International Journal of Early Childhood Environmental Education

ISSN: 2331-0464 (online)

# Supporting School Readiness Naturally: Exploring Executive Function Growth in Nature Preschools

**Jenna Zamzow**
*Little Hawks Discovery Preschool, USA*

**Julie Ernst**
*University of Minnesota Duluth, USA*

Submitted June 30, 2019; accepted February 14, 2020

**ABSTRACT**

This study utilized the Minnesota Executive Function Scale to quantitatively explore the influence of nature preschools on executive function skills, which are a critical component of school readiness. Executive function skills are malleable skills that allow goal setting and follow through, skills that determine success in school and beyond. Four nature and two non-nature preschools participated in the study. These six preschools shared a child-centered, play-based approach toward supporting holistic development across the domains. The primary difference between the nature and non-nature preschools was in the proportion of the day spent outdoors and the location of the outdoor play time (in nature v. in maintained outdoor settings). Results suggest significant executive function skill growth among the nature preschool participants; this growth was similar to that observed in the non-nature preschool participants. Additionally, children across the nature and non-nature preschools had growth in executive function skills that exceeded what would be expected in typically developing children. Implications for further research are discussed.

***Keywords****:* executive function skills, nature preschool, school readiness

Splashing in puddles, creating confections out of mud, and experiencing the natural world with all of one's senses are experiences that are rapidly diminishing from childhood. Concerned early childhood educators have designed nature-based programs that allow young children to experience the freedom and wonder of the outdoors. The number of nature preschools operating in the United States is at an all-time high and steadily growing, with a 66% increase in nature preschools and forest kindergartens between the years of 2016 and 2017 (NAAEE, 2017). However, nature preschools have yet to be embraced as mainstream. There is often a tendency in the United States to position child development as a race and children as something that need to be "readied" for school, a movement that has "academified" early learning in order to support the standards-based accountability movement in K-12 schools. For example, the U.S. Department of Education's Office of Early Learning (2017) has several key initiatives underway. One focuses on early literacy, emphasizing effective reading instruction to ensure students read on grade level by third grade. Another set of initiatives focuses on screening and assessment, with guidance for comprehensive early learning assessments and recommendations to help educators effectively use data to monitor students' academic progress and evaluate instructional practices. In the landscape of early learning, nature preschools evolved as a counter movement to viewing development as a race. Further research is needed to promote the transfer of the pockets of implementation into mainstream, routine use.

Due to concerns regarding the ability of nature preschools to prepare children academically for Kindergarten, a concern that has limited widespread acceptance of nature preschools, this study explored nature preschoolers'

growth of executive functions skills, as they are a critical component of school readiness. Executive function (EF) skills are the attention-regulation skills that allow conscious and goal-oriented planning. The subset of skills involved includes working memory, cognitive flexibility and inhibitory control. These skills are highly predictive of academic achievement (Ackerman & Friedman-Krauss, 2017; Zelazo, Blair & Willoughby, 2016; Moreno, Schwayder, & Friedman, 2016). While executive function skill development is essential to a preschooler's future academic success, the development of these skills coupled with a love for nature could also support the next generation in their effort to achieve sustainability goals. The purpose of this study was to compare the growth in executive function skill development over the course of a school year between children attending nature preschools and children attending non-nature preschools.

**REVIEW OF LITERATURE**

Nature preschools offer high-quality early childhood curriculums that put nature at the heart of the program and use children's interests and seasonal changes to guide daily experiences in nature (NAAEE, 2017). Nature preschools typically differ from traditional or non-nature preschools in several ways. Nature preschoolers often spend more than half of their class time outdoors, in settings that range from maintained natural playscapes to hundreds of acres of wild natural space (Larimore, 2011; Sobel, 2014). Forest schools are sometimes misconstrued as synonymous with nature preschools as the philosophies of the two are similar. Nature preschool programs are typically defined as licensed programs that include indoor classroom space where nature has been infused, whereas a forest school may have no indoor space at all, or provide something very minimal such as a yurt for severe weather (Sobel, 2014; Larimore, 2016). The nature preschool setting and philosophy encourages more child-directed decision making and risk-taking than a non-nature preschool typically does. Further, a nature preschool class period is predominantly devoted to free or guided play as opposed to teacher-led instruction. This last component is not unique to nature preschool; many preschool programs implement free play in their curriculum both indoors as well as outdoors. However, the combination of daily and sustained time periods of free play in *natural* outdoor spaces is unique to nature preschools.

