Animal coats* and *Squirrel*). For example, in the *Squirrel* episode Brad discussed the bud as a part of the tree and how those parts work together which provided a foundational experience for understanding the shape of structures of natural objects related to their functions. In *Animal Coats* he talked about the structure and function of animal furs with phrases like "…what's attached to the skin?" and "Do you want to see an animal's summer coat?" The other three CCCs in the study (i.e., cause and effect, systems and system models, and stability and change) were each present in one of the four episodes (Table 3.3)

Though five CCCs were present in this study, none were addressed explicitly by the teachers. Each episode, for example, connected to patterns with statements such as "Wait there's a different sound," but the teacher did not follow up with an explicit statement such as "We're noticing a pattern." Similarly, at no point did Brad say anything about the buds being part of a

system called a tree. Despite this lack of explicit discussion of CCCs, these episodes showed children returning to these big science ideas over and over again and in different contexts—particularly different phenomena.

Table 3.3

Crosscutting Concepts Present in the Four Episodes

"In grades K-2…"	**Episode 1: Animal coats**	**Episode 2: Bird**	**Episode 3: Love**	**Episode 4: Squirrel**
Patterns "…children recognize that patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence." (NGSS, Appendix G, p. 82)	*"But this is brown too"* Temperatures in various seasons	Seasonal shifts in river level	Repeated bird calls	*"Wait, there's a different sound"* *"Caw, caw, caw"* *"Chick-a-dee-dee-dee"* *"That's a big animal too."*
Cause & Effect "…students learn that events have causes that generate observable patterns. They design simple tests to gather evidence to support or refute their own ideas about causes." (NGSS, Appendix G, p. 83)	---	What caused the bird to disappear?	---	---
Systems & System Models "…students understand that objects and organisms can be described in terms of their parts and that systems in the natural and designed world have parts that work together." (NGSS, Appendix G, p. 85)	---	---	---	*"That holds the buds. This one is opening…the little…see these little?"* Feeling the soft, green features Tree bark
Structure & Function "…students observe that the shape and stability of structures of natural and designed objects are related to their function(s)." (NGSS, Appendix G, p.87)	*"…what's attached to the skin?"* *"Do you want to see an animal's summer coat?"*	---	---	*"That holds the buds."*
Stability & Change "…students observe some things stay the same while other things change, and things may change slowly or rapidly." (NGSS, Appendix G, p.88)	---	*"Oh, the island is back isn't it!"*	---	---

Embedded Science Language and Discourse. The presence of three-dimensional science in the four episodes suggests some inherent level of science discourse. Yet, as mentioned, the SEPs and CCCs were not explicitly discussed by the teachers. There were, however, many science-related words, particularly nouns, spoken by teachers in the four episodes—most of which were used in context and not explicitly defined. The complete list of science-related words is provided in Appendix C and here I highlight the findings.

When science words were used, they were in connection to phenomenon the teachers and children were experiencing and labeled components of the phenomenon rather than defining terms or concepts. For example, in *Squirrel* when Brad told a child "You gotta have rubber boots to go in liquid," he did not define liquid. Instead, this science term was embedded in language connected to the context of standing in the pond. Similarly, when talking about the buds Brad simply said, "That holds the buds" but did not define the term "bud." Brad also observed the springtime pool of water in the woods by pointing and simply labeling the feature with, "That's a big vernal pool."Nicole used the same approach to labeling. In *Bird*, for example, she mentioned birds, feathers, woodpecker, and yellow-bellied sapsucker without defining the terms but rather used them in context (e.g., "We found the feathers. See all those feathers."). Also, during *Bird* Nicole repeated a child's idea saying, "The island is floating? Oh, the island is back isn't it!" yet she did not correct the term "floating," explain the concept of floating, or even explain what constitutes an island.

While most of the science language did not explicitly define terms or concepts, in *Squirrel* Brad did define the process of decomposition. He first described what was happening (i.e., the concept) and then followed that with the vocabulary term—"The log is starting to break apart. It's starting to turn into dirt. It's decomposing."

Research Question #2: How Did These Interactions Unfold?

In addition to understanding how nature-based settings and instruction supports three-dimensional engagement with rich phenomena, this study explored how the interactions came to be and played out. Analysis indicated significant contextual aspects of how these episodes unfolded—learning occurred outside of formal, teacher-led science lessons, with a small group of children beyond the fence, and the teachers supported a "figuring out" approach to science rather than "learning about."

Learning Outside Formal Science Lessons

All but one of the four science episodes in this study occurred outside of formal teacher-led activities (i.e., science lessons). The *Bird* and *Squirrel* episodes both occurred during outdoor time where children had a choice as to how they would play (i.e., free choice). The *Love* episode was not only outside of a teacher-led activity, it occurred during a transition between activities. While *Animal Coats* began as part of a formal science lesson with Brad discussing the purpose of animal furs, the episode included play that was child-led and outside of the didactic "lesson" being outside of the formal lessons had three important contextual factors in these episodes. First, the episodes outside of formal lessons involved small groups of children with one teacher. Yes, the *Animal Coats* episode began as a whole group, but it then shifted to a small group playing among the forts and the predatory-prey game. The other three episodes all involved fewer than six children. Second, the exploration and conversation in the four episodes was primarily child-driven. Third, all occurred beyond the fenced outdoor play area.

While all four episodes were primarily child-led, two of the episodes did have a teacher-led component but were still primarily child-driven. In *Animal Coats* Brad, for example, began with a brief teacher-led discussion about furs and then the children led a shift to the predator/prey

game. While *Bird* occurred at a leisurely pace and children had a choice whether or not to join, Nicole continually returned to her goal of documenting what they found by the trail camera. She allowed children to share personal, off-topic ideas, but rather than building on those stories she instead brought the group's attention back to the dead bird. For example, after a couple minutes of stories unrelated to the bird, Nicole redirected their attention with "…bring that feather over here. Let's make sure that feather's from our bird." Though the children were engaged and following her lead, at no point did the children provide language suggesting they would like to see the feathers by the camera. Thus, while there was some child-led language, the episode was very much teacher-led.

However, these two examples of teacher-led conversation were outside the norm for these episodes. Most of the episodes included child-driven exploration with a slower pace more aligned with the children's interests as was seen in the casual exploration and conversations during *Squirrel* and *Love*. Children also made many suggestions about what to do next. This was particularly true during *Squirrel* where when new discoveries ran their course, one member of the group would refocus the group on "getting the squirrel" and they would all move on. This refocus was not Brad's responsibility. In fact, in most cases it was the children who re-directed the group with phrases like "Let's go find the big scaredy squirrel." In other words, Brad allowed the children's interests to guide where and how long they spent their time, and even the content of the conversation. He does this initially by supporting the group in leaving the play area and then throughout with phrases like, "Should we go further?," "Oh, we're gonna hunt for the squirrel," and "Let's do it!" He also supports shifts in focus from one phenomenon to another without asking children to stay focused on one phenomenon to receive additional information from him. In the tree bud exchange, for example, Brad first tried to extend the conversation by

pointing out the catkin on a nearby tree. While all of the children looked, none indicated a desire to explore this idea further. Brad followed their lead and abandoned the tree bud phenomenon line of discussion. This allowed for the next moment when a child explored the mossy log.

Teachers Supported "Figuring Out" Science Versus "Learning About"

The four episodes in this study demonstrate a range of science instruction from explicit, direct instruction to a more child-led "figuring out" approach with most of the emphasis on the latter. This "figuring out" emphasis is evidenced is three key ways—modeling or facilitating rather than direct instruction, emphasizing process over outcome, and valuing children's ideas.

