THE EFFECTS OF NATURE-BASED PRESCHOOL ON CHILD DEVELOPMENT

By

Arianna E. Pikus

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ABSTRACT

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Nature-based preschools are on the rise in the United States. Currently, they can be found in over 43 states in the United States and more nature-based education facilities are being added every year (Merrick, 2016; North American Association for Environmental Education (NAAEE), 2017). While there has been an increase in this type of early childhood program, it has yet to be determined if these programs are preparing children to the same degree as a more traditional preschool would. This study takes a mixed-methods approach to determine if children who attend a nature-based preschool are developing the skills needed to be successful in kindergarten, at a rate similar to children in traditional, high-quality preschool settings. While types of activities varied by preschool location, children at both locations developed early literacy, reasoning and some aspects of executive function at similar rates. Other aspects of executive function, including performance on the HTKS task (McClelland et al., 2014), were associated with greater growth for children in the traditional preschool classrooms.

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Children are spending increasing amounts of time indoors, which could be detrimental to their learning. The National Institutes of Health reports that, on average, children under the age of 18 spend 4 hours a day watching television and 5-7 hours total on screens (Roberts, Foehr & Rideout, 2005). For preschoolers specifically, children are spending 3-5.5 hours watching a screen daily (Tandon, Zhou, Lozano & Christakis, 2011), leading many educators to question whether children are getting the educational experiences needed to be successful in kindergarten. This high level of 'screen time' may also be troubling for children's development in other domains as well. Research has found that children play outside for just over 4 hours a week, which is less than half the amount of time their parents spent outdoors as children (Moss, 2012). This decrease in time outside is associated with a wide range of behavior problems in children (Louv, 2005) and may be associated with what Richard Louv has called "nature deficit disorder" (2005). Nature deficit disorder is not a medical diagnosis, but it has raised a growing desire in organizations and in parents to reconnect children to nature.

In order to provide children with more experiences away from technology and more interactions with nature as seen in previous generations, there has been an increase in nature-based education facilities. These facilities go by a number of names, including: nature-based preschools, forest kindergartens, and forest schools. Although programs vary in the amount of time spent outside (Larimore, 2016), they all center around children having frequent experiences with nature that support their development and build a lasting connection to nature. The current study focuses specifically on one type of a nature educational facility for young children: nature-based preschools. Currently, nature-based preschools can be found in over 43 states in the United States. From 2008 to 2017, the number of nature-based preschools in the U.S. has increased from 20 to over 250, with more nature-based education facilities being added every year (Merrick, 2016; North American Association for Environmental Education (NAAEE), 2017), however, no empirical studies have measured socio-emotional and academic outcomes for children who attend these preschools.

Nature-Based Classrooms

The focus of this paper is to determine if children who attend a nature-based preschool are developing the skills needed to be successful in kindergarten, at a rate similar to children in traditional, high-quality preschool settings. Nature-based preschools are licensed early childhood programs for 3-5 year olds, with 25-50% of time spent outdoors (Bailie, 2010; Larimore, 2011). Curriculum in these programs centers around nature, with natural elements also being infused into indoor spaces (Larimore, 2011; Moore, 2014). These programs can vary in the amount of time they spend outdoors, their use of indoor space, the curriculum used, the length of the program, the ages they serve, and the role of parents and families (NAAEE, 2017). Despite these variations, nature-based preschools must meet three key criteria according to Bailie (Natural Start Alliance, 2017), one of the founding contributors to the development of nature-based education. These criteria are: 1. Nature must be the central organizing theme of the program and tie together the philosophy, curriculum, and design of the preschool. 2. The program must engage in early childhood education practices that meet statewide standards and guidelines set forth by the North American Association for Environmental Education guidelines, and 3. The program utilizes the natural world to support goals that address a child's cognitive, physical, social and emotional development, as well as the development of an environmental ethic within the child (Natural Start Alliance, 2017).

Children attending nature-based preschools are expected to achieve the same developmental goals as those attending a more traditional preschool, however there are fundamental differences in the methods used to help children reach these goals: specifically, overall philosophy, time outside and classroom schedule (NAAEE, 2017). While both types of preschools regularly spend time outdoors, how each preschool uses this time is very different. At a traditional preschool, children spend on average 60 minutes outside (Tandon et al., 2013) and outdoor time is sometimes, but rarely, used as an opportunity for learning. In contrast, children who attend a nature-based preschool spend anywhere from 30 to 100% of their day outside and their time outside is interwoven with learning (Finch & Bailie, 2015; Larimore, 2011). For example, rainy weather could keep a traditional classroom indoors for an afternoon, but a nature-based classroom would see this event as an opportunity for children to collect and learn about the worms who have come above ground (Jacobi-Vessels, 2013). Even indoor activities in a nature-based preschool use nature themes and are centered around discoveries made by the children (Finch & Bailie, 2015). Both high-quality traditional and nature-based preschool classrooms are child-centered and allow children to learn through play (Frost, Wortham, & Reifel, 2012; Samuelsson & Johansson, 2006) and both types of preschools have consistent schedules for moving through the day. However, the schedule in a nature-based preschool allows for more flexibility, which emphasizes frequent and unstructured time for children to explore nature (Finch & Bailie, 2015). Traditional preschools have a focus on teacher-planned activities and specific subject content knowledge with an emphasis on preparing children for formal schooling (Bennett & Tayler, 2006), whereas teachers in nature-oriented educational settings tend to have a teaching style that provides a multidimensional approach towards different learning areas, with nature being intertwined into other content areas (Klaar & Ohman, 2014). This philosophy towards emergent curriculum allows lessons to develop based on what is happening in the natural environment and the curiosity of the children (Finch & Bailie, 2015). For example, a nature-based classroom may have planned to spend the first week of spring learning about flowers, however, the lesson could be adapted to one about how plants survive winter temperatures if there is still snow on the ground. A traditional classroom spends less time outside and thus may not need to adjust their lesson plan.

Interactions with Nature and Child Development

Although not studied directly within nature-based school settings, there is some evidence to suggest that these outdoor opportunities might be beneficial in a number of areas of development, at least for adolescents and adults. Nature has been shown to act as a buffer for stressful life events (Wells & Evans, 2003). This reduction of stress has been shown to have a positive impact on a person's physical and psychological well-being (Kaplan, 1973; West 1986). In addition, a short walk through nature improves a person's ability to sustain attention relative to walks in urban areas (Hartig et al., 2003). Participants reported that attending an intensive outdoor wilderness program led to positive outcomes that lasted for several years after the experience (Kellert, 1998). However, exposure to nature during recreational interactions may benefit people differently than exposure to nature during school settings.

Most of the literature on children's interactions with nature revolve around physical health and activity levels. Children who participate in more outdoor activities, particularly in nature, are less likely to have asthma, myopia, and chronic pain issues (McCurdy, Winterbottom, Mehta, & Roberts, 2010). Cleland and colleagues (2008) found that for every extra hour children spend outdoors, children's physical activity increased, perhaps explaining why children who were more active were less likely to be overweight three years later. Finally, access to natural play areas have been shown to improve coordination, balance and agility, prevent sickness (Fjortoft, 2001), and help reduce stress in children (Wells & Evans, 2003).

Children's behaviors have also been shown to improve through interactions with nature. Natural environments have been shown to help stimulate interactions between older children (Bixler, Floyd, & Hammutt, 2002), while also helping them develop independence and autonomy. Teachers have reported noticeable decreases in children’s anti-social behaviors, such as violence and bullying, when schools incorporate more diverse and natural environments for children to play in (Malone & Tranter, 2003; Moore & Cosco, 2000). Additionally, teachers report that children exhibit increases in self-regulation, creativity, and self-confidence after being in nature; they also noted that children had increased socialization skills, problem-solving skills, and ability to focus (Brussoni, Ishikawa, Brunelle, & Herrington, 2017).

There have been promising studies that have broadly looked at the effects of nature-based early education on a young child’s development. Playing in nature can provide children an opportunity to be more adventurous and take appropriate risks, which can build confidence and teach children to make personal judgements (Finch & Bailie, 2015). Some have suggested that nature-based educational settings can enhance children’s critical thinking and leadership skills and allow children to develop social and emotional skills through play in nature (Finch & Bailie, 2015). While research has shown that interactions with nature are beneficial to young children, no studies have been performed (to date) to determine if nature-based education programs are preparing children to enter a formal school system, which is the focus of the present work.

School Readiness

A vast amount of research has shown the importance of preschool in preparing children for kindergarten and beyond, as children who do not attend any type of prekindergarten programming tend to perform less well in academic and behavior domains (Fantuzzo, Bulotsky-Shearer, Fusco, & McWayne, 2005; Gormley, Gayer, Phillips, & Dawson, 2005; Wong, Cook, Barnett, & Jung, 2008). The growing importance of preschool education has led many states to enact standards for quality prekindergarten programs with specific emphasis on language and early-literacy development, social, emotional, and physical health development, and early math, science and social studies skills (California Department of Education, 2008; Michigan State Board of Education, 2005; New Jersey State Department of Education. 2014). Of these standards, this study has chosen to focus on three domains that have been hypothesized to be enhanced by experiences with nature: literacy, reasoning, and executive functioning. Research has shown that these skill sets are predictive of academic success in elementary and middle school (Duncan et al., 2007; McClelland, Acock, & Morrison, 2006), however it is still unclear how a nature-based preschool helps to develop these domains in young children in ways similar to and different from a traditional preschool classroom.