Executive function (EF) skills are the attention-regulation skills that allow conscious planning and the ability to work towards goals. Based on the findings of recent brain imaging studies, executive function skills are comprised of a set of subskills: working memory, cognitive flexibility, and inhibitory control (Zelazo, Blair & Willoughby, 2016). Working memory involves keeping some piece of information in mind while (usually) manipulating it in some way, for example remembering to raise your hand and wait to be called on before giving an answer. Cognitive flexibility involves thinking about something from multiple perspectives, for example, considering someone else's point of view in a disagreement. Inhibitory control is the process of consciously suppressing attention (and subsequent response) to a stimulus, for example, focusing on the teacher when peers are causing distractions (Zelazo et al., 2016; Ackerman & Friedman-Krauss, 2017).

Executive function skills are critical, as they are the foundation for learning, follow through, and goal achievement. Executive function skills support higher-level cognitive processes, such as goal-directed problem solving, and are directly related to self-regulation (Marcovitch, Jacques, Boseovski & Zelazo, 2008). Along with the reflective processes that underlie them, executive function skills allow for more engaged, active, and reflective forms of learning (Marcovitch, et al., 2008). These skills are separate from IQ, and a better predictor of academic outcome than IQ. IQ is a construct that is considered to be more "fixed" while executive function skills can be taught, learned and developed (Executive Functioning Assessments, 2017). Over the past decade, executive function skills have emerged as critical predictors of developing positive approaches to learning and therefore school readiness (socially and academically), as well as academic performance at school entry and long-term (Barker et al., 2014; Vitiello and Greenfield, 2017). In a 2013 study, executive function skills were shown to significantly contribute to emergent literacy, mathematical, and orthographic (e.g. word recognition, phonological awareness) knowledge (Shaul and Schwartz, 2013). Further, greater executive function skills in children are shown to be associated with higher involvement in learning opportunities and social learning interactions, and less occurrences of disruptive behaviors in a school setting. These were related to making greater gains in pre-literacy and mathematics (Nesbitt, Farran, and Fuhs, 2015).

Suboptimal circumstances may play a role in executive function development. Studies have shown a relationship between socioeconomic status and executive functioning in childhood, where children from lower SES households also showed lower EF functioning (Lawson, Hook & Farah, 2017). Prenatal and child health issues can also negatively affect the development of EF skills (Ackerman & Friedman-Krauss, 2017). Research suggests that children with low levels of executive function skills grow to have poorer health, social, and economic outcomes when they reach adulthood (Moffitt et al., 2011).

Brain development during early childhood occurs at an unprecedented rate, and the development of executive function skills is no exception. Executive function skills are housed in the prefrontal cortex; the malleability of this area of the brain is heightened in early childhood and once again in early adolescence. Heightened malleability during these time periods of life means that experiences have a more powerful impact on the wiring of the brain than during other periods of the lifespan. This elevated level of malleability underscores the importance and influence of experiences at these times (Center on the Developing Child, 2011).

Much of the work investigating experiences that support executive function skills has involved adult-led, targeted training or interventions, where children practice a particular executive function skill while the adult provides guidance and feedback (Barker, et al. 2014). These appear to be successful in fostering externally-driven executive function, with children making improvements in their ability to carry out the goal-directed behavior when instructed on what behavior to do and when (Holmes, Gathercole & Dunning, 2009). Longer-term interventions also have been implemented within preschools through curriculum designed to practice these skills through games and activities, scaffolded activities integrated into the daily routine, and even comprehensive, full day curriculum programs, such as *Tools of the Mind* (Diamond, Barnett, Thomas & Munro, 2007). Diamond and Lee (2011) suggest more holistic approaches that address emotional, social, and physical development alongside executive function skills are likely more effective than interventions solely focused on executive function skills. More recent research has uncovered a relationship between self-directed executive functioning and amount of time spent in structured activities. Barker, et al. (2014) found that when young children's daily schedule had less structure, they had higher levels of executive functioning, even when controlling for age, verbal ability, and household income. Recent research by White et al. (2017) suggests a relationship between symbolic skills and executive functioning, with tentative implications for pretend role-play as a means for supporting executive function skill development through helping children learn to adopt a new way of thinking about a task or problem at hand.