The first element of "figuring out" science evidenced in these episodes was teachers' emphasis on modeling or facilitating science rather than providing direct instruction. That is, teachers were more focused on eliciting children's ideas or sharing their own curiosity than on providing information. In terms of facilitation, during *Animal Coats* Brad used some direct instruction language such as "This is a winter coat" and "This is the winter coat so, Logan, they grow thicker hair in the winter when it gets cold. So, they grow their coat." Yet, even with this direct instruction, Brad facilitated student thinking with focused questions such as "Is there anything different about this one?" and "Can you grow your coat?" The *Bird* episode was also a generally teacher-led activity and yet included teacher language facilitating children's thinking such as "What happened? Is it completely gone?" The other two episodes, with little to no direct instruction, also included extensive facilitating of children's ideas. In *Squirrel*, for example, to encourage an explanation about the tree buds Brad asked, "Where are they coming from?" In relation to the downed tree, Brad prompted the children for an explanation with, "Why do you think this tree fell down?"

In addition to facilitating children's ideas, the teachers in these four episodes modeled their own curiosity and thinking around science. This was particularly true, both verbally and non-verbally, in the episodes with less direct instruction of science ideas. This modeling not only demonstrates science in action, but also allows conversation space for science sense-making. For example, in *Bird* about the dead bird while walking back to the building Nicole said, "I can't wait to see what happened." The *Love* episode begins with Nicole making an observation herself saying, "Man, I hear those birds. Singing in the sunshine." She then made a non-verbal observation by whistling like the bird, and then followed-up by facilitating an observation, "What do you hear in the sky?" After the child responded with "It's a bird," Nicole repeated and extended the child's idea. She did not, however, ask a specific question, but rather expressed out loud her own question saying, "I wonder what that bird is saying." While there is no additional conversation about the bird's communication, this statement opens the door for future exploration and explanation around the phenomenon.

Brad used a similar modeling approach to draw out science ideas in the squirrel episode when he said, "It's hard on the inside. It's wood." and "The log is starting to break apart. It's starting to turn into dirt. It's decomposing." These statements were made without focusing the children's attention, but rather were statements Brad made aloud while looking at the log himself. He also modeled an explanation during the birch bark interaction. During this exchange Brad never actually said "birch" or "bark." He simply suggested where the "weird" white and black thing may have come from by holding up the bark piece to the standing tree. Again, on his own and without calling children over or ensuring their attention. Similar to Nicole whistling like the bird, Brad was making a non-verbal move to explain his thinking.

In addition to teacher language modeling and facilitating science, the second element of "figuring out" approach was evidenced through an emphasis on process over outcome—both in the short- and long-term. When searching for the squirrel, for example, the process of finding the squirrel was more important than actually finding the squirrel. This process, a leisurely exploration around the pond, allowed for science learning and discovery along the way. When new discoveries ran their course, one member of the group would refocus the group on "getting the squirrel" and they would all move on. This refocus was not the responsibility of Brad. In fact, in most cases it was the children that re-directed the group. For example, one child said, "Let's go find the big scaredy squirrel" and the group followed his lead. Another example of science learning being a process was the *Bird* episode where Nicole was building on science ideas over days of time—not just a few minutes. In this episode Nicole and the children revisited the trail camera they had placed in the woods five days prior. She included this measure of time when documenting their observations with, "…when we came back 5 days later... What happened? You said the bird was gone."

The third element of "figuring out" of science evidenced in these episodes was how the teachers demonstrated value for children's ideas and prior knowledge. In addition to attempting to elicit children's ideas, which demonstrates an inherent value of their thinking, the teachers often avoided correcting children's ideas when they were incorrect or implausible. In searching for the dead bird, for example, children suggested a wolf or bear had eaten the bird. Although the likelihood of wolf or bear having eaten the bird was small—given the general absence of those species in this part of the state—Nicole did not correct their statements. Late in the episode one child provided an explanation as to what happened with, "But, but squirrels can't eat birds cuz they can't fly." Nicole repeated and clarified the explanation, "Oh! You have to be able to fly to

eat him?" but did not judge it as right or wrong. Brad had a similar approach as evidenced in the *Squirrel* episode. He did not, for example, evaluate or praise the child's correct answer of "deer poop!" when identifying the pile of scat. At the same time, he allowed imaginative responses such as blood on the bud, crocodiles in the vernal pool, and the t-rex pushing over the log. Ultimately the teachers' valuing of children's ideas and resources appeared to lead to longer interactions around science.

Taken together the teachers' facilitating and modeling of science, emphasis of process over outcome, and a demonstrated value for children's ideas and prior experience and knowledge led to more "figuring out" of science rather than teachers providing didactic instruction of scientific facts (i.e., "learning about").

Discussion and Implications

This study analyzed teacher-child interactions around science and how these interactions unfolded to determine affordances of nature-based preschool for science learning opportunities. The findings suggest teaching in nature-based preschools can support rich science sense-making, using a variety of science and engineering practices and cross-cutting concepts. This is done through experiences with a variety of phenomena, particularly life science, in context and over time. Additionally, these science experiences occurred with a small group of children beyond the fenced and were mostly led by the children themselves. Further, the teachers in this particular nature-based setting were relaxed, and joyful.

Strong Potential for Rich Science in Nature-Based Settings

All four episodes in this study involved a range of in-depth and cursory interactions with phenomena, but all episodes involved exposure to multiple phenomena in the areas beyond the fence. That is, the phenomena were not simply outside of a building, but rather immersed in the

natural ecosystems with little to no human organization to the space. Science education scholars have emphasized how science learning occurs in or out of school time and that educators should facilitate and leverage both (National Research Council, 2015). The present study suggests science should not just be thought of as in or out of school time, but also whether in or out of the school *building*—particularly outside the school *playground*. By doing so, children can experience at any given time a wide range of phenomena, in a variety of disciplinary core ideas. The small groups of children exploring beyond the fence seemed to also allow for more doing of science through the use of SEPs and CCCs. The current findings not only support previous work which identified more science-related language occurring in natural playground environments (Kloos et al., 2018), but also build on that study. The current study suggests natural ecosystems outside of a playground may support even more science-related language than natural playgrounds.

These affordances of the space beyond the fence and the immersion with natural phenomena have several implications for early years science teaching. First, immersion with natural phenomena may support in-depth time science teaching. In this study the four episodes last anywhere from seven to 22 minutes. This is significant when we consider that currently time spent on science instruction in preschool is rare (Tu, 2006) and less than any other domain (Piasta et al., 2014). Additionally, the episodes of *Squirrel* and *Bird* illustrate the potential for science learning in nature-based settings to build over time through ongoing investigation. More connected learning over time may also provide greater exposure to crosscutting concepts by not only experiencing different concepts, like patterns, in multiple contexts but also connected to a variety of phenomena. In essence these daily and connected experiences build a rich foundation of experiences and knowledge to be leveraged throughout their lifetime. Prior research on

science learning is clear that connected learning is a more productive approach to teaching science than disconnected, one-off lessons (Reiser et al., 2017; Zivic et al., 2018).

So while scholars have suggested this lack of time may be due to emphasis on language and literacy instruction (Greenfield et al., 2009) or limited knowledge on the teachers' part around science content and pedagogy (Garbett, 2003; Gerde et al., 2018; Kallery & Psillos, 2001; Tu, 2006), perhaps there is another reason. Perhaps the lack of time is because of the burden on teachers to provide a science-rich environment. It is hard work to provide young children, in a play-based environment, with new and varying materials every day—let alone materials related to scientific phenomena. Add to that the notion of providing a wide range of different kinds of phenomena at any given moment and it is a lofty ask of teachers. The natural world, which is inherently ever-changing, may ease some of the burden teachers have in preparing the learning environment and make more time available for science-related interactions.