Early Literacy. Early literacy skills, such as oral language, phonological processing abilities, and print knowledge, are developmental precursors to reading and writing (Lonigan, Burgess, & Anthony, 2000; Whitehurst & Lonigan, 1998) and are necessary skills for children to be successful in kindergarten. A meta-analysis by the National Early Literacy Panel found large correlations between a number of early literacy skills in preschool and children's success in later literacy skills such as decoding, comprehension, and spelling (Lonigan, Schatschneider, Westberg [National Early Literacy Panel], 2008). Specifically, skills such as letter knowledge and phonological awareness (the understanding of the sound structure of language) are considered seminal in helping children to perform well academically in later grades (Downer & Pianta, 2006; Duncan et al., 2007). Literacy skills also remain fairly stable over time (Morris, Bloodgood, & Perney, 2003; Scarborough, 1998; Storch & Whitehurst, 2002), suggesting that if a child falls behind in this area during preschool, it may be challenging for them to catch up to their peers (Adams, 1990; Catts, Bridges, Little, &Tomblin, 2008; Skibbe et al., 2008; Torgesen & Burgess, 1998).

Given the importance of these early skills for children's later literacy performance, preschool classrooms spend a substantial amount of time (almost 20% of their day) focused on literacy relative to other types of skills (Early et al., 2010). Although different from traditional preschool classrooms, nature-based classrooms can foster early-literacy development in unique ways by allowing children to investigate the world around them, which can provide opportunities for growth in receptive and expressive language, print knowledge, and writing skills (Conezio & French, 2002). Researchers have found that children gain and solidify literacy skills when they have the opportunity to use these skills in authentic situations (Duke, Purcell-Gates, Hall, & Tower, 2006; Goodman, 1984; Sulzby & Teale, 1984). For instance, it has been found that children who play in natural environments are shown to have more imaginative and creative play (Fjortoft, 2000), which can foster language growth (Taylor, Wiley, Kuo, & Sullivan, 1998). Specifically, an understanding of phonological awareness, alphabetic knowledge, and decoding skills are needed to ensure children have the skills to be successful in kindergarten and beyond (Juel, Biancarosa, Coker, & Deffes, 2003).

Phonological awareness is one of the main focuses in high-quality preschool classrooms (Juel et al., 2003) and curriculum (Skibbe, Gerde, Wright, & Samples-Steele, 2016). In preschool, phonological awareness usually consists of children's abilities to generate rhymes (Chaney, 1992; Goswami & East, 2000; Maclean, Bryant, & Bradley, 1987) and identify the beginning, middle, and ending sounds of words (Bradley & Bryant, 1983; Lonigan et al., 2000;

Maclean et al., 1987). Phonological awareness in early education has been linked with reading and writing growth in children (Catts, Fey, Zhang, & Tomblin, 2001; Scarborough, 1998; Storch & Whitehurst, 2002). In a typical preschool classroom, teachers are recommended to focus on phonological awareness in daily activities (Pullen & Justice, 2003) and this importance can be seen by the emphasis of phonological awareness on professional development topics (Juel et al., 2003). In nature-based classrooms, the outdoor environment serves as a platform for children to expand their early literacy skills. Harwood and Collier (2017) discuss the many ways a nearby forest helped to enhance communication, storytelling and other literacy skills in children. The prevalent use of science journals in nature-based classrooms is another unique opportunity for teachers to help children practice sounding out the letters to spell particular words as they label their observations (Brenneman & Louro, 2008). Phonological awareness has also been linked to language development in young children, with some studies showing that preschool language ability was moderately correlated with later phonological awareness (Chaney, 1998; Olofsson & Neidersoe, 1999). Carroll and colleagues (2003) found a moderate correlation between phonological awareness and vocabulary growth in preschool children and vocabulary knowledge has been shown to increase reading comprehension in children (Stahl & Fairbanks, 1986). Nature-based elementary classrooms have been shown to increase the motivation to read, write, and draw, particularly in children who previously struggled with participating in literacy activities, because children wanted to learn more about what they were witnessing in nature (Eick, 2011).

Alphabetic knowledge is another key component to children's early literacy development (Al Otaiba et al., 2008). Alphabetic knowledge (or letter name knowledge) refers to the association between letters and their corresponding sounds; this allows children to understand that words contain individual phonemes, represented by letters, and those sounds will be used in the decoding process (Nicholson, 1997). Burgess and Lonigan (1998) found a reciprocal relationship between phonological awareness and alphabetic knowledge, suggesting that learning letter names and their corresponding sounds can help develop phonological representations (Treiman & Bourassa, 2000). Typically, preschool classrooms focus on children's ability to recognize shapes, names, and the sounds associated with letters of the alphabet, which are some of the best predictors of later reading achievement (Adams, 1990; Lonigan, 2006; National Reading Panel, 2000; Strickland & Shanahan, 2004). A strong understanding of alphabetic knowledge is required for children to develop decoding skills (Chard, Simmons, & Kameenui, 1998; Kendeou, Broek, White, & Lynch, 2009).

Decoding, or the ability to translate written symbols into meaningful words (Adams, 1990; Ehri, 2005; Perfetti, 1985; Stanovich, 1986), is also a main focus of early literacy education in preschool classrooms (Al Otaiba et al., 2008). Some studies have shown that a focus on these skills results in greater early reading ability (Baker, Simmons, & Kameenui, 1998; Connor, Morrison, & Slominski, 2006; Cunningham & Stanovich, 1998; Juel, Griffith, & Gough, 1986). Teachers regularly evaluate children's decoding skills and give letter-sound instruction to children based on their current skill (Juel et. al., 2003). To develop decoding skills, children need strong phonological awareness skills (Ball & Blachman, 1991; Brady, Fowler, Stone, & Winbury, 1994; Byrne & Fielding-Barnsley, 1991; Stanovich, 1992; Torgesen & Wagner, 1998) and a strong alphabetic knowledge (Chard, Simmons, & Kameenui, 1998; Kendeou et al., 2009). These skills are predictive of later language and decoding skills (Kendeou et al., 2009) and contribute to reading comprehension in elementary school (Dickinson & Tabors, 2001; Hart & Risley, 1995; Kendeou et al., 2009). In addition, language is strongly related to decoding skills for preschool aged children (Scarborough, Neuman, & Dickinson, 2009). Language development in children may see greater growth in nature-based classrooms due to the benefits general exposure to nature has on this skill. Specifically, exposure to nature has been shown to stimulate vocabulary growth as a result of children figuring out new words to describe what they have discovered (Finch & Bailie, 2015) which could lead children to develop stronger decoding skills.

Reasoning. Reasoning skills in preschool children, also referred to as scientific reasoning, is another domain that may develop in a separate and unique way in a nature-based setting, compared to traditional preschools. Reasoning skills are broadly defined as the ability to identify a problem or question, form and test hypotheses, determine variables, and evaluate experimental outcomes (Bao et al., 2009; Zimmerman, 2007). These deductive and inductive reasoning skills have been shown as prerequisite skills children need to develop a strong academic foundation, including in areas of math and reading (Csapo, Molnar, & Nagy, 2014).

Children naturally explore the world in ways that resemble hypothesis testing. However, this exploration is usually limited, since children need to learn the skills to manipulate and control variables (a strategy required for formal hypothesis-testing; Klahr, 2000). Children enhance their reasoning skills by developing strategies to help them achieve a goal (Morris, Croker, Masnick, & Zimmerman, 2012). Children learn new strategies for problem solving through individual discovery, formal instruction, and other social interactions (Gauvain, 2001). Children can learn these new strategies by being explicitly taught a strategy, imitating a strategy, or by collaborating in problem solving (Gauvain, 2001). For preschoolers, children who worked with parents, or other adults, on a hypothesis testing task were more likely to identify causal variables than children who worked alone (Schauble & Gleason, 2000). Teachers also play a critical role in scaffolding children’s scientific reasoning skills. Teachers can provide direct guidance when children are testing variables to help facilitate their learning and help children develop the skills to apply their knowledge to new contexts in the future (Klahr & Nigam, 2004; Strand-Cary & Klahr, 2008). Scaffolding is also effective for problem-based and inquiry learning, whose structure allows children to explore and develop problem-solving skills (Alfieri et al., 2011; Hmelo-Silver, Duncan, & Chinn, 2007).

Nature-based preschools are presumed to have the development of scientific reasoning embedded in their daily activities. Nature-based education allows scientific thought to emerge in preschool age children as they collect and sort natural objects, make observations about the natural world, and try out simple experiments (such as floating leaves in a puddle), all by using the natural environment as a catalyst for learning (Finch & Bailie, 2015). Most nature-based classrooms incorporate journals into their science activities, which have been shown to increase observational skills, in addition to early literacy skills, in preschoolers (Brenneman & Louro, 2008). Nature-based education can provide children additional opportunities to explore using their own curiosity, interact and learn within a natural setting, and develop their problem-solving skills, all of which have been shown to enhance children's science knowledge (Yoon & Onchwari, 2006). For example, nature-based preschool classrooms typically spend time in the "beyond," which allows children to navigate and problem-solve through exploration of nature that is not typically found in most traditional preschool programs. Most parents have reported that their children's observation skills have improved after attending a nature preschool (Finch & Bailie, 2015) and are surprised by how often children incorporate the inquiry skills they learned at preschool into their home environment (Conezio & French, 2002). However, it should be noted that there is still little empirical evidence supporting nature-based education and its influence on children's reasoning skills.

In contrast, most traditional preschools do not focus on scientific reasoning skills often and science is not usually listed on teachers' daily schedule (Gerde, Pierce, Lee, & Van Egeren; 2018; Tu, 2006). While some traditional preschool classrooms have sufficient science materials (Harper-Whalen & Spiegle-Mariska, 1991; Kostelnik, Soderman, & Whiren, 2004; Worth & Grollman, 2003) to help children work through scientific concepts independently (Kostelnik et al., 2004), this area usually receives little classroom attention as most of class time is spent focused on other skills, specifically early literacy and math skills (Early et al., 2010; Tu, 2006). This is one domain where children who attend a nature-based preschool could show more growth than children in a traditional setting.