Play is the vehicle of learning in early childhood, and thus having a focus on play is fundamental to any curriculum that is developmentally appropriate for preschool (Brussoni, Olsen, Pike & Sleet, 2012). Nature play (freely chosen, unstructured, and open-ended playful interactions with and in nature) is a feature of nature preschools. Nature play provides children with open-ended unstructured time, and thus much of children's time in nature preschools is spent in unstructured rather than structured activities. Further, nature preschools typically view children as capable decision-makers and encourage autonomy, especially through allowing them to lead play and learning rather than the teacher's direct instruction using the majority of the class time. Studies have shown that when influential adults, such as parents, allow children to have agency and control over some decisions, executive function skills can thrive (Meuwissen and Carlson, 2015). Thus, these aspects – amount of unstructured time and opportunities to be autonomous decision-makers through child-initiated, free play – may also be supporting executive function skill development.

The composite effect of a play-based curriculum in a natural environment may positively influence executive function development in nature preschool participants, grounded in the unique experiences participants are afforded through interactions with and in nature. A space devoid of typical plastic toys and metal playground equipment yet replete with natural loose parts organically encourages imaginative, pretend play (Banning and Sullivan, 2011). Imaginative play often involves the components of executive function; a child must remember the storyline they are imagining, switch their mindset when others take on characters or objects take on new purposes, and inhibit the reflex to behave in their typical manner (Moreno et al., 2016)In addition to the abundance of loose parts, natural settings afford diverse and expansive opportunities for young children to take appropriate risks, set their own goals, problem-solve, and choose roles and activities that produce feelings of competence. While child-initiated play in an indoor setting or on a playground might allow for some of this, it seems possible that the

opportunities for these experiences are even greater in nature, as the boundaries, variety, and holistic challenges are likely to be more authentic and extensive.

Carr, Brown, Schlembach & Kochanowski (2017) investigated the influence of nature playscape affordances on children's executive function skills by identifying examples of goal-directed and focused problem-solving during children's free play in nature playscapes. Through their research, they found evidence of inhibitory control, flexibility, working memory, as well as initiation, planning and organization, and monitoring, speculating that well-designed nature playscapes, with the opportunities for problem-solving, risk-taking, and using natural loose parts, encourage and potentially even enhance executive function skills. Thus, it may be that outdoor natural environments are actually more conducive than indoor environments to the kind of play that supports the development of executive function skills.

## METHODOLOGY

### Research Purpose and Overarching Design

The exploratory study at hand investigated executive function skill growth in children attending nature preschools. It was speculated, building upon Carr's (2017) research, that nature preschoolers would not only grow in their executive function skills, but that the growth would exceed that seen in non-nature preschool participants, due to the affordances of natural settings as places for unstructured play. Three research questions were addressed in this study:

1) Do executive function skills significantly increase from the beginning to the end of the school year in participants attending a nature preschool?
2) Is the growth in executive function skills seen in nature preschools participants over the course of the school year greater than the growth seen in non-nature preschool participants?
3) Is the executive function growth seen in nature preschool participants different than growth expected from typical, cognitive maturation?

This exploratory study was undertaken during the 2017-2018 academic year using a pretest-posttest non-randomized comparison group design. Four nature preschools in northern Minnesota, U.S., served as the treatment group, and two non-nature preschools in northern Minnesota, U.S., served as the comparison group. At each of these four nature preschools, there was a lead teacher who had been at that particular nature preschool since its inception. A child-directed approach was used at all four of these nature preschools to support development and learning across the domains, with the majority of time spent outdoors in nature play, regardless of weather conditions (approximately four to five hours daily of play in and with nature for the full day programs, and for half-day preschoolers, two to three hours). All four utilized a combination of natural settings for nature play, including unmaintained ("wild") natural settings, natural spaces that were minimally managed for nature play, and natural playscapes designed specifically for nature play. Each had indoor areas that were used minimally throughout the day; one-half to two hours were spent indoors, with the majority of that time in free play, and approximately 30 minutes of that time in teacher-led, playful learning experiences. There was a total of 78 participants from these four nature preschools, and participants had a mean age of 58 months.