Another important finding in this study relates to children's prior experiences and knowledge. All of the phenomena children experienced were part of their lived experience. That is, conversations primarily emerged from engagement with the environment rather than a teacher-led activity that was inserted into the children's world. As a result, not only is the content more meaningful, but the science-related vocabulary has more meaning as well when used in context (Wright & Gotwals, 2017b, 2017a) and thus better supports diverse learners (Suárez et al., 2020). "Yellow-bellied sapsucker" is not, for example, a common term in most preschoolers' lexicon. Yet in the *Bird* episode, it was connected to a tangible, concrete object (i.e., the dead bird). Thus, the term now had meaning to their lives. This approach to preschool teaching, not only aligns with K-12 three-dimensional science approaches, but also with developmentally appropriate practices in early childhood education (Copple & Bredekamp, 2009). The

Framework, for example, specifically suggests students in the early grades (i.e., K-2) "focus on visible phenomena with which students are likely to have some experience in their everyday lives or in the classroom" (National Research Council, 2012, p. 303). In a nature-based setting, children are experiencing phenomena every day in their preschool classroom.

A third implication of immersion with phenomenon beyond the fence is the context of learning moments and interactions. Part of what made the child-led interactions possible in this study was the episodes occurred outside of formal science lessons and with a small group of children (i.e., <6) rather than whole class. Yes, the nature-based setting seems to afford the potential for science in formal group activities such as we saw with Brad's lesson in *Animal Coats*, but we also saw a great deal of science outside of teacher-directed lessons. In fact, the majority of the interactions occurred during what is typically called "free play" or "free choice." *Bird* and *Squirrel*, for example, were impromptu small-group explorations during free play time. Even though *Animal Coats* started as a teacher-directed, whole-group lesson, Brad allowed for free play to extend the lesson which is when the shelter and predator-prey ideas came into the conversation. The idea of science during free play is particularly important because in preschool children generally spend a third of their time in free play (Early et al., 2010). The other two thirds of the day are equally divided between teacher-led activities and routines (Early et al., 2010). And yet it was during a transition (i.e., routine) in *Love*, where the goal of the time of day was simply to get from one location to another, where Nicole took an opportunity to have a casual and yet meaningful science conversation. This particular moment shows the power of transition times which are often thought to slow down the functioning of a preschool classroom. Thus, while teacher-led science instruction is rare, perhaps the other two-thirds of the day (i.e., outside teacher-led activities and routines) are opportunities for more science engagement.

In summary, the nature-based setting affords an ongoing three-dimensional science discourse. This study seems to provide a specific example of how teachers might implement the National Science Teachers Association's position to, "provide numerous opportunities every day for young children to engage in science inquiry and learning by intentionally designing a rich, positive, and safe environment for exploration and discovery" (2014, p. 3).

Role of the Teacher—Relaxed, Joyful Teachers Modeling Enthusiasm About Discovering the World

There were several contextual factors at play throughout this study (e.g., being located in the "beyond," child-led activities, small group), all of which the teachers had a significant level of control over. Other factors over which teachers had control included their joyful attitude and own sense of wonder, valuing of children's ideas, and willingness to allow children to guide the activities and pace. All of these factors contributed to how the science episodes unfolded.

The teachers in this study were relaxed and joyful while modeling enthusiasm for discovering the world around them—particularly science phenomena. For example, teachers made positive statements like *Love* and "I can't wait to see what happened." Additionally, both teachers at times were casually whistling with the birds as they walked. Previous studies in preschool are clear— teachers' job satisfaction and overall attitude has direct impacts on their interactions with children (de Schipper et al., 2008; Hur et al., 2016; Jeon et al., 2016). Such as, when teachers are under more stress there tends to be more conflict in teacher-child interactions (Whitaker et al., 2015). Of course these joyful interactions can in turn can positively impact child learning outcomes as one study found among third graders (Proity, 2015). Specific to nature-based preschools, at least one previous study suggests that teachers have higher job satisfaction when teaching in nature-based settings (Marchant et al., 2019). Further, there is evidence that

time in nature reduces stress for both children (Faber Taylor & Kuo, 2009; Wells & Evans, 2003) and adults (Bratman et al., 2015; Ward Thompson et al., 2012). While these previous studies might suggest Brad and Nicole's relaxed pace in the science moments is a result of the setting, there may also be other factors at play (e.g., personality traits, administrative support).

The current study included evidence of teachers modeling wonder with phrases like Nicole saying, "I wonder what that bird is saying" and her reverence for natural phenomena with *Love*. The sheer number of and variation in natural phenomena may allow teachers to tap into their own sense of wonder and reverence about the world around them. A teacher's own wonder and enthusiasm about the world may allow them to more easily embrace the uncertainty inherent in the discipline of science (Manz & Suárez, 2018). The present study suggests teacher joy and personal wonder, along with inherent science affordances given the wide-range of rich natural phenomena, may lead to more science-related interactions. This is particularly important because wonder has been theorized to be important in children's development of science concepts (e.g., Hadzigeorgiou, 2013)—and especially in preschool (Lindholm, 2018). Further, teacher philosophy about science teaching has a greater impact on children's learning of science than a teacher's confidence in teaching science (Fleer, 2009).

Yet another important role of the teachers in the current study was how they valued children's thinking and explanations. On occasion the teachers in this study re-voiced and extended a child's statement for accuracy—a widely accepted technique for supporting cognitive development (Cabell et al., 2015; Massey, 2004). Yet even in these moments of re-voicing, the teachers did not judge the comment as right or wrong. Much more common than re-voicing in this study was the acceptance of any explanation about the phenomena the group was experiencing. This included imaginative responses such as a t-rex pushing over a log and more

serious responses like “squirrels can’t eat birds cuz they can’t fly.” The valuing of children’s perspectives has been noted in other science-related studies where preschool teachers supported play and fantasy (Gustavsson et al., 2016; Gustavsson & Pramling, 2014). The small groups may have made it easier for teachers to value individual children’s ideas because they were only having to listen to and respond to a handful of children rather an entire class.

Similarly, the small groups we saw in all four episodes may have allowed for another significant finding of this study which was an extension of listening to and valuing children’s ideas. Specifically, teachers in the current study allowed children’s ideas to guide the learning in the classroom. Early childhood educators refer to this developmentally appropriate practice as child-guided (Copple & Bredekamp, 2009) or child-led where the children are guiding the play and interactions that happen in the class day. Rather than a discrete science activity being provided by a teacher, children in this study decided what was interesting to them and teachers allowed that curiosity to lead the conversation. In *Squirrel*, for example, it was children that most frequently re-directed the group with phrases like “Let’s go find the big scaredy squirrel” and Brad followed. This finding reflects those of Waters and Maynard (2010) who also found natural outdoor spaces provided opportunities for teachers to build on children’s interests and respond to child-initiated ideas.

Taken together, teacher wondering, valuing of children’s ideas, and allowing children to lead, positions teachers more as co-learners than as didactic instructors of science. The teachers appeared less concerned about conveying information and more concerned with exploring, discovering, and figuring out the world alongside children. Particularly related to science language, teachers were taking a concept-first approach as research has illustrated is valuable for children’s development (Brown & Ryoo, 2008). Further, the teachers being positioned as co-

learners disrupts the power dynamic and supports more equitable learning—an idea many have argued as critical in the science classroom (Bang et al., 2017). This present study suggests the natural world may help facilitate the disruption of that power dynamic and support more of a "figuring out" approach to science teaching and learning.

Limitations and Future Directions

The episodes in this study illustrate that phenomena-rich, context-based teacher-child interactions around three-dimensional science *are* possible in preschool. Furthermore, these interactions, while remaining developmentally appropriate, *can* align with science education goals at the K-12 level as other scholars have suggested (e.g., Greenfield, 2017). Though *A K-12 Framework for Science Education* and NGSS do not provide direction for preschool, I compared the findings to these science reform documents in order to highlight the way preschool science does and can support the science teaching and learning children will experience in preschool, kindergarten, and beyond. While science is possible in preschool, there are challenges to consider moving forward—particularly in identifying what SEPs and CCCs look like in action.