Executive Function. Executive function has been identified as a core component for not only children's school readiness, but also for future success in school (Razza & Raymond, 2014). Executive function (EF) includes the mental processes that enable a person to plan, focus attention, remember instructions, and juggle multiple tasks successfully (Garon, Bryson, & Smith, 2008; Welsh, Pennington, & Groisser, 1991). Models of EF often incorporate skills related to: inhibitory control (i.e., one's ability to control impulses), cognitive flexibility (i.e., one's ability to switch attention), and working memory (i.e., one's ability to hold onto and use information; Ackerman & Friedman-Krauss, 2017).

Individual EF skills are related to children's academic performance. For example, inhibitory control has been shown to predict children's ability to understand that others have perspectives and emotions different from their own (Astle, Kamawar, Vendetti, & Podjarny, 2013; Benson & Sabbagah, 2010; Sabbagh, Moses, & Shiverick, 2006). Children's inhibitory control, at age three, is a significant negative predictor of behavioral problems (Olson, Smeroff, Kerr, Lopen, & Wellman, 2005) and is longitudinally related to better emotional regulation, stronger conscience, and fewer externalizing problems (Kochanska, Coy, & Murray, 2001; Kochanska & Knack, 2003; Kochanska, Murray, & Harlan, 2000). Preschool children who have better inhibitory control were also more likely to be rated higher by teachers on social skills (Rhoades, Greenberg, & Domitrovich, 2009). Cognitive flexibility has been shown to be associated with math and reading in children (see Yeniad, Malda, Mesman, van IJzendoorn, & Pieper, 2012 for a review) and school readiness (Vitiello, Greenfield, Munis, & George, 2011). Specifically, cognitive flexibility is required for print awareness and reading comprehension, as children need to be able to mentally switch between written and spoken language to create meaning from words (Cartwright, 2015; Engel de Abreu et al., 2014). Working memory is necessary for many academic subjects, including math and reading (van der Sluis, de Jong, & van der Leij, 2007). For example, Swanson and colleagues (2009) found that children with reading disabilities displayed a lower working memory capacity than their peers without such disabilities. Working memory is also related to phonological awareness and reading comprehension in children (Cartwright, 2015; Garcia-Madruga, Gomez-Veiga, & Vila, 2016; Purpura, Schmitt, & Ganley, 2017), as children need to be able to hold many sounds and words in their memory and combine them to produce a word or sentence (Purpura et al., 2017).

While each of these components have their own unique function and contribution to learning, research argues that the integration of these three components also helps to guide goal-directed behavior, specifically in young children (Best, Miller, & Jones, 2009; Diamond, 2013; Garon et al., 2008; McClelland et al., 2007). For example, in order to understand the story a teacher is reading, a child must listen and not talk to others around them (inhibitory control), mentally switch between questions the teacher asks and the story being read (cognitive flexibility) and remember what happened from the beginning of the story to the end (working memory), all simultaneously. This integration of all three EF processes are required for children to successfully navigate the demands of school (McClelland & Cameron, 2012). The combination of all three EF skills have been linked to academic achievement in preschool (McClelland et al., 2007) and kindergarten (Howse, Calkins, Anastopoulos, Keane, & Shelton, 2003; McClelland, Morrison, & Holmes, 2000). Specifically, the integration of EF skills are positively related to levels of engagement in sequential task-related activities, positive interactions with teachers and peers, and less disruptive behaviors, all of which have can lead to better academic outcomes (Nesbitt, Farran, & Fuhs, 2015) in areas related to math (Clark, Pritchard, & Woodward, 2010), literacy (Blair & Razza, 2007), and science (Nayfeld, Fuccillo, & Greenfield, 2013). Research has shown that children's early integration of EF skills also have long-term effects on their school success (McClelland et al., 2007; Schunk & Ertmer, 2000).

Developing EF skills in children has been the focus of many preschool programs and can be seen in the curriculum chosen by classrooms and in the way classrooms are structured. Many commonly used curricula have components designed to help develop children's EF skills (Bodrova & Leong, 2007; Diamond, Barnett, Thomas, & Munro, 2007; Diamond & Lee, 2011; Kusche & Greenberg, 1994; Raver et al., 2008; Webster-Stratton & Reid, 2004). For example, some curricula implement a planning and review process before and after play time (e.g., "Plan-Do-Review" in HighScope and "Play Plans" in Tools of the Mind; Bodrova & Leong, 2007). During the planning stage, children decide how they want to spend their play time and communicate this plan with teachers or fellow classmates. EF skills can be utilized in this process as children may rely on their working memory when remembering which toys were in each area, implement cognitive flexibility in deciding where they want to play, and display inhibitory control when waiting for their turn to tell their plan. Their plan for playing can also be utilized later if disagreements arise. For example, if two children both want the same toy, a teacher can help mediate the conflict by referencing each child's individual plan. This requires each child to engage their working memory when remembering their plan and the plan of other child, and display cognitive flexibility when finding ways to resolve the conflict (Bodrova & Leong, 2007). After play time, children are then asked to review or remember what activities they participated in throughout play time. Children again rely on working memory to remember where they played and with whom, cognitive flexibility when sharing how they solved problems during play time, and inhibitory control when listening to others share.

Regardless of curriculum, there are other ways teachers enhance EF development in children. Teachers promote EF skill development in children when they teach children to understand and express their emotions, how to negotiate conflicts, and by building prosocial skills in children (Domitrovich, Greenberg, Kusche, & Cortes, 1999). Activities in nature have been shown to provide a unique setting for the development of EF skills. For example, Torquati, Schutte, and Kiat (2017) found children performed better on a working memory task outdoors, compared to indoors. The children in this study showed no differences in level of achievement on attention or inhibitory control assessments, based on environment. However, more neurological activity was found when the tasks were completed indoors. This suggests that more cognitive resources may be needed to complete some EF Tasks at the same level indoors compared to outdoors. In addition, multiple EF interventions have shown that a predictable classroom structure, and one in which self-directed learning is promoted, can support EF development in children (Bierman, Nix, Greenberg, Blair, & Domitrovich, 2008; Raver et al., 2009; Ursache, Blair, & Raver, 2011). Physical exercise has also been shown to improve EF in children (Best, 2010). Considering how time spent outside and in recess is decreasing in schools in favor of more academic time indoors (Burris & Burris, 2011), this may be one unique way EF develops in nature-based preschools.

Simply viewing nature regularly has been shown to enhance children's cognitive abilities, including areas that could be related to EF (Dadvand et al., 2015; Jenkin, Frampton, White, & Pahl, 2017; Taylor, Kuo, & Sullivan, 2002; Ulset, Vitaro, Brendgen, Bekkhus, & Borge, 2017). In Spain, children who were exposed to more greenness outside their elementary school had a higher degree of working memory and more attentiveness (Dadvand et al., 2015). Girls whose home included more opportunities to observe green spaces were better able to concentrate, inhibit impulses, and delay gratification, however no relationship was shown for boys (Taylor et al., 2002). One experimental study found that even a short video of a natural environment (compared to a short video of an urban environment) can have immediate benefits to self-regulation abilities in children 8 to 11 years old (Jenkin, Frampton et al., 2017).

Cognitive benefits continue to be present when children physically interact with nature. Children who have more contact with nature are shown to have increased attention spans, creative thought processes, problem solving abilities, self-discipline, and self-regulation (Burdette & Whitaker, 2005). Children with ADHD were able to concentrate better after a walk in the park than after a walk through downtown or a neighborhood (Faber-Taylor & Kuo, 2009). For children ages 5 and 6, researchers found positive relation between the amount of time a child spends outside daily and their attention skills (Ulsent et al., 2017). In addition, preschoolers who had taken a walk in nature performed better on attention tasks and spatial working memory tasks than children who went on a walk in an urban area (Schutte, Torquati, & Beattie, 2017). While no studies have specifically analyzed how EF develops in nature-based preschool classrooms, it is hypothesized that more time to interact with nature will lead to an increase in the development of EF skills.

Research Aims

To date, no empirical research has been conducted that shows specific developmental outcomes of nature-based education for young children. This is critical to examine as the number of nature-based preschools continues to increase in the United States. This study aims to provide extensive analysis (through direct assessment and classroom observations) to describe how nature-based preschools are developing school readiness skills in young children compared to traditional preschools, specifically in the domains of early literacy, reasoning, and EF.

Research Aim 1. - Describe the similarities and differences between nature-based preschools and traditional preschools in how they support children's development of early literacy, reasoning, and executive function skills.

Research Aim 2. - Determine if children who attend a nature-based preschool are developing early literacy, reasoning, and executive function skills at the same rate as children who attend a traditional preschool.

Methods

Participants

Two preschools, a nature-based preschool and a traditional preschool, were used to collect data in the fall and spring of one school year. Both preschools were located in suburban areas of Michigan and had a 5-star rating in Michigan's Quality Rating Improvement System.

Nature-Based Preschool. Eighty-two children were assessed from the nature-based preschool (N = 27 female, 55 male). Children ranged in age from 3- to 5-years-old (M = 47.75 months, SD = 7.04). Mothers were asked to report their highest level of education; 1.2% reported completing high school (n = 1), 17.1% reported completing some college (n = 14), 46.3% reported completing an undergraduate degree (n = 38), and 32.9% reported completing graduate/professional school (n = 27). In this sample, 90.2% of the participants identified as White/Caucasian (n = 74), with 2.4% American Indian/Alaskan (n = 2), 3.7% Asian/Pacific Islander (n = 3), and 3.7% as other (n = 3).