While the intent was to include four non-nature preschools in the control group, it was difficult to find non-nature preschools who were willing to participate. The two non-nature preschools were selected based on their willingness to participate, and due to being located in a similar geographic location, having a similar tuition structure, and being of a similar demographic make-up. One of the non-nature preschools was administered by the local university, and the other was affiliated with a local parochial elementary school. Both non-nature preschools had experienced and stable teachers, with a responsive care-giving style. The guiding philosophy at both non-nature preschools emphasized child-directed play for supporting cognitive, social, emotional, and physical development, with the majority of time spent indoors in free or loosely guided play (four to five hours), with about one hour daily of teacher-led playful learning. Children at both non-nature preschools had one to two hours of daily outdoor playtime (weather permitting) in a maintained outdoor space that contained playground equipment. Tuition for the non-

nature preschools was similar to the costs associated with the nature preschools (with none of the 6 preschools receiving public or governmental funding), and therefore it was assumed that participants across the nature and non-nature preschools were relatively similar in terms of economic background, as well as similar in terms of age. Participants were also similar in terms of gender. In the nature preschools, 45% of the participants were female and 55% were male. In the non-nature preschools, 48% were female and 52% were male. There was little ethnic and racial diversity across non-nature preschools, with the majority of participants being Caucasian, which was similar to the nature preschools. (Permission to collect data on ethnicity and racial backgrounds was not sought, due to the lack of variation among participants). There was a total of 44 participants in the two control preschool programs, with a mean age of 57 months. Data regarding gender has been incorporated into Table 2.

Thus, participants across the preschools shared similar demographic characteristics and experienced caring and responsive teachers and a child-centered, play-based, developmentally-appropriate preschool program that aimed to support holistic development across the domains. The primary difference between the nature and non-nature preschools was in the proportion of the day spent outdoors and the location of the outdoor play time (in nature v. in maintained outdoor setting). These shared characteristics allowed for exploring the potential influence of sustained *nature* play (child-initiated play that takes place in and with nature) on executive function skills, beyond what one might expect to see from a high quality, play-based non-nature preschool program. These shared characteristics allowed for testing the hypothesis of unstructured play in natural outdoor environments being more conducive to executive function skill development.

**Instrument**

The instrument used was the Minnesota Executive Function Scale (MEFS), a tool developed in 2014 that measures executive function in young children through adults. The tool was based upon the Dimensional Change Card Sort, a measurement tool that has been used in hundreds of executive function studies (Carlson and Zelazo, 2016). The tool was created by the same researchers that created the NIH Toolbox, an executive function assessment available as a medical app "not intended for use outside of clinical application." The MEFS was chosen for its uniqueness in that it can be used with children as young as two years old and takes only an average of four minutes to administer. Due to the range of data suggesting the convergence of EF skills in early childhood, the MEFS produces an executive function skills total score, rather than three distinct scores for the domains of cognitive flexibility, inhibitory control, and working memory (Zelazo et al., 2016; Executive Functioning Performance Tests, Assessments Apps, 2017; Steenbergen-Hu, Olszewski-Kubilius, & Calvert, 2017). Participants' scores can be compared to current norms of EF development based on age of participant.

While relatively new, the MEFS has shown to be reliable and valid as a measurement tool. Test-retest reliability of the instrument is 0.93. The iPad program directs the measurement, so the administrator does not introduce subjectivity into MEFS scores. Validity has been established in several ways. First, the MEFS is significantly correlated with other commonly used research measures of EF (such as the NIH Toolbox Battery of EF Measures often used for clinical purposes). The MEFS does not show a strong correlation with IQ, suggesting it is measuring EF rather than intelligence (Executive Functioning Performance Tests, 2017).

**Procedures**

Prior to administering the pretest, Institutional Review Board approval was obtained and consent forms were distributed to guardians of the children enrolled in the six participating preschools. Children with parental consent for participation were included in the data collection. Pre-test data was collected September 2017 and post-test data was collected in late April of the same school year.

The researcher was trained by the test publisher, Reflection Sciences, to use the MEFS and subsequently administered the MEFS using an iPad. The program comes in the form of an app, which must be downloaded on a regular size tablet. The MEFS starts each individual on the testing level corresponding with his or her age. Participants are required to sort (by dragging) virtual cards on the iPad screen to virtual boxes according to certain rules. Executive function is employed when the child must keep current sorting directions in mind, flexibly switch sorting

behavior when instructions are changed, and inhibit the reflex of sorting in the same way as previously. Each child will advance to the next level if the current level is passed, and he or she will continue advancing until failure of a full level. If a child fails his or her starting level, the program will automatically switch to an easier level until current level of functioning is reached. Each participant's performance is scored automatically and compiled into an Individual Score Report.