In this study I took an inclusive approach when labeling if an interaction involved a science practice or crosscutting concept. Whether one sees the inclusive approach as a strength or limitation of this study, it highlights the importance of clearly articulating what preschool science looks like in action—what counts as science. Preschool early learning standards primarily emphasize "process skills" (e.g., French, 2004; Gelman & Brenneman, 2004; Greenfield et al., 2009; Jirout & Zimmerman, 2015), whereas reform documents emphasize practices which integrate skills with content knowledge (National Research Council, 2012b). Observation, for example, is a common process skill in preschool learning standards (Greenfield et al., 2009), but with which practice does that skill best align? The NGSS practice of analyzing

and interpreting data, planning and carrying out investigations, or something else? Similar challenges of identifying what is considered science arose when considering crosscutting concepts. Teachers in this study did not ever use explicit language related to CCCs yet they were talking about CCS such as structure and function. What level of awareness on the part of the teacher and/or preschool child needs to be present for us to identify science learning related to CCCs?

In short, moving forward it would be helpful for early childhood and science educators to be more intentional about describing how to identify when preschool-aged children are engaging in three-dimensional science. Continued muddiness around defining the components of three-dimensional science in preschool hinders effective research efforts as well as the support we provide teachers. One argument as to why formal science engagement is rare in preschool is teacher comfort and self-efficacy (Garbett, 2003; Gerde et al., 2018). Perhaps widening what "counts" as science in preschool will help teachers see that in many ways they already *are* supporting science and can do even more without being science experts themselves. Articulating what SEPs in look like in preschool may help teachers recognize that they may already be helping young children learn science—though it may not look like canonical notions of what it means to do science.

Engaging with children outside the school building and the boundaries of the fenced play area appeared to make it easier for teachers and children to engage in the doing of science (i.e., SEPs and CCCs) by having frequent exposure to phenomena. Both the affordances of nature and the power of child-led portions of the day (i.e., free play) and transition times for science, suggest researching science instruction only at the lesson-level may not be sufficient. Lesson-level analysis may miss the presence of impromptu science teaching in both nature-based and

non-nature settings. Researchers should be intentional about capturing science teaching and learning that is occurring throughout the preschool day—not just during formal science lessons. Previous research provides support for this notion. One study, for example, found the addition of science materials into the preschool classroom can support more science conversations during free play (Tu, 2006). Another identified "informal" and "incidental" science activities in preschool classrooms (Gomes & Fleer, 2018). In addition to observing science interactions outside of formal lessons, further exploration is also needed around the influence of the physical environment on these interactions—how wild or natural must a space be to spark rich science conversations? How can we support teachers in exploring areas beyond the fence, and then to take advantage of the inherent science affordances found there?

This study captured teachers who were relaxed, joyful, and curious in their interactions with young children. The teachers also appeared to value children's ideas without correcting or insisting children have the "right" canonical answers. What this study did not capture, however, was why teachers were behaving this way. That is, this particular study did not capture the teachers' perspectives on their own teaching. Both Brad and Nicole were experienced preschool teachers with 10 and five years respectively at the nature-based preschool. Their education, experience, or other personal factors, such as personal comfort with science ideas, likely all contributed to their joyful, child-centered approach. Given the frequent and ongoing exposure to phenomena and their many years in the nature-based setting, have these teachers come to realize not every moment needs to be "corrected" because there will be many more opportunities to build on and extend the science ideas? Insights into the influential factors might help foster a relaxed, curious, and child-led approach among preschool teachers—to leverage the potential experiences with phenomena in the natural world. Another opportunity for future work is to

study the influence of the individual children in these teacher-child interactions. This is particularly important as the field explores more equitable approaches for science teaching and learning—both in nature-based and more conventional settings.

All of this is to say, there is a remaining need to identify how to best support nature-based teachers to confidently and curiously take advantage of the rich science moments possible in the natural world. The first step is identifying how can we help more teaches in more conventional preschools to engage with the natural world and thus take advantage of the science affordances outdoors? Previous studies have highlighted teachers' discomfort with teaching science and one specifically asked teachers about using nature as means for teaching science (Kloos, Waltzer, Maltbie, Brown, & Carr, 2018). It is promising the preschool teachers in that study, while uncomfortable with classroom-based science curricular, were highly motived to learn more about teaching science in nature. By taking advantage of the science affordances in the natural world, widening our definitions of developmentally appropriate science, researching science learning outside of structured lessons, and supporting curiosity among teachers, perhaps we can increase the amount of science learning that occurs in preschool classrooms.

Conclusion

Given children's innate curiosity, the importance of science education, and the growth of nature-based preschools, it is critical to understand science teaching occurring in early childhood—particularly in relation to nature-based preschools. This study highlights the affordances of the natural world for meaningful science experiences and how those might be leveraged in both nature-based and more conventional settings. This is a starting point for advancing our knowledge about opportunities and limitations of using nature-based science teaching in a broader range of preschool settings—not just those that identify as nature-based.

The findings in this study, for example, highlight the potential importance of providing a physical environment which encourages connection with a variety of phenomena. This might mean more natural outdoor play areas or leaving the fenced play area altogether to explore more natural spaces. Additionally, the findings suggest, while the environment is important, figuring out science is also influenced by the teacher's attitude and behavior. Finally, these findings illustrate rich science teaching and learning is possible in preschool. There remains a need for clear articulation of what the three-dimensions look like at the preschool level and how we can support teachers in implementing effective developmentally appropriate science teaching. After all, preschoolers are not only capable of learning science, but deserve opportunities to make sense of their world.

CHAPTER 4: SYNTHESIS

The purpose of this dissertation was to compare nature-based preschools with non-nature approaches in early childhood education, particularly around teacher-child interactions. This included analyzing video of preschool teaching to broadly describe teaching practices among the two schools. It also included a deeper exploration of science interactions at the Nature-based preschool. This work was driven by a need to better understand how the growing of movement of nature-based education, particularly nature-based preschools, compares to more conventional approaches.

The rapid growth in nature-based preschools in the United States (Bailie, 2012; Natural Start Alliance, 2020; North American Association for Environmental Education, 2017) suggests these programs are appealing to educators and families. Yet, little is understood about the ways the nature-based approach impacts children in comparison to more conventional approaches. Additionally, there have been state-level policy mandates for the outdoors to be utilized as learning environment, that is, an extension of the classroom (e.g., Michigan State Board of Education, 2013; State of Texas, 2014). One teacher practice which influences a broad range of learning outcomes is teacher-child interactions—both verbal and non-verbal interactions. Previous research has shown the number and quality of teacher-child interactions are greatly influenced by context (Cabell, DeCoster, LoCasale-Crouch, Hamre, & Pianta, 2013; Chien et al., 2010; Turnbull, Anthony, Justice, & Bowles, 2009; Wasik & Jacobi-Vessels, 2017). One contextual factor that distinguishes nature-based approaches from others is the extensive time in and connection with the outdoors.

This dissertation examined how teacher-child interactions compare at a nature-based and non-nature preschool, paying particular attention to the role outdoor spaces plays in those interactions. This work was guided by the following research questions:

1. What is the general nature of teacher-child interactions in two preschools—one nature-based, one non-nature?
    a. How does the frequency, diversity, and quality of the language in interactions compare?
    b. How might contextual factors (e.g., physical setting) play a role in these interactions?
    c. How do these interactions unfold and conclude?
2. How might one characterize extended interactions within a nature-based preschool setting?
    a. Are science-related interactions occurring? If so, what is the nature of these science-related interactions and how do the interactions align with current approaches to science education?
    b. How might the outdoor setting play a role in these interactions?