Traditional Preschool. Fifty-eight children were assessed from the traditional preschool (N = 29 female, 29 male). Children ranged in age from 3- to 5-years old (M = 50.16 months, SD = 6.51). Mothers were asked to report their highest level of education; 6.9% reported completing some high school (n = 4), 1.7% reported completing high school (n = 1), 10.3% reported competing some college (n = 6), 31% reported completing an undergraduate degree (n = 18), and 48.3% reported completing graduate/professional school (n = 28). In this sample, 67.2% identified as White/Caucasian (n = 39), with 12.1% Asian/Pacific Islander (n = 7), 3.4% Black/African American (n = 2), 3.4% American Indian/Alaskan (n = 2), 1.7% Hispanic/Latino (n = 1), and 12.1% as other (n = 7). The traditional preschool was NAEYC (National Association for the Education of Young Children) accredited, which ensures preschool programs align with best practices in early childhood education.

Procedures

Observations. To understand how nature-based preschools differed from traditional preschools, classrooms at both centers were observed for one day during the fall assessment session. Three nature-based classrooms and three traditional classrooms were used in analysis. Half-day morning preschool sessions (M = 165.39 minutes, SD = 20.35) were video-recorded and two teachers per classroom were audio-recorded to provide greater detail on what was happening in the classroom. Classroom activities observed included large group, small group, meal time, and free play time. These observations were analyzed for similarities and differences in early literacy, reasoning, and EF practices for each preschool setting (See Appendix A for the coding scheme). All codes were observed at both preschool locations.

Assessments. Direct assessments were used to measure child outcomes in the fall and spring and a parent questionnaire was used to collect demographic information in the fall. Trained research assistants would first obtain verbal assent from the child to do the assessments. If the child assented, the research assistant would take the child to a quiet space to conduct the assessment battery. For children at the traditional preschool, testing usually took place in a hall or a quite side room. For children at the nature-based preschool, testing occurred in the indoor classroom space while lessons were continuing outside.

Measures

Coding of Observations. Research assistants watched recorded video observations of both nature-based and traditional classrooms to determine to what extent early literacy, reasoning, and EF practices were similar (or different) at each preschool setting. Half-day preschool sessions were recorded at both the nature-based (*M* = 163.16 minutes, *SD* = 31.77) and traditional preschool (*M* = 167.63 minutes, *SD* = 3.30). During the observations, all classrooms engaged in a large group activity, small group activities, snack time, and free play time. Both the time in the indoor classroom and time spent outside were recorded for all classrooms. For one traditional preschool classroom, we were unable to record the transition from the indoor classroom to the outdoor play area.

Trained research assistants noted the frequency that various activities occurred in each classroom that met the three domains focused on in this study. The coding system was created from established criteria in the field for early literacy (Neuman & Dickinson, 2011), reasoning (Alfieri et al., 2011; Bao et al., 2009; Hmelo-Silver et al., 2007; Zimmerman, 2007), and EF (Bodrova & Leong, 2006). Examples of early literacy activities coded included reading books, singing songs, and promoting phonological awareness skills (such as rhyming and identifying sounds in words). Since reasoning skills and science activities/skills strongly overlap in children (Bao et al., 2009; Zimmerman, 2007) the frequency of a science lesson occurring in a classroom was coded as a reasoning activity. Additional examples of reasoning activities included when teachers asked children "how" or "why" questions and when children were asked to describe phenomena they were observing. Examples of activities focused on EF development in young children were adapted from curriculum focused on this skill (Tools of the Mind Curriculum; Bodrova & Leong, 2006) and include: providing children warnings of upcoming transitions, conflict mediation, and asking children to recall previous events. The full coding scheme is included in Appendix A.

Videos were coded in 10-minute sections and totaled for each classroom. The amount of time each classroom was observed was statistically equivalent (t (4) = -0.24, p = .82, two-tailed).

All classroom activities were coded, including time outdoors for both preschools. One lead teacher and one assistant teacher were audio-recorded during the observation for every classroom, but all classrooms observed had at least three adults present throughout the observation (e.g., lead teacher, assistant teacher, and additional staff). Only the lead and assistant teachers with the microphone were coded on items that assessed talk between teacher and child. Inter-rater reliability between the author and research assistant ranged from 93 - 100%. At least 20% of the videos (*n* = 6 classrooms) were double coded by the author and research assistant to ensure a reliability of over 90%.

Assessment Battery. Direct child assessments were used to measure early literacy, reasoning, and EF in children at both preschools.

Test of Preschool Early Literacy (TOPEL). The Test of Preschool Early Literacy Skills (TOPEL; Lonigan, Wagner, Torgesen, & Rashotte, 2007) is a standardized measure of early literacy skills. The current study used only the Phonological Awareness subtest. This subtest focused on elision and blending tasks, each section included multiple choice and free-response items. The elision task required children to drop part of a word to create a new word. For multiple-choice items, children were shown four pictures and told their names (e.g., "Look at these pictures. This is a table, box, brush and tooth."). The children were then told a word and asked to repeat the word (e.g., "My word is shoot, say shoot.") The child was then asked to delete a part of the word and point to the picture that represents the new word (e.g., "Point to shoot without /t/"). For free-response items, the child was told they were going to answer some questions without pictures (e.g., "Say driveway. Now say driveway without way.") The blending task required children to combine words or sounds to make new words. For multiple-choice items, the child was shown four pictures and told their names (e.g., "Look at these pictures. This is cupcake, doormat, hotdog, and basket.") The child was then asked what word was formed when combining two other words (e.g., "Listen carefully to what I say and point to the word you hear. What word do these make? Hot—Dog.") For the free-response items the child was instructed that they were going to answer some questions without pictures and to listen carefully (e.g., "What word do these make? Air—Plane.") The pause between words was approximately one second. Total correct items were added up and are transformed into a standard score, based on age (M = 98.26, SD = 15.90). The internal consistency was above .90 for 3- to 5-year-olds and concurrent validity ranged from .59 - .65.

Letter Name Knowledge. The Quick Letter Name Knowledge (Q-LNK) assessment (Tortorelli, Bowles, & Skibbe, 2017) was used to measure participants' knowledge of letter names. This measure was developed using Item Response Theory as a way to accurately assess children's letter name knowledge from eight items (Bowles, Pentimonti, Gerde, & Montroy, 2014). Children were asked to identify lower and uppercase letters presented to them. Their assessment score (range 0-8) was translated to their Expected Total Letters Known (Range 0-52). Reliability for the different forms ranged from .89 to .92.

Letter Sound Knowledge. The Letter Sound Knowledge (LSK) assessment (Piasta, Phillips, Williams, Bowles, & Anthony, 2016) was used to measure participants' knowledge of the sounds letters produce. Similar to the Q-LNK, Item Response Theory was used to accurately assess children's knowledge of letter sounds from six items. Children were asked to pronounce the sounds associated with letters (Range 0-6). This raw score was converted to a scale to measure a child's expected letter sound knowledge (Range 0-26). All forms of this measure have shown reliability between .89 and .93.

Mouse House. The Mouse House task is used to should a child's scientific reasoning ability (Sodian, Zaitchik, & Carey, 1991). Children were given a scenario involving different sized mice and were asked to identify what size mouse (e.g., big or small) could fit into different sized houses (e.g., "Can a small mouse fit in the house with the big opening?" A child must answer the first 4 control questions correctly before moving on to the test questions. The answer to each question was scored 0 for incorrect and 1 for correct. Possible summed scores ranged from 0 to 8.

Head-Toes-Knees-Shoulders. Head-Toes-Knees-Shoulders (HTKS; McClelland, et al., 2014) measures children's behavioral self-regulation. After learning two oral commands (e.g., "touch your head" and "touch your toes"), children were asked to respond with the opposite action (i.e., when told "touch your head," the child touches their toes). After the first section, the child adds on two more commands and corresponding actions (knees/shoulders, shoulders/knees). A third section changes the actions that correspond to each command (i.e., when told "touch your head," the child touches their knees, and when told to "touch your knees," the child touches their head. Same with shoulders and toes.) Each section has a number of practice questions before moving on to 10 test questions per section. A child can only move to the next section by scoring 4 or more points on the previous section. Correct responses earn the child 2 points; incorrect responses earn 0 points; and 1 point is earned if the child makes to motion for an incorrect response, but then corrects themselves to the right response (self-correct). HTKS has shown interrater reliability of .90 and demonstrated predictive validity for academic achievement outcomes (Schmitt, Pratt, & McClelland, 2014).

National Institutes of Health Toolbox. *Flanker inhibitory control and attention test.* The NIH-TB Flanker Inhibitory Control and Attention Test (Weintraub et al., 2013) is used to measure EF and attention in participants. It tests the ability to inhibit visual attention to irrelevant task dimensions. On each trial, a central target (fish are used for children younger than 8-years-old) is flanked by similar stimuli on both sides. The task is for the child to identify the direction of the central fish. For early childhood, a scoring algorithm was used to determine accuracy and reaction time. Reliability was measured at 0.96 and validity was .60 for convergent validity and .67 for discriminant validity in 3 to 6 year olds.

Picture sequence memory test. The NIH-TB Picture Sequence Memory Test (Weintraub, et al., 2013) is used to measure episodic memory in participants. For each trial, pictures are shown, then moved to a fixed location, one at a time until the entire sequence is displayed. The pictures are returned to the center and the participants must move them back into the sequence previously demonstrated. The level of difficulty is adjusted based on age. Reliability has been measured at 0.78

Research Analysis Plan

To address Research Aim 1, videos of classroom observations will be coded for activities that could promote early literacy, reasoning, and EF development in young children. The frequency of these activities will be reported to help provide a greater picture of the similarities and differences between a nature-based preschool and a traditional preschool.

To answer Research Aim 2, multiple analysis steps were performed. First, descriptive statistics were analyzed for each domain, separated by preschool setting. Next, due to differences in demographic characteristics, such as household income and parental education, propensity scores were calculated for each child to reduce any possible bias due to these confounding variables. A propensity score is the conditional probability of being assigned to a particular group (in this case, nature-based or traditional preschool) given a range of observed covariates

(Rosenbaum & Rubin, 1983). A participant's propensity score is a single number that summarizes all relevant information/confounding variables of an individual (Rosenbaum & Rubin, 1983). Covariates included in an individual's propensity scores included gender, age, household income, SES, and parental education.