To begin answering these questions, the first study comparing the two preschools directly and the second focused more deeply on interactions at the Nature-based preschool (Table 4.1). In this chapter, I summarize the findings of the two research papers and discuss the common themes across both studies. I also address the importance of these findings and themes, in relation to both theory and practice, and identify possible directions for future research.

Table 4.1
Summary of Two Papers Within the Dissertation

Chapter and Study Title	Overarching Research Question(s) Addressed	Study Research Questions	Method
Chapter 2: Moving Beyond Recess—Examining the Use of the Outdoors as an Extension of the Classroom at a Nature-based and Non-nature Preschool	RQ1	1. What similarities and differences might exist in teacher-child interactions between the nature-based and non-nature preschool (both inside and outside the classroom)? 2. How might teacher language and behavior leading up to, during, and after outdoor experiences generate possible insights for any variation in teacher-child interactions between school type and settings?	Sequential explanatory mixed-methods analysis of how a nature-based and non-nature preschool enacted vision of the outdoors as an extension of the classroom
Chapter 3: "I love nature!"—Teachers' Interactions with Children about Three-Dimensional Science in a Nature-based Preschool	RQ2	1. What science moments occur between teachers and children in a nature-based preschool? 2. How do these moments align with three-dimensional science teaching approaches? 3. How do these science moments unfold?	Observational study to determine affordances of nature for early science learning opportunities by examining science-related interactions in one nature-based preschool

Summary of Findings

Chapter 2 Findings

The purpose of the Chapter 2 study was to compare the general nature of teacher teacher-child interactions at a Nature-based and Non-nature preschool. Using an explanatory mixed-methods approach, I explored how the frequency, diversity, and quality of teachers' language compared, the role contextual factors played in interactions, and how the interactions unfolded. The findings suggest that context, particularly the physical setting, influenced the frequency and quality of teachers' talk directed at children. The findings also suggest not all outdoor

experiences are created equal, but rather how teachers use outdoors spaces, including the outdoor play area and spaces beyond the fence of the play area, influenced interactions.

When indoors, teachers at the two schools generally used similar amounts and type of talk with children. Further, when indoor time was part of the class day, both schools spoke most frequently inside and during free choice activities. Teachers in both schools also primarily used statements followed by questions/prompts. When teachers engaged in multiple turns of talk with children (i.e., conversation), the conversations were primarily short (i.e., 6 or fewer turns) and occurred during teacher-led activities. In contrast, the longer conversations (i.e., 7 or more turns) were primarily observed during Free Choice and Large Group. Extensive conversations, or those lasting 10 or more turns, made up 11% of all conversations in this study. In-depth analysis of the eight longest conversations at each school showed these conversations primarily involved one teacher with few children, were initiated by children, focused on concepts, and were somehow connected to the physical environment. Further, these extensive, concept-related conversations primarily occurred, at both schools, in the outdoor play area.

In this study, the Nature-based preschool spent at least half of their day outdoors, divided between the fenced play area and spaces beyond the fence. In contrast, the Non-nature preschool spent less than 30 minutes each day outdoors and that time was always spent in the fenced play area. Yet, when they did spend time outdoors, the two schools used the outdoor play spaces differently in three important ways. First, the Nature-based preschool used the outdoor play area at the beginning of their class day, whereas the Non-nature preschool used the outdoors at the end of the day. Second, the Nature-based preschool only had one class using the outdoor space at a given time. In contrast, the Non-nature preschool shared the outdoor play space with multiple classes, which may help explain why teacher-to-teacher talk occurred most frequently outdoors

at the Non-nature school. Third, at the Non-nature preschool free choice was the only activity setting that occurred outdoors, where at the Nature-based preschool, all social settings occurred outdoors. However, the teacher-led activity of small group only occurred once outdoors. These findings indoors and outdoors suggest all preschools have the potential to use the outdoors in more meaningful ways to facilitate teacher-child interactions, and thus children's learning. That is, the teachers at the two preschools were not vastly different, but rather what varied was how they used the outdoors as a learning space.

In addition to the fenced outdoor play area, the Nature-based preschool also visited outdoor spaces beyond the boundary of the fence each day. During this time in the Beyond, the classes engaged in large group or routines like snack. Further, the large group activities in the beyond differed from large group in other locations in that they lasted longer and mostly involved walking a fair distance as a whole group. While the teachers used statements most frequently in all locations, they used questions the least often when in the Beyond. These findings suggest the way Nature-based teachers used the beyond spaces may not align with the intended purposes nature-based educators have theorized.

Chapter 3 Findings

The Chapter 3 study was an observational study focused solely on the nature-based preschool with the goal of determining affordances of nature for early science learning opportunities by examining science-related interactions. I analyzed both verbal and non-verbal aspects of four long-lasting episodes involving science-related interactions, and how those interactions aligned with three-dimensional science teaching approaches (i.e., content, science practices, crosscutting concepts). The findings suggest the physical setting, particularly areas beyond the fence, afforded many opportunities for science sense-making, using a variety of

science and engineering practices and cross-cutting concepts. This sense-making happened through direct experiences with a variety of phenomena, particularly life science, that children noticed themselves. Additionally, these experiences were often connected over time. The findings also suggest these longer-lasting interactions primarily occurred outside formal science lessons in small groups led by teachers who seemed relaxed and joyful.

The four episodes included access to multiple scientific phenomena, yet how these phenomena were included in interactions varied greatly. For example, not every phenomenon was explicitly discussed, but when it was, the focus ranged from being core to the conversation to a connector within the conversation. Additionally, when discussions occurred around a particular phenomenon, they primarily emerged out of a child or teacher's observation in the moment. These phenomena connected to three different disciplinary core ideas—Physical Science, Earth Systems, and Life Science. However, most were connected to Life Science.

Teachers and children also engaged with science and engineering practices (SEP) and crosscutting concepts (CCC) in these episodes. In regard to SEPs, there was evidence of five of the eight practices in use. The SEP of "analyzing and interpreting data" was observed at least once in all four episodes. Of the seven CCCs described in the Framework (National Research Council, 2012a), five were observed among the episodes in this study. While both SEPs and CCCs were observed, the teachers did not explicitly discuss either of these two dimensions of science in their interactions. Though there was no explicit language related to these two dimensions of science, the presence of three-dimensional science in the four episodes suggests some inherent level of science discourse. For example, there were many science-related words, particularly nouns, spoken by teachers in the four episodes. These words were not taught as

vocabulary words, in fact they were rarely defined, but rather used in context as teachers and children were experiencing a relevant phenomenon.

As with the Chapter 2 study, the findings from this research suggest context matters for interactions. Being in the "beyond," occurring in small groups, and child-led interactions played a role in the quality of the interactions. Further, teachers' attitude, sense of wonder, and valuing children's ideas also contributed to how the science episodes unfolded. The large number of and variation in natural phenomena in these "beyond" settings may encourage teachers to tap into and share their own sense of wonder and reverence about the world. For example, they also modeled their own wonder with phrases like, "I wonder what that bird is saying." Additionally, while modeling this enthusiasm for discovering science phenomena, the teachers appeared relaxed and joyful. This may have been in part to the fact the interactions occurred among small groups. By not worrying about the care of a large group of children, the small groups may allow space for teachers to really listen to and value children's ideas.

Taken together these factors position teachers as co-learners rather than deliverers of science information. That is, these factors may better allow teachers to explore, discover, and figure out the world alongside children in a way that values children's unique individual perspectives.

Common Themes Across Both Studies

In both research studies, the outdoor environment seemed to influence how teachers interacted with children, particularly regarding conceptual development. In this section, I discuss aspects of the outdoors that may have contributed to this seemingly simple relationship. Two common themes cut across both studies that I argue are essential for us to better understand how

to meaningfully support young children's learning through nature-based approaches. The first theme focuses on the structure of the day, and the second is about the processes of interactions.

Theme 1: Free Choice Time Outdoors Supports Longer Teacher-Child Interactions

The longest lasting interactions between teachers and children occurred during free choice when children were able to freely move about, and when the teachers were less focused on leading and activity or transitioning to the next activity. Furthermore, these interactions primarily occurred during impromptu, child-led, small group interactions. For example, at the nature-based preschool the classes had extensive, transition-free time for free play outside. In the first study, this resulted in more extensive conversations. In the second study, this structure allowed teachers in two of the episodes to take a small group of children outside the fenced play area to experience a variety of natural phenomena. On a macro-level, this free choice structure highlights that the longer interactions occur when children have time to engage with the world around them, settle into their play, and then engage in conversation. Additionally, when this free choice occurs outdoors there appears to be less competition for space and fewer distractions from other children's play.

Theme 2: Outdoors Provided Contextual Supports for Interactions Not Available Indoors

The first study's findings suggest the Beyond affords fewer opportunities for long teacher-child interactions than other physical settings and the second study's findings suggest the Beyond affords the most opportunities for long science-related interactions. At first glance these findings may seem to contradict one another, but when we look at how these interactions play out, we see similar patterns. In both studies, the longest, most sustained interactions were with a small group of children, with minimal distractions from other people in the area. These interactions were also primarily child-initiated, child-led, and connected to the physical

environment in some way. The interactions predominantly ended due to interruptions from outside the group, suggesting a relaxed pace on the part of both teachers and children. Also, when teachers interacted with the children they were at the child's level—whether sitting at a table next to a child, digging in the dirt alongside a child, or crouching down to notice a natural phenomenon. For example, one of the longest conversations at the non-nature preschool occurred when a teacher and three children were sitting on the ground together, away from the rest of the class, searching for worms. Similarly, at the nature-based preschool, the *Squirrel* episode involved a child seeing a squirrel, announcing they should go get it, and then a teacher and a few other children following. They proceeded to converse about the natural world around them with the teacher following the children's lead and occasionally interacting with the phenomena around them. In both studies, these interactions, occurring during free choice, may have made it easier for teachers to follow children's lead because they were able to listen to and respond to a handful of children rather than an entire class. In other words, the outdoors provided space and subjects for conversation (e.g., squirrels and worms) that indoor spaces did not.

Importance of These Findings

Nature-based learning scholars recently published a coordinated research agenda for nature-based learning (Jordan & Chawla, 2019). This included recommendations for studying child outcomes related to nature-based approaches, mechanisms of influence for nature-based learning, and identifying implications for policy and practice—including the preparation of teachers. They went on to suggest that beginning with observations of teachers in order to identify similarities and differences would be useful to understand how nature-based learning and more conventional approaches compare and complement each other. The findings from this dissertation contribute to these research questions within the developing field of nature-based

early childhood education. The evidence indicates a need to focus on how outdoor learning environments are used, the role the physical environment plays in interactions, and the impact of outdoor experiences on teacher affect.

First, the findings suggest that simply being outside is not sufficient for utilizing the outdoors as a learning environment, but rather educators must attend to *how* the outside is used. Teachers must consider when to include outdoor time as well as free play and teacher-led activities outside, and the logistics of the outdoor space which may better support learning beyond simply physical development (e.g., not sharing play areas with multiple classes at once). Considerations also include ensuring all developmental domains are supported outside if, in fact, the goal is for the outdoors to be an extension of or the entire classroom. For example, do children have opportunities for engagement with literacy, math, and science activities?

The importance of how space is used is relevant in the Beyond as well. Scholars have theorized that the role of the Beyond is to connect children with something greater than themselves and learn with nature rather than simply about nature (Larimore, 2019; Warden, 2015, 2019b). If this is in fact the intended purpose of visiting the Beyond as part of the nature-based approach, how the space is used must reflect that purpose. For example, this might include additional free choice time in the Beyond. It might also include intentional pauses during the whole-group activities for quiet observation of the world around them.

The findings of this dissertation also indicate how these outdoor spaces are used directly impacts the teacher-child interactions that occur in these spaces. This begins to address one of the nature-based research agenda questions which was "How do interpersonal dynamics among children, parents, friends, and teachers influence nature-based learning?" (Jordan & Chawla, 2019, p. 5). That is, the current study suggests how the outdoor spaces are used influences the

interpersonal interactions, which in turn influences children's learning. The findings also suggest, however, that these interpersonal dynamics may also be influenced by the physical environment itself. That is, moving forward we not only need to examine interpersonal dynamics, but also the impact the physical environment has on these dynamics. This aligns with previous literature related to learning *with* nature (Larimore, 2019; Warden, 2015). These scholars have suggested that in nature-based pedagogical approaches, the natural world serves as another teacher, providing both children and teachers with new and ever-changing learning opportunities which connect across the spaces of the inside, outside, and beyond (Larimore, 2019; Warden, 2015). Of course, this is only possible if teachers and children are able to hear one another and are not overwhelmed with too many people in the space.

Finally, Jordan and Chawla (2019) posed the importance of answering the question, "What are key elements of nature experiences that affect children?" This question directly relates to how experiences in nature impact children. However, it also begs the question, how do nature experiences affect teachers? The nature-based teachers in these studies appeared relaxed, curious, and joyful suggesting the outdoor settings may influence teachers—not just children. How does extensive time outdoors impact teachers' physical and mental health? How does it impact their job satisfaction? While this dissertation did not specifically focus on these questions, the findings suggest that perhaps they do. They point to the idea that the physical environment does more than providing sparks for conversation as these studies suggest, but also impacts children and teachers' overall happiness. This line of research would be meaningful for the field of nature-based early childhood education, but also for the field of education more broadly.

Implications for Teaching and Teacher Education

This dissertation study has implications for how to better support teachers to use the outdoor setting for teaching and learning. In particular, it emphasizes the importance of intentional use of the outdoors, rather than simply "going outside." This has implications for teacher preparation or ongoing professional development for both early childhood education in general and nature-based early childhood education in particular.

Regarding early childhood education more broadly, it is important to support teachers in interacting in the outdoor spaces as extensions of the classroom. First, the results of this dissertation suggest a few simple shifts in the scheduling and logistics may increase outdoor time as well as increase opportunities for longer teacher-child interactions. For example, beginning the day outdoors may allow for longer time outdoors. Additionally, limiting the outdoor space to one classroom of children at a time may allow teachers to engage with children more fully. The combination of more time outdoors, few children, and children the teachers are familiar with may allow for longer, more meaningful interactions between teachers and children—particularly related to science.

The findings of this dissertation suggest another implication for early childhood education is the role the physical environment itself plays in teacher-child interactions, including those related to science. As educators are designing outdoor spaces, they should consider the size, allowing for small groups of teachers and children to interact without excessive distractions from others, as well as the features in the site. That is, we should continue to build on the work of scholars such as Moore and Cosco (2014), to go beyond the outdoor space as facilitating physical activities and consider what materials could be added to the space to facilitate learning in other developmental domains. For example, shovels and buckets allow for the open-ended

search for worms. As educators develop outdoor spaces, we should constantly be asking what features and materials not only support children's ways of engaging with the environment (Kahn et al., 2017), but also those that facilitate child-child and teacher-child interactions. This dissertation involved preschools in suburban settings, but we should also consider how these outdoor spaces vary across rural and urban spaces.

With respect to nature-based early childhood education specifically, this dissertation highlights the importance of structuring the class day to integrate different social settings (e.g., small group, free choice) and activities, as well as the use of the Beyond space. First, nature-based teachers should consider ways to include free play as well as teacher-led activities such as large and small groups to ensure all social settings are included in the day. This could mean holding small group activities earlier in the day or including them in other parts of the day. For example, classes could, on occasion, hike a short distance into the Beyond and then have a focused small group activity. Also, nature-based teachers should be intentional about including the same types of learning that occurs indoors, outdoors as well. For example, consider ways literacy activities, such as reading and singing, can be integrated into the outdoor setting in more purposeful ways such as an outdoor library space.