To determine if there were significant mean differences on children's early literacy, reasoning, and EF skills based on preschool setting multiple Analysis of Covariance were performed for each assessment, using children's propensity scores as a covariate.

Results

Research Question 1

To answer Research Question 1, recorded videos were analyzed of six total preschool classrooms (3 nature-based, 3 traditional). First, a general description of both types of classrooms are presented. Then, evidence is presented from the classroom observations to look at how early literacy, reasoning, and EF are supported at both locations.

General Descriptions. All preschool classrooms in this study began their day with children engaging in free play. The three nature-based classrooms were shown to start their day outside in the outdoor play area with children engaging in a range of activities. The outdoor play area consisted of a "mud" kitchen, a climbing tree, logs to climb or sit on, real tools (e.g., metal shovels & hammers for putting nails into pumpkins), dirt/sand box, hay bales, quiet areas, an outdoor painting easel, and meeting spaces for large group activities. There were also conventional toys, such as toy trucks to play with and bikes to ride. Children were observed engaging in the activities available throughout the outdoor play area, with teachers stationed around to monitor safety, mediate conflicts, and to engage with the children. The three classrooms at the traditional preschool all began their days inside, but also in free play. Children had the options to play with toys around the room. Teachers at the traditional preschool were also stationed around the room to monitor safety, help mediate conflicts, and engage with the children. In addition to free play options, every classroom had a predetermined activity, with a teacher present, that children were able to choose to engage in if they wanted to. For instance, in one traditional classroom, the teacher had set-up an art activity where children would paint leaves. In one nature-based classroom, the teacher had set-up a cooking station where children could help make applesauce. In this example, children were able to help with every step of the cooking process (e.g., peeling apples, cutting them, stirring the pot on the camping stove). The amount of time each classroom engaged in free play was determined by the time each child arrived and the time classroom activities began, but was approximately 60 minutes for every classroom.

After free play, all classrooms gathered for large group. All three nature-based classrooms held their large group meetings outdoors, while the traditional preschool remained indoors. The way in which large groups were conducted was similar across both preschool settings. Although the order of activities within the large group were shown to vary, every classroom sang a song, counted the children who were there that day, and went over the daily schedule. All three traditional classrooms and one nature-based classroom were observed reading a book during large group time.

After large group was over, the next activities varied by preschool location. At the traditional preschool, children went from large group to small group. The small group activities varied between the traditional classrooms. In one classroom, a short learning activity was conducted, then children were asked to make a plan for their free play time; in the other two traditional classrooms, this small group meeting served only as planning time. At the nature-based preschool, after the large group meeting each classroom ventured outside of the outdoor play area and into the woods for another activity. Each classroom was shown taking a short walk through the woods to get to the next activity. Two nature-based classrooms, utilized learning spaces in the woods that had logs/tree stumps set up for children to sit on for their next activity. The third nature-based classroom continued walking, as their activity was to collect various objects they found in the woods. The amount of time each nature-based classroom spent in outside of the outdoor play area ranged from 26.20 to 42.50 minutes.

When the nature-based classrooms returned from the woods, all three engaged in snack time. Two nature-based classrooms stayed outside and had snack on picnic tables in the outdoor play area; one nature-based classroom went inside into the indoor classroom for snack. The meal was served ‘family-style’ and teachers in all three nature-based classrooms were observed engaging children in conversations and mediating conflicts if they arose. After snack, children transitioned into free play time. Some children were asked to make a plan for their free play time, while others were able to go directly to free play time. At the traditional preschool, snack was available during free play for children to sit and eat if they wanted to.

Children’s engagement in free play activities was similar to the observed free play at the start of the observation. All three traditional classrooms remained indoors and children had access to a variety of activities throughout the classroom. Two of the nature-based classrooms engaged in free play in the outdoor play area, with access the same materials that were available at the beginning of the day. The one nature-based classroom that ate snack inside stayed inside for free play. The indoor classroom at the nature-based preschool had books available for children to read, blocks, art materials, and elements of nature throughout the activity areas, such as logs to sit on. Children were observed engaging in various activities throughout the indoor nature classroom and teachers were located throughout to engage children in conversations and mediate conflicts as they arose. Similar to free time at the beginning of the day, this episode of free play also contained a predetermined activity set-up by the teacher that children were able to engage in if they wanted to. For example, one traditional classroom and one nature-based classroom had playdough available on a table to children to play with. The nature-based preschool also had natural materials accessible, such feathers and sticks, for children to use to manipulate and create things with the playdough. At the traditional preschool, the teacher had letter stamps available that children could use to create letters or words in the playdough.

After free play, every classroom asked children to recall where they had played. In all classrooms, this happened in a small group. When recall was completed, one traditional classroom went to their outdoor play area, while all three nature-based classrooms and two traditional classrooms began their small group activity. Once the two traditional classrooms finished their small group activity, the classrooms went to their outdoor play area. The traditional outdoor play area consisted of manufactured play structures, a sandbox, bikes for children to ride, and hay bales for children to climb. At the nature-based preschool, children left small group to go home for the day.

Early Literacy. To assess to what extent early literacy activities occurred at both preschool settings, video observations were coded for common early literacy classroom practices (Neuman & Dickinson, 2011). In general, both the nature-based classrooms and the traditional classrooms were shown to read books, sing songs, and practice letter name/sound identification. The extent to which each activity happened at each location varied.

While both types of classrooms were observed reading books, children were exposed to more books in the traditional classroom than in the nature-based outdoor classroom. At the traditional preschool, all three classrooms read a book during large group time. In addition, children were shown to interact independently with books throughout the observation. In one classroom, a felt board was used by children to act out stories during free play. Children took turns telling a story, or using a book to help tell a story, through the felt-board. Children were also observed reading books on their own or bringing books to teachers for them to read aloud. At the nature-based preschool, most books were kept in the indoor classroom. When children were in the indoor nature classroom, they were observed reading books independently, reading books with peers, or asking a teacher to read aloud to them. When children were in the outdoor classroom, they were still able to go into the classroom to retrieve a book when they wanted to, but this was rarely requested. One nature-based classroom was observed reading a book during large group time.

Teachers at both the nature-based preschool and the traditional preschool were shown to sing songs throughout the day. The amount of songs being sung varied by classroom, but not by preschool location. That is, some teachers were observed singing songs frequently throughout the day at both locations, while others only engaged in this activity a few times. These songs were used for a variety of reasons (e.g., to ease transitions, to entertain/on request, or to enhance skill development).

Both nature-based and traditional classrooms were also observed conducting activities that could promote children's phonological awareness development. These activities were observed throughout the day (i.e., large group, small group), but primarily happened during free play. Teachers at both locations were observed helping children identify sounds associated with letters: "What sound does that letter make? /t/ /t/. That's right, a 'T' makes a /t/ /t/ sound." The frequency with which classrooms engaged in development of this skill related to the type of activity and children's interest, as opposed to classroom setting. For example, one of the traditional classrooms set-up a Post Office in their dramatic play area. Teachers were observed helping children write and address letters to others and helping children identify who the letter was addressed to for delivery throughout the classroom. This involved helping the children identify letters and sounds in the names they were reading/writing. At the nature-based preschool, children were observed using their snack time to turn pretzels into letters. The teacher expanded on this activity by asking children what sounds the letters they created made and if the child had created an uppercase or lowercase letter.

Children were shown to practice writing skills in the traditional preschool classrooms more than in the nature-based classrooms. In the traditional classrooms, most children wrote their names on art they had created, any papers that were used during small group, and throughout free play. For example, one preschool classroom had a Post Office theme in their dramatic play area. Children were observed practicing their writing skills as they wrote and addressed letters to others. In another preschool classroom, children were observed writing their name on a list for a turn with a popular toy. Although it happened less frequently at the nature-based preschool, some writing was still observed. For example, during one nature-based classrooms' large group, children were asked to write their name on a Whiteboard under what type of weather they predicted would occur that day.

Reasoning. Teachers at both the nature-based preschool and the traditional preschool were observed incorporating strategies that could help promote children's reasoning development (Bao et al., 2009; Zimmerman, 2007). Teachers at both sites frequently asked the children in their classrooms questions that could help children to develop reasoning skills. The teachers in nature-based classrooms tended to ask more open-ended questions, while teachers in the traditional classrooms scaffolded children's responses. For example, in the nature-based classroom teachers were observed asking children, "How does an animal stay warm?" Children were able to generate answers such as, "They go inside their home" or "They have fur." At the traditional preschool, children were asked questions such as, "Does this have more or less than X?" This provided children with a choice of how to respond.

Classrooms were also analyzed for the amount of science lessons that occurred throughout the observation. Two nature-based classrooms were observed engaging in a science lesson. Both of these lessons occurred when the classes left the outdoor play area and entered the woods. One nature-based classroom made 'potions' by mixing together different colored water and materials they found on the ground such as dead leaves and rocks. The other nature-based classroom that was observed conducting a science lesson that showed children properties of different animal skins. No science lessons were observed in the traditional classrooms.

Executive Function. Both preschools demonstrated strategies to help children develop various components of EF. The strategies coded throughout the observations were taken from curricula shown to improve EF skills in young children (Bodrova & Leong, 2007; Diamond & Lee, 2011; Kusche & Greenberg, 1994; Raver et al., 2008; Webster-Stratton & Reid, 2004). Throughout the observations, teachers asked children to recall events that had recently happened, which can promote working memory skills (Bodrova & Leong, 2007; Lockhart, 2010). This occurred at both preschool locations through casual conversations. For example, teachers at both locations were observed asking children, "What were you and (another child) playing earlier?" In addition, both preschools had time on their daily schedule for Recall, where children were asked to remember, or recall, activities they had done that day. While Recall was shown to happen in all classrooms, the extent to which it happened varied by location. In the traditional preschool classrooms, Recall occurred in small group settings, with teachers asking each individual child questions to prompt them to remember their play in greater detail. In the nature-based classrooms, Recall was observed happening in both small and large groups, but some children were not prompted to Recall.

The frequency of planning time also varied by preschool setting. All three traditional classrooms were observed asking children to plan where they were going to play during free play time, which can promote working memory (Bodrova & Leong, 2007; Lockhart, 2010). Teachers in the traditional classrooms asked children questions that allowed them to expand on their plans. For example, when a child said they were going to play in the block area, the teacher would ask, "What are you planning to build there?" In the nature-based classrooms, no planning time was observed.

All preschool classrooms were shown to provide children warning of when one activity would end and another was about to begin. All classrooms provided children multiple reminders of upcoming transitions; this helped remind children of their daily schedule/routines (Webster-Stratton & Reid, 2004). Some examples include: "5 more minutes of free play, then it's time to clean up." or "1 more minute, finish up what you are working on before we move on to our next activity." In the nature-based classrooms, teachers reminded the whole group of upcoming transitions; while, in the traditional classrooms the teacher told small groups of children about the upcoming transition.

Some behavioral self-regulation skills were encouraged more at the traditional preschool than at the nature-based preschool. For example, children at the traditional preschool were required to sit down during large group (Kusche & Greenberg, 1994; Webster-Stratton & Reid, 2004). While children were able to fidget as needed, if a child got up to move, the teacher remind, "We stay seated during large group, after we will go and play." At the nature-based preschool, children were also required to sit during large group, but children were observed leaving group and going to play nearby. At both locations, children were encouraged to raise their hand and wait to be called on before sharing to the group. Teachers in all of the classrooms were observed telling children to, "Be patient. It's almost your turn." While this was the primary strategy for teachers at the nature-based preschool when children wanted a turn at an activity during free play, teachers at the traditional preschool showed other strategies to help children wait for their turn. For example, while waiting for a popular item at the traditional preschool, a teacher created a list with students to determine who was next in line for the activity. This gave children an opportunity to conceptualize when it would be their turn for the activity. All three traditional classrooms were also observed singing a song that reminded children to control their bodies. This song was first observed when children at the traditional preschool went to large group, however it was utilized throughout the observations as needed. One teacher at the nature-based preschool was observed playing 'Simon Says' their classroom, which can help children develop behavioral self-regulation skills (Browne, 2015).

Research Question 2

To answer Research Question 2, multiple one-way between-groups analysis of covariance were conducted to compare the effects of nature-based education on early literacy, reasoning, and EF. Participants propensity scores (comprised of gender, age, household income, and maternal education) were used as the covariate in this analysis. Means and standard deviations for each assessment, separated by group are presented in Table 1.

Early Literacy

Children who attended the nature-based preschool showed equivalent growth to children who attended a traditional preschool, on all three early literacy skills.

Test of Preschool Early Literacy (TOPEL). An independent-samples t-test was conducted to compare the initial phonological awareness skills for children at both preschools. There was no significant difference in fall scores for children who attended the nature-based preschool (*M* = 100.23, *SD* = 15.08) and children who attended the traditional preschool (*M* = 94.60, *SD* = 16.70); *t* (111) = 1.85, *p* = .07, two-tailed). The magnitude of the differences in the means (mean difference = 5.62, 95% *CI:*-.41 to 11.66) was small (eta squared = .03).

Children's spring phonological awareness scores (nature-based: *M* = 103.03, *SD* = 13.82; traditional: *M* = 97.60, *SD* = 17.45) were used to calculate the growth each child made over the school year. After adjusting for participants propensity scores, there was no significant difference between the two preschools on phonological awareness growth, *F* (1, 95) = 1.49, *p* = .23, partial eta squared = .02. This shows children at both preschools gained equivalent phonological awareness skills over the course of the school year.

Letter Name Knowledge. An independent-samples t-test was performed to assess any initial differences in letter name knowledge for children at both preschools. While, on average, children who attended the traditional preschool know about 5 letters more at the start of the year (*M* = 23.26, *SD* = 17.67) than the children who attended the nature-based preschool (*M* = 18.36, *SD* = 17.30), this difference was not statistically significant (*t* (122) = -1.52, *p* = .13, two-tailed). The magnitude of the differences in the means (mean difference = -4.90, 95% *CI:*-11.27 to 1.45) was small (eta squared = .03).

Children's letter name knowledge growth was calculated from their spring scores (nature-based: *M* = 24.74, *SD* = 16.87; traditional: *M* = 31.77, *SD* = 16.84). After including children's propensity scores, no significant difference was found between children who attend the nature-based and the traditional preschool, *F* (1, 103) = .001, *p* = .98, partial eta squared = .00. This shows that children were able to grow in their letter name knowledge at similar rates at each preschool.

Letter Sound Knowledge. To assess if there were initial differences in children's letter sound knowledge, an independent-samples t-test was conducted. There was no significant difference between children who attended the nature-based preschool (*M* = 5.23, *SD* = 6.56) and children who attended the traditional preschool (*M* = 6.96, *SD* = 7.10; *t* (120) = -1.38, *p* = .17, two-tailed). The magnitude of the differences in the means (mean differences =-1.73, 95% *CI:* -4.22 to .76) was small (eta squared = .02).

Children at both preschools showed growth in their spring letter sound knowledge (nature-based: *M* = 7.50, *SD* = 7.33; traditional: *M* = 9.87, *SD* = 8.76). There was no significant difference in growth in letter sound knowledge between children who attended the nature-based preschool and children who attended the traditional preschool, *F* (1, 102) = .10, *p* = .68, partial eta squared = .002. This shows children grew equivalently at both preschools in their letter sound knowledge.

Reasoning

In this study, we found most children were unable to answer all the control questions that were necessary to move on to the scored assessment. For this reason, children's score on the control questions were used to assess children's reasoning ability. An independent-samples t-test was used to assess differences in fall scores on the control questions of the reasoning task for children who attended the nature-based preschool and the traditional preschool. There was no significant difference in scores for children who attended the nature-based preschool (*M* = 3.21, *SD* = .79) and children who attended the traditional preschool (*M* = 3.02, *SD* = .75; *t* (116) = 1.28, *p* = .20, two-tailed). The magnitude of the differences in the means (mean difference = .19, 95% *CI*: -.10 to .47) was very small (eta squared = .01).

Children's spring reasoning scores (nature-based: *M* = 3.19, *SD* = .63; traditional: *M* = 3.16, *SD* = .64) were used to calculate the growth each child made on their reasoning skills. After adjusting for participants propensity scores, there was no significant difference between the two preschools on reasoning growth, *F* (1, 97) = 1.58, *p* = .21, partial eta squared = .02. This shows children at both preschools did not differ in their growth of reasoning skills over the course of the school year.

Executive Function

Data were analyzed to measure children's growth in working memory, inhibitory control, and the integration of EF components.

Picture Sequence Memory Test. An independent-samples t-test was conducted to compare the initial differences is working memory for children based on preschool setting. There was no significant difference in scores for children who attended the nature-based preschool (*M* = 2.99, *SD* = 3.09) and children who attended the traditional preschool (*M* = 3.38, *SD* = 3.13; *t* (118) = -.70, *p* = .49, two-tailed). The magnitude of the differences in the means (mean difference = -.40, 95% *CI:* -1.53 to .73) was very small (eta squared = .004).

Children's growth in working memory was calculated from children's spring scores (nature-based: *M* = 4.44, *SD* = 3.57; traditional: *M* = 3.32, *SD* = 3.90). There was no significant difference between the two schools on working memory growth, *F* (1, 97) = .12, *p* = .73, partial eta squared = .001. This shows children at both preschools gained equivalent working memory skills over the course of the school year.

Flanker Inhibitory Control and Attention Test. To assess if there were initial differences in children's inhibitory control, an independent-samples t-test was performed. There was no significant difference in scores for children who attended the nature-based preschool (*M*

= 19.98, *SD* = 10.51) and children who attended the traditional preschool (*M* = 19.17, *SD* = 11.07; *t* (109) = .39, *p* = .69, two-tailed). The magnitude of the differences in the means (mean difference = .74, 95% *CI:* -3.28 to 4.91) was very small (eta squared = .001).

Children's growth in inhibitory control was calculated from children's spring scores (nature-based: *M* = 23.38, *SD* = 11.96; traditional: *M* = 26.69, *SD* = 11.99). There was no significant difference between the two schools on inhibitory control growth, *F* (1, 87) = 2.44, *p* = .12, partial eta squared = .03. This shows children at both preschools gained equivalent inhibitory control skills over the course of the school year.

Head-Toes-Knees-Shoulders. To assess if there were differences in children's fall scores on the behavioral self-regulation measure, an independent-samples t-test was conducted. There was no significant difference in the scores for children who attended the nature-based preschool (*M* = 14.26, *SD* = 17.62) and children who attended the traditional preschool (*M* = 13.47, *SD* = 16.34; *t* (111) = .24, *p* = .81, two-tailed). The magnitude of the differences in the means (mean difference = .79, 95% *CI:* -5.79 to 7.37) was very small (eta squared = .001).

Children's growth in behavioral self-regulation was calculated from their spring scores (nature-based: *M* = 13.25, *SD* = 16.87; traditional: *M* = 22.70, *SD* = 18.59). There was a significant difference between the two schools on children's growth on behavioral self-regulation, *F* (1, 88) = 13.67, *p* < .001, partial eta squared = .134. This shows children at the traditional preschool gained more skills in this area, compared to children who attended the nature-based preschool.