Nature-based teachers should also ensure the time and activities beyond the fence align with the intended purpose of the Beyond. That is, if the purpose of time in the Beyond is for children to connect with something bigger than themselves and discover the wonder and awe nature provides, we must structure the day to allow for that. One way to do this is planning for activities in the Beyond other than whole-group activities and snack—particularly those which allow for more free choice. That is, visiting a wetland and allowing children to explore for frogs, but also providing materials and time for children to engineer ramps for moving the water, for

drawing the plants, and so forth. Another way to utilize the Beyond, as illustrated in the science episodes in this dissertation, is exploration beyond the fence with one teacher and a small group of children. The group may not be able to travel a long distance for safety reasons, but this small group exploration may allow for children to lead the exploration of the wide variety of natural phenomena in the spaces beyond the fence. Both study findings also suggest the importance of having lower teacher to child ratios in the Beyond. This is not only important for safety (Natural Start Alliance, 2019), but also in creating opportunities for meaningful teacher-child interactions.

A final implication, for both early childhood and nature-based education, is the importance of including outdoor learning as part of teacher preparation. That is, as part of their preparation to be teachers, pre-service teachers should learn about ways to use the outdoors as an extension of the classroom and also, as previous scholars have suggested, have opportunities to see the nature-based teaching in action (Torquati & Ernst, 2013). This may mean providing additional support to university laboratory schools in designing and using outdoor learning spaces. It may also mean teacher preparation programs collaborating with nearby nature-based programs to support pre-service teachers' observation hours and/or field placements. This integration of nature-based learning into teacher preparation is useful for all teachers—whether they want to teach in a nature-based program or in a more conventional setting. Including nature-based learning in teacher preparation will broaden the number and diversity of students—with respect to race, geography, ability, or so forth—who will have access to this approach to early childhood education.

Conclusion

The field has much to learn about the affordances of outdoor environments for learning and how teachers can leverage those affordances. Nature-based early childhood education is an

emerging field that could benefit from studying the ways the outdoors may support and influence learning in a variety of domains. Research should also focus on how NbECE supports diverse learners in a variety of settings beyond the suburban ones discussed in this dissertation. However, this line of research is promising. The present study highlights that the outdoor experiences can influence how teachers interacted with children, particularly regarding conceptual development such as science learning. It further highlights that all time outdoors is not equal, but rather it matters how the outdoor experiences are structured. Exposure to nature has positive impacts on children's physical, cognitive, and social-emotional development (Gill, 2014). Further, children have a right to experience and develop a respect for the natural environment (UNICEF, 1989). Continued examination of the ways in which early childhood teachers can leverage these benefits, as part of the formal school day, is critical. In the end, this dissertation and ongoing work is important for understanding the potential for nature-based learning as an intentional and meaningful tool for early childhood education—both in conventional and nature-based schools.

APPENDICES

APPENDIX A: ADDITIONAL TABLES FOR CHAPTER 2 FINDINGS

Table A.1

Number (Percentage) of Utterances by Physical Setting and Social Setting at the Nature Preschool by Timepoint

Utterances by Physical Setting

	Nature Timepoint 1	Nature Timepoint 2	Row Total
	n (%)	n (%)	n (%)
Inside	3559_b (54.30)	0_a (0.00)	3559 (29.70)
Outside	2676_b (40.80)	3185_a (58.70)	5861 (48.90)
Beyond	325_b (5.00)	2237_a (41.30)	2562 (21.40)
Column Total	6560 (100.00)	5422 (100.00)	11982 (100.00)

Pearson x^2(2) = 4966.835a, p < .001.

Utterances by Social Setting

	Nature Timepoint 1	Nature Timepoint 2	Row Total
	n (%)	n (%)	n (%)
Free choice	3291_a (50.20)	2774_a (51.20)	6065 (50.60)
Large group	1534_b (23.40)	1934_a (35.70)	3468 (28.90)
Routines	488_a (7.40)	393_a (7.20)	881 (7.40)
Small group	1247_b (19.00)	321_a (5.90)	1568 (13.10)
Column Total	6560 (100.00)	5422 (100.00)	11982 (100.00)

Pearson x^2(3) = 544.136a, p < .001.

Each subscript letter denotes a subset of Timepoint categories whose column proportions do not differ significantly from each other at the 0.05 level.

Table A.2

Number of Video Segments by Physical Setting and Social Setting at Both Preschools

	Nature				Non-Nature				
	Inside	Outside	Beyond	Nature Total	Inside	Outside	Beyond	Non-Nature Total	**Row Total**
Free choice	7	25	0	33	23	6	0	29	62
Large group	2	6	11	18	8	0	0	8	26
Routines	2	0	2	4	8	0	0	8	12
Small group	6	2	0	8	9	0	0	9	17
Column Total	17	33	13	**63**	48	6	0	**54**	117

Note: This table includes the 26 segments that occurred Inside at the Non-nature preschool which were eliminated from utterance- and conversation-level analysis

Table A.3

Number (Percentage) of Utterances by Type and Setting at Non-nature Timepoint 1 only

Utterances by Physical Setting

	Inside	Outside	Row Total
	n (%)	n (%)	n (%)
Question/Prompt	466_a (13.80)	21_b (7.70)	487 (13.30)
Statement	2154_a (63.60)	177_a (65.10)	2331 (63.70)
General Reflection	207_a (6.10)	10_a (3.70)	217 (5.90)
Singing/reading	197_a (5.80)	0_b (0.00)	197 (5.40)
Greeting	36_a (1.10)	2_a (0.70)	38 (1.00)
Teacher-to-Teacher Talk	326_a (9.60)	62_b (22.80)	388 (10.60)
Column Total	3386 (100.00)	272 (100.00)	3658 (100.00)

Pearson x^2(5) = 66.742a, p < 0.01

Utterances by social Setting

	Free Choice	Large Group	Routines	Small Group	Row Total
	n (%)	n (%)	n (%)	n (%)	n (%)
Question/Prompt	$187_{a, b}$ (13.30)	$107_{a, b}$ (12.70)	77_b (16.50)	116_a (12.30)	487 (13.30)
Statement	870_a (62.10)	607_b (72.00)	296_a (63.40)	558a (59.00)	2331 (63.70)
General Reflection	68a (4.90)	40a (4.70)	35b (7.50)	74b (7.80)	217 (5.90)
Singing/reading	60a (4.30)	17b (2.00)	6b (1.30)	114c (12.10)	197 (5.40)
Greeting	22a (1.60)	11a (1.30)	2a, b (0.40)	3b (0.30)	38 (1.00)
Teacher-to-Teacher Talk	195a (13.90)	61b (7.20)	51a, c (10.90)	81b, c (8.60)	388 (10.60)
Column Total	1402 (100.00)	843 (100.00)	467 (100.00)	946 (100.00)	3658 (100.00)

Pearson x^2(15) = 181.551a, p < 0.01

Each subscript letter denotes a subset of Timepoint categories whose column proportions do not differ significantly from each other at the 0.05 level.

Table A.4

Number (Percentage) of Conversation Length by Preschool at Timepoint 1, Inside Only

	Nature	Non-Nature
	n (%)	n (%)
Brief Conversation (2-3 turns)	51_a (51.50)	91_b (72.80)
Moderate Conversation (4-6 turns)	32_a (32.30)	23_b (18.40)
Long Conversation (7-9 turns)	6_a (6.10)	5_a (4.00)
Extensive Conversation (10+ turns)	10_a (10.10)	6_a (4.80)
Column Total	99 (100.00)	125 (100.00)

Pearson x^2(3) = 10.961a, p = 0.012.

Each subscript letter denotes a subset of Context categories whose column proportions do not differ significantly from each other at the 0.05 level.

Nature M = 4.79 (SD = 4.41), Range 2-31
Non-Nature M = 3.34 (SD = 2.45), Range 2-14

Table A.5

Number (Percentage) of Conversation Length by Utterance Type at the Nature Preschool

	Brief Conversation (2-3 turns)	Moderate Conversation (4-6 turns)	Long Conversation (7-9 turns)	Extensive Conversation (10+ turns)	Row Total
Question/prompt	305_a (29.70)	302_a (28.10)	130_a (25.10)	427_a (27.20)	1164 (27.80)
Statement	598_a (58.30)	632_a (58.70)	315_a (60.80)	937_a (59.60)	2482 (59.20)
Other Child-Directed	123_a (12.00)	142_a (13.20)	73_a (14.10)	207_a (13.20)	545 (13.00)
Column Total	1026 (100.00)	1076 (100.00)	518 (100.00)	1571 (100.00)	4191 (100.00)

Pearson x^2(6) = 4.795a, p = 0.57

Each subscript letter denotes a subset of Context categories whose column proportions do not differ significantly from each other at the 0.05 level.

Table A.6

Number (Percentage) of Conversation Length by Utterance Type at the Non-Nature Preschool, Timepoint 1

	Brief Conversation (2-3 turns)	**Moderate Conversation (4-6 turns)**	**Long Conversation (7-9 turns)**	**Extensive Conversation (10+ turns)**	**Row Total**
Question/prompt	126_{a} (22.60)	54_{a} (22.90)	21_{a} (19.30)	38_{a} (20.90)	239 (22.00)
Statement	352_{a} (63.20)	146_{a} (61.90)	81_{b} (74.30)	$127_{a, b}$ (69.80)	706 (65.10)
Other Child-Directed Utterance	79_{a} (14.20)	36_{a} (15.30)	7_{b} (6.40)	$17_{a, b}$ (9.30)	139 (12.80)
Column Total	557 (100.00)	236 (100.00)	109 (100.00)	182 (100.00)	1084 (100.00)

Pearson x^2(6) = 10.470a, p = 0.106.

Each subscript letter denotes a subset of Context categories whose column proportions do not differ significantly from each other at the 0.05 level.

APPENDIX B: SCIENCE AND ENGINEERING PRACTICES IN CHAPTER 3 EPISODES

Table B.1
Science and Engineering Practices in Chapter 3 Episodes

	Episode 1: Animal coats	Episode 2: Bird	Episode 3: Love	Episode 4: Squirrel
Asking Questions "Ask questions based on observations to find more information about the natural and/or designed worlds." (NGSS, Appendix G, p. 51)	---	---	*"I wonder what that bird is saying."*	*"What sounds?"* *"What are they doing?"* *"Where are they coming from?"* *"How's it feel?"*
Developing & Using Models "…using and developing models that represent concrete events…" (NGSS, Appendix F, p.53)	---	*"…write down or draw a picture of what happened."*	---	---
Planning & Conducting an Investigation "With guidance, plan and conduct an investigation in collaboration with peers (for K)." (NGSS, Appendix F, p. 55)	---	*"Do you guys remember where we put it?"* *"Right now we're checking on the bird. Remember?"* *"Where's the trail cam?"*	---	*"Should we go get closer?"* *"Should we go further?"* *"Look at the top of that tree. See all the black."* *"Did you see this? Look at this part."* *"See the green. And then look at these coming out of the moss."* *"Look what's growing out."* Brad holds bark up to tree *"Yeah, I found some but it's peeling off of this tree."* *Counting scat "one, two…"*

Table B.1 (cont'd)

Analyzing & Interpreting Data "Record information (observations, thoughts, ideas)." (Appendix F, p. 57)	*"…you can even feel it on your cheek."* *"Is there anything different about this one?"* *"Hmm, what do you think? What color? What are the clues?"*	*"Where's the bird? Where did it go?"* *"Look at all the feathers."* *"Hmm, wait a minute! Look it! I see a sign!"* *"Where'd you find that at?"* *"A bug snail?"* *"You found a nut!"*	*"Man, I hear those birds. Singing in the sunshine."*	*"Wait…ope, I thought I heard the squirrel."* *"Caw, caw. Hear that?"* *"Wait, I hear it. We're getting closer."* *"I see em!"* Brad whistling *"It's hard on the inside."* *"Oh! There's a lot of water. That's a big vernal pool."* *"White and black?"* *"Yeah, I found some but it's peeling off of this tree."* *"Look at all that scat."* *Counting scat "one, two…"*
Constructing Explanations & Designing Solutions "Make observations to construct evidence-based account of natural phenomena." (NGSS, Appendix F, p.61)	---	*"What happened to our bird?"* *"Where's the bird? Where did it go?"* *"What's floating?"* *Child: "I think it's something you shoot a bow and arrow in"*	---	*"What do you think that is?"* *"Blood. From what?"* *"That holds the buds."* *"It's hard on the inside. It's wood."* *"The log is starting to break apart. It's starting to turn into dirt. It's decomposing."* *Child: "Deer poop!...He went right here and then he pooped."* *"Why do you think this tree fell down?"*

APPENDIX C: SCIENCE-RELATED LANGUAGE IN THE FOUR EPISODES

Table C.1
Science-Related Language in the Four Episodes

Episode 1: Animal coats	Episode 2: Bird	Episode 3: Love	Episode 4: Squirrel
"You're adapting…"	*"Right now we're checking on the bird."*	*"Man, I hear those birds. Singing in the sunshine"*	*"There's a squirrel."*
"Do wild animals wear coats?"	*"Where's the bird?"*	*"It is nature. I love nature."*	*"Squirrrrreeelll!"*
"…what's attached to the skin?"	*"Look at all the feathers."*	*"What do you hear in the sky?"*	*"The crows. Ok."*
"Do you want to see an animal's summer coat?"	*"We found the feathers. See all those feathers."*	*"What do you like about summer?"*	*"Oh, there's something in this tree. This bush right here."*
"This is a piece of a deer summer coat."	*"A yellow-bellied sapsucker."*	*"What do you like to do at the lake?"*	*"Chickadees, Gabe says."*
"This is a winter coat."	*"And we put that woodpecker out here, the sapsucker, and now it's gone."*	*"It's pretty fun too, but you do ice fishing in the wintertime, so it's kinda chilly."*	*"You gotta have rubber boots to go in liquid."*
"I have a lot more animal furs or animal pelts in this bin."	*"Umm, so I heard you guys say maybe a bear ate him, right?"*		*"Look at the top of that tree."*
"A leaf was falling down?"	*"I wonder if the squirrel ate our bird."*		*"That holds the buds."*
"Winter's coming. It's gettin' cold. And what happens in the winter?"	*"Remember guys this is the river, we need to keep our bodies safe."*		*"This is called moss. It's a type of plant."*
"What's if it's so cold…what happens, what would happen in the rain if it was so cold?"	*"What's floating?"*		*"It's wood."*
"This happened the other day…it snowed."	*"The island is floating? Oh, the island is back isn't it!"*		*"The log is starting to break apart. It's starting to turn into dirt. It's decomposing."*
"Oh, we got to stay warm for the snow."	*"A bug snail."*		*"Oh! There's a lot of water. That's a big vernal pool."*
"The predators are coming."	*"Where did you find that nut at?"*		*"Yeah, I found some but it's peeling off of this tree."*
"Wait, what if I go in the shelter. Will that keep me safe?"			*"Look at all that scat."*
"This is a squirrel house?"			*"Deer poop"*
"That's nature, huh?"			*"That's a big animal too."*
"Well, he's the fox and I'm the squirrel. Who eats who?"			
"…we're bears."			

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