Discussion

Nature-based preschools are on the rise across the United States (NAAEE, 2017), so it is important to assess to what extent these programs provide children the skills necessary to be successful in kindergarten and beyond. Nature-based preschools provide supports for children to gain early literacy, reasoning, and some EF skills at rates equivalent to children who attend a traditional preschool. Early literacy instruction happened at a similar frequency in both the nature-based preschool and the traditional preschool, with literacy activities at the nature-based preschool resembling those that occurred in the traditional preschool. Science instruction was more likely to occur at a nature-based preschool, but children at both types of preschool showed equivalent growth in their reasoning skills over the school year. Children at both preschools showed similar growth in their working memory and inhibitory control/attention skills; however, behavioral self-regulation scores were greater for children who attended the traditional preschool.

Early Literacy

Children at both schools showed equivalent developmental gains on early literacy skills; suggesting that nature-based preschools help children develop early literacy skills. Early literacy skills are necessary precursors to later conventional literacy skills, such as reading, writing, spelling and comprehension (NELP, 2008; Lonigan et al., 2000; Whitehurst & Lonigan, 1998) and predict success in later schooling (Duncan et al., 2007). The current study shows children were able to develop a wide range of early literacy skills in a nature-based setting.

The growth in early literacy skills for children who attended the nature-based preschool may be due to the frequency of activities that could promote the development of this skill. All preschool classrooms engaged in a variety of early literacy activities. These activities occurred throughout the day for every classroom, suggesting a focus on literacy activities in preschool classrooms, regardless of setting. This is consistent with prior observational research in traditional preschool classrooms that shows teachers spend a majority of their classroom instructional time engaged in literacy activities (Early et al., 2010; Gerde et al., 2018).

In addition to the time spent on literacy skills, the nature-based and traditional preschools incorporated similar activities for children to accumulate the early literacy skills measured as part of the present work. Specifically, there was a focus in all classrooms on phonological awareness, letter identification, and early decoding skills. All teachers sang songs throughout their day which have been shown to support language and literacy skills in children (Hansen, Bernstorf, & Stuber, 2014; Mizener, 2008; Wiggins, 2007). Many classrooms, at both locations, asked children to generate rhymes during activities, which can help to develop phonological awareness skills (Chaney, 1992; Goswami & East, 2000; Maclean et al., 1987). For the development of decoding skills, both preschools focused on children's understanding of letter names and the sounds associated with them (Chard et al., 1998; Kendeou et al., 2009; Nicholson, 1997). All three of these activities help preschool children gain skills necessary to be successful in later grades (Downer & Pianta, 2006; Duncan et al., 2007). Findings suggest that early literacy instruction provided in an outdoor setting can be as efficacious as instruction provided indoors.

In addition to large group early literacy activities, there were numerous opportunities for children to gain early literacy skills throughout other times during the day. For example, one of the traditional classrooms set-up a post office in their pretend play area. During free play, children were observed writing letters to fellow classmates, teachers, and family member. One of the classroom teachers helped children address their letters so they could be delivered. Not only was this an opportunity for children to practice their early writing skills, the teacher also used it as an opportunity for some informal phonological awareness and decoding instruction. The teacher was observed helping a child determine who to deliver a letter to by sounding out the name on the letter, “This person’s name starts with what letter? M! What sound does ‘m’ make? Whose name starts with a /m/ /m/ sound?” At the nature-based preschool, letters were discussed at snack time due to a child’s observation that they could form their pretzels into letters. Children were heard creating and identifying both uppercase and lowercase letters, which they were excited to show others at the table. Teachers at the nature-based preschool supported this activity by asking questions such as, “What letter did you make?” or “Can you create an uppercase ‘H’?” This entire learning opportunity arose organically from children’s observations and interests, which the teacher was then able to support by helping children correctly identify and create letters. Both preschool environments showed many opportunities for children to gain early literacy skills throughout daily activities, which is consistent with findings in other preschool classrooms (Connor et al., 2006).

While both preschools provided similar opportunities for early literacy instruction, there were differences in the availability of resources to assist with children’s early literacy learning, specifically books and writing materials. Both preschool’s indoor classrooms had books available for children; however, the indoor classroom was used infrequently at the nature-based preschool. While almost every classroom was shown to engage in book reading during the observations, children at the traditional preschool were more likely to read books outside of whole group experiences. For example, during free play at the traditional preschool, children were observed asking a teacher to read them a book, reenacting a story on a felt board, or reading books by themselves. At the nature-based preschool, children who were in the indoor classroom were observed initiating book reading sessions; however, children who remained outdoors for free play were rarely observed initiating a book reading session. This may be because most of the books at the nature-based preschool were kept in the indoor classroom. While children were not restricted from going into the classroom to retrieve a book, having books readily available to children in the classroom is associated with literacy development (Neuman, 1999). This also appeared to be true for writing materials. While it has been hypothesized that children would have opportunities for more meaningful writing experiences due to the use of science journals at a nature-based preschool (Brenneman & Louro, 2008; Eick, 2011), this study found children engaged in writing activities more at the traditional preschool. This may be due to the prevalence of traditional materials available in the immediate environment. For example, in the traditional preschool classrooms writing materials were available to children throughout the day. When writing activities did occur in the nature-based classrooms, traditional materials were used (e.g., children wrote their name on a whiteboard to make a prediction). While it may be challenging for children at nature-based preschools to have regular access to pencils and paper outdoors, teachers can encourage children to use sticks to write letters in the mud or use natural objects to create letters.

Reasoning

It was hypothesized that children who attended the nature-based preschool would show more growth in their reasoning ability, due to the inherent opportunities for science exploration in a nature-based classroom. However, this study found children at both preschools gained equivalent reasoning skills over the school year.

This study hypothesized children at nature-based preschools would gain more reasoning skills due, in part, to their exposure to more natural materials; however, this study found children at both preschools had access to natural materials in their classroom environment. The nature-based preschool incorporated natural materials into the indoor classroom, the outdoor play space, and the woods where they took daily hikes. The traditional preschool used in this study had natural materials available around the classroom (such as leaves used for an art activity) and in the outdoor play space (the traditional preschool had Nature Explore Certification; Nature Explore, 2017). Most classroom science assessments use the presence of natural materials in the classroom as one way to assess the quality of the science-learning environment (see Brenneman, 2011 for a review). While both preschools provided access to natural material, children at the nature-based preschool were observed engaging with these materials more frequently than children at the traditional preschool. Children's early engagement with science materials predicts later interest in science (Alexander, Johnson, & Kelley, 2012), a subject children in the United States are continually underperforming in (NCES, 2012). The nature-based preschool provided children with numerous opportunities to grow their science reasoning knowledge, such as learning in a natural setting and letting children's curiosity guide their learning process (Yoon & Onchwari, 2006), which could lead to a lasting impact on children's later reasoning ability. Future studies should consider the long-term effects of nature-based education on children's development of scientific reasoning skills.

While the nature-based classrooms engaged in more science activities than the traditional classrooms, the amount these activities focused on developing children's reasoning skills varied. No science instruction was observed in the traditional classrooms. When science activities occurred at the nature-based preschool, these activities tended to focus more on developing conceptual knowledge and less on reasoning skills. For example, one nature-based classroom was observed conducting a science lesson on different animal's furs. The focus of the lesson was more on facts associated with different animal furs, as opposed to why these furs differ based on the needs of the animal. There was however variability; another nature-based preschool classroom was observed incorporating more reasoning skill when children did an activity that involved making “potions” during large group. Children were able to mix different colored water and add materials found around the outdoor space (i.e., sticks, dried leaves, etc.) to create their “potion.” Throughout this process, teachers were observed asking questions about the potions that could facilitate the development of reasoning skills (Bao et al., 2009; Zimmerman, 2007), such as, “What do you think will happen if you add blue water to your potion?” or “How do we make a green potion?” This type of scaffolding by teachers allows children to develop their scientific reasoning skills (Alfieri et al., 2011; Hmelo-Silver et al., 2007). While teachers at both preschool locations asked “how” and “why” questions throughout the day that could promote the development of children’s reasoning skills, teachers at the nature-based preschool were more likely to ask these types of questions during a science activity.

While young children are capable of reasoning (Gopnik, 2012), this study found children’s reasoning ability to remain fairly stable over the course of the school year. This trend was true for children who attended either the nature-based or the traditional preschool. The minimal growth observed in children’s reasoning ability could be the result of the measure chosen in this study. The data from the Mouse House task showed significant floor effects for all children; with almost two-thirds of children at either preschool not being able to take the assessment due to incorrect answers on the control questions. Thus, the measure used may not have been sufficiently sensitive to the reasoning gains children were making over the course of the school year.

Executive Function

The findings related to EF were mixed, as children displayed equivalent growth in working memory and inhibitory control, yet children who attended the traditional preschool showed more growth in behavioral self-regulation compared to children who attended the nature-based preschool. These results are surprising, as previous research has found positive effects of nature on children's EF skills (Burdette & Whitaker, 2005; Dadvand et. al., Faber Taylor & Kuo, 2009; Ulset et al., 2017).

Children at the nature-based preschool showed equivalent growth to children at the traditional preschool in individual components of EF, specifically working memory and inhibitory control/attention. The growth in these EF components may be due to the practices used in both preschools. For example, both the nature-based preschool and the traditional preschool asked children to 'recall' where they had played throughout the day. This is often used as a strategy to promote working memory in young children (Bodrova & Leong, 2006). Children were also reminded to focus during group activities regardless of setting which can contribute to their development of attention skills (Kusche & Greenberg, 1994; Webster-Stratton & Reid, 2004).

While this study hypothesized children would show more growth in EF skills, the equivalent growth in children may be attributed to the nature of the EF skills investigated as part of the present work. In particular, current research suggests that working memory may not be as malleable as previously thought (Rapport, Orban, Kofler, & Friedman, 2013). There is currently debate in the field of how malleable individual components of EF are. Some researchers have shown working memory can be improved through specialized training (Green et al., 2012; St.

Clair-Thompson, Stevens, Hunt, & Bolder, 2010); while others argue that previous studies have been too quick to generalize their findings (Shipstead, Hicks, & Engle, 2012).

These findings help expand the existing literature on the role nature plays in the development of children's working memory and inhibitory control/attention skills. Only one previous study was found that compared the development of these skills in preschool children who had more exposure to nature to children who had less exposure to nature (Schutte et al., 2017). Schutte and colleagues (2017) assessed children in a lab setting; children were first asked to complete a mentally fatiguing task in the lab, then went for a walk either with urban surroundings or natural surroundings. Finally, children were brought back into the lab to complete the assessments. The current study differed in that it was conducted in a naturalist setting. This helps provide more information about the effects of nature on children's working memory and inhibitory control/attention in the real world. This study found equivalent growth in working memory and inhibitory control/attention for children at both preschool settings, showing children who attended a nature-based preschool were able to develop these skills as well as if they had attended a traditional preschool.

Despite equivalent growth in working memory and inhibitory control/attention, children at the traditional preschool showed a greater change in scores on the behavioral self-regulation assessment, compared to children who attended the nature-based preschool. Evidence demonstrates that, beginning around the age of three, EF skills, including those related to behavioral self-regulation, begin to show rapid, exponential growth, which does not begin to taper off until later in life (Pointz, McClelland, Matthews, & Morrison, 2008; Chang, Shaw, Dishion, Gardner, & Wilson, 2014; Clark et al., 2013; Montroy, Bowles, Skibbe, McClelland, & Morrison, 2016; Wiebe, Sheffield, & Espy, 2012). The scores for the children who attended the nature-based preschools did not reflect the developmental trajectory observed across a number of studies, as many children had scores that decreased over the course of the study. It is possible that the decreases observed in the present study are illusory and represent confounds associated with the testing process itself. Children attending the nature-based program exhibited a high rate (approximately 15%) of refusal, especially when compared to children who attended the traditional preschool, when asked to be assessed, particularly during the spring assessment occasion. During the fall and in the spring, assessors noted that children at the nature-based preschool were eager to return to the classroom and were concerned about what was happening in the classroom while they were taking the assessments, perhaps because assessments occurred indoors and required children to forgo hikes or other outdoor activities.

In addition, classroom observations suggested that teachers at the nature-based preschool might have missed opportunities to support some aspects of children's EF, particularly with regard to the ways in which they managed children's behaviors within their classes. At the nature-based preschool, teachers allowed children to wander away from group meetings to play independently without permission. When this happened at the traditional preschool, teachers would redirect the child back to the group activity. In addition, children at the nature-based preschool were allowed to shout and run around throughout the outdoor classroom. If these actions occurred in the traditional preschool, teachers were observed redirecting these behaviors. Classroom management strategies and child redirection have been shown to improve EF skills in children (Diamond & Lee, 2011; Webster-Stratton, Reid, & Stoolmiller, 2008). Other behavioral self-regulation practices, such as raising one's hand at group, were emphasized at both preschool locations. Overall, these behaviors appeared to be more closely monitored and redirected at the traditional preschool; indicating behavioral self-regulation skills may have been more highly prioritized at the traditional preschool.

Limitations

There were several limitations to this study. First, this study looked at how specific activities or classroom practices contributed to children's early literacy, reasoning, and EF development for children attending a nature-based preschool. However, the skills examined in this study are only a subset of those thought to benefit most from exposure to nature. For example, it is hypothesized that play outdoors may lead to the development of more complex vocabulary use in children due to a natural curiosity to learn more about the world around them (Eick, 2011; Finch & Bailie, 2015). Children who attend a nature-based preschool may show growth in areas such as language, math, gross and fine motor skills, and connection to the environment (NAAEE, 2017). Future studies on nature-based education should include assessment of additional domains to present a more complete picture of how nature-based education affects children's development.

Next, this study compared nature-based preschool classrooms and traditional preschool classrooms in the Midwest from upper-middle class families. While both of the preschools used in this study were chosen as representatives of high-quality early childhood education, preschool programs and how activities are conducted, vary by program and state (Hatcher, Nuner, & Paulsel, 2012; Kindle, 2011). Preschools located in urban environments have been shown to spend less time outside than the preschools used in this study (Marino, Fletcher, Whitaker, & Anderson, 2012). Interactions with nature may have a greater impact on children from communities where children have less access to nature.

As mentioned earlier, the difference in exposure to nature at both preschools was not as great as in previous research (Burdette & Whitaker, 2005; Dadvand et. al., Faber Taylor & Kuo, 2009; Ulset et al., 2017). Previous studies have compared limited interactions with nature and interactions with an urban environment (Berman et al., 2008; Faber Taylor et al., 2003; Schutte et al., 2017; Wells, 2000), the amount of "greenness" at home and school (Dadvand et al., 2015) or were correlational in nature (Kuo & Faber Taylor, 2004). It is possible that developmental gains in early literacy, reasoning, and EF would be greater if this study had compared children at the nature-based preschool to children at a preschool with less exposure to nature, but still equivalent in other areas. Using an experimental design in future studies on nature-based education would provide a more rigorous methodological approach.

Conclusions

Nature-based preschools can be successful at promoting children's development in a variety of domains. Children who attended the nature-based preschool showed equivalent growth in early literacy, reasoning, and most EF skills, suggesting high-quality preschool programs can occur in a variety of settings. Nature-based preschools were shown to spend significantly more time outside throughout the day, which may have additional benefits for children's development that were not analyzed in the present study. As more parents are choosing non-traditional preschool programs for their children, it is important to ensure these programs are providing children with skills necessary to be successful in kindergarten and beyond. Preschools set in nature, or in other unique settings, can excel in providing children these skills.

APPENDICES

APPENDIX A. Tables

Table 1.

Demographic Information of Study Participants by Preschool Type

	Nature-Based (*n* = 82)	**Traditional (*n* = 58)**
Fall Age (months)		
Mean (*SD*)	47.76 (*7.04*)	50.16 (*6.51*)
Range	37 - 60	35 - 61
Gender		
Female	27 (32.9%)	29 (50%)
Male	55 (67.1%)	29 (50%)
Race		
White/Caucasian	74 (90.2%)	39 (67.2%)
African-American/Black	--	2 (3.4%)
Hispanic/Latino	--	1 (1.7%)
American Indian/Alaskan	2 (2.4%)	2 (3.4%)
Asian/Pacific Islander	3 (3.7%)	7 (12.1%)
Other	3 (3.7%)	7 (12.1%)
Maternal Education (highest degree)		
Some high school	--	4 (6.9%)
High school diploma	1 (1.2%)	1 (1.7%)
Some college	14 (17.1%)	6 (10.3%)
Undergraduate degree	38 (46.3%)	18 (31%)
Graduate/Professional school	28 (34.1%)	28 (48.3%)
Missing	1 (1.2%)	1 (1.7%)
Income		
< $25,000	5 (6.1%)	11 (20.8%)
$25,000 - $49,000	14 (17.1%)	6 (11.3%)

Table 1. (cont'd)

$50,000 - $74,999	20 (24.4%)	7 (13.2%)
$75,000 - $99,999	17 (20.7%)	4 (7.5%)
> $100,000	26 (31.7%)	25 (47.2%)

Table 2.

Descriptive Statistics for Outcome Variables by Preschool Type

	Nature-Based				Traditional			
	Fall		Spring		Fall		Spring	
Outcome	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Early Literacy								
TOPEL	100.23	15.08	103.03	13.82	94.60	16.70	97.60	17.45
Letter Name	18.36	17.90	24.74	16.87	23.26	17.67	31.77	16.84
Letter Sound	5.23	6.56	7.50	7.33	6.96	7.10	9.87	8.76
Reasoning								
Mouse House	3.21	0.79	3.19	0.63	3.02	0.75	3.16	0.64
Executive Function								
Picture Sequence Memory	2.99	3.09	4.44	3.57	3.38	3.13	3.32	3.90
Flanker Inhibitory Control and Attention	19.98	10.51	23.38	11.96	19.17	11.07	26.69	11.99
Head-Toes-Knees-Shoulders (HTKS)	14.26	17.62	13.25	16.87	13.47	16.34	22.70	18.59

APPENDIX B. Observational Coding Scheme

Nature-Based Preschool Video Coding Sheet

Video ID:____________________ Time:___________________

Coder ID:____________________

Early Literacy (Neuman & Dickinson, 2011 unless otherwise cited)

Read a book ____

Evidence:

Sang songs (Hansen et al., 2014) ____

Evidence:

Phonological/Sound development (e.g., rhyming, "s makes a ssss sound") ____

Evidence:

Introduces new vocabulary word __________________________________

Evidence:

Writing activities ____

Evidence:

Other ____

Evidence:

Reasoning

Asks "why" or "how" questions (Bao et al., 2009; Zimmerman, 2007)___________________

Evidence:

Conducts a science lesson _______________________________________

Evidence:

Children have access to natural materials (Brenneman, 2011) _________________

Evidence:

Other: ____

Evidence:

Executive Function

Children were asked to recall events (Bodrova & Leong, 2007) ____________________

Evidence:

Children were asked to provide a plan ((Bodrova & Leong, 2007) ____________________

Evidence:

Teachers helped mediate a conflict (Bodrova & Leong, 2007; Lockhart, 2010) ______________

Evidence:

Encourages a child to control their actions (Kusche & Greenberg, 1994; Webster-Stratton & Reid, 2004) ____

Evidence:

Teachers give children notice of transitions (e.g., 5 more minutes; Webster-Stratton & Reid, 2004) ____

Evidence:

Other ____

Evidence:

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