Testing occurred by the researcher taking each participant aside separately, to a spot that was within view and earshot of the participant's teacher, but that was out of the way of the other children and as minimally distracting as possible. The researcher invited the child to sit next to her with the iPad on a table or other surface directly in front of the child. Testing happened at different points of the day, and participants were tested indoors or outdoors based on the current location of their class. The researcher selected the child's pre-loaded profile (containing ID number, age, and gender) on the MEFS app. The researcher then proceeded to select a starting level preselected by the MEFS app based on each participant's age. The researcher then read each line that appeared on the screen and demonstrated the card sorting tasks on the activity as trained by Reflection Sciences. When it was the participant's turn to sort cards, the researcher did not indicate which box it should be sorted into, nor were any verbal or nonverbal praise cues given during test trials. If a child said they did not want to play anymore, they were urged by the researcher to play a bit longer, as suggested by Reflection Sciences. As the MEFS takes only an average of 4 minutes to administer and is quite engaging being on an iPad and narrated by the researcher, this issue arose infrequently over the course of testing. Every participant was willing to complete the entire activity once they began.

## RESULTS

General linear modelling (test of within-subjects effects) was used to investigate if there was significant growth in nature preschoolers' executive function skills from beginning to end of school year, using age, gender, and prior participation as covariates in the model (Research Question 1). Results suggest significant executive function skill growth ($F(1,74) = 45.51$, $p < .001$) in the nature preschool participants across the school year, with a large treatment effect ($\eta p^2 = .38$). Unadjusted pretest and posttest means, as well as the adjusted posttest mean (taking into consideration age, gender, and whether they had attended the preschool the previous year) are reported in Table 1.

Table 1
*Comparison of Pretest and Posttest Executive Function Means and Standard Deviations and Adjusted Posttest Means for Nature and Non-Nature Preschools*

| | Pretest M (SD) | Posttest M (SD) | Adjusted Posttest M (Stnd. Error)[1] |
|---|---|---|---|
| Nature | 41.78 (14.89) | 51.46 (14.57) | 50.86 (1.29) |
| Non-Nature | 38.54 (14.40) | 48.66 (14.99) | 49.72 (1.73) |

[1] Adjusted for the covariates of pretest, age, gender, and prior participation

Research Question 2 addressed whether there was more growth in EF seen in nature preschoolers over the school year than non-nature preschoolers. General linear modelling (univariate analysis of covariance) was used to investigate the difference between the nature preschool and non-nature preschool participants' posttest level of executive function skills, when controlling for pretest level, age, gender, and prior participation (did nature preschoolers have higher posttest levels of executive function skills than non-nature preschoolers, after controlling for pretest, age, gender, and prior participation). Duration of participation (full day v. half day; partial week v. full week) was not used as a covariate, due to multicollinearity with the levels of the treatment variable (great degree of overlap in information represented in the levels of the treatment – the individual preschool programs – and duration of participation). Because the only preschool with half-day participation was a nature preschool, and the only full day, every day preschool was a non-nature preschool, the analysis would be a conservative estimate of growth in nature preschoolers relative to their non-nature counterparts. Unadjusted pretest and posttest means, as

well as the adjusted posttest means, are reported in Table 1. The results of the analysis of covariance suggests a significant model, $F(5) = 18.13$, $p < .001$, with age and pretest being the significant variables in the model ($p < .01$ and $p < .001$ respectively). The pairwise comparison of adjusted posttest means indicated a mean difference of 1.14 points (Standard Error of 2.18) and no significant difference between the nature and non-nature participant posttest levels, after adjusting for age, gender, prior participation, and pretest level ($F(1) = .28$, $p = .60$, $\eta p^2 < .01$). This suggests nature preschool participants did not have higher posttest levels of executive function skills than non-nature preschool participants; there was similar growth in executive function skills during the school year for participants in the nature preschools and non-nature preschools.

*Table 2. Comparison of Pretest and Posttest Executive Function Means and Standard Deviations and Adjusted Posttests Means by Preschool Site*

| | Pretest M (SD) | Posttest M (SD) | Age at Posttest | Adjusted Posttest M (Stnd. Error)[1] |
|---|---|---|---|---|
| Nature Preschool A[2] | 41.52 (20.64) | 54.42 (17.60) | 58.10 months | 53.64 (2.60) |
| Nature Preschool B[3] | 34.27 (14.92) | 43.80 (14.59) | 53.53 months | 48.37 (2.99) |
| Nature Preschool C[4] | 46.52 (10.92) | 55.40 (14.06) | 62.20 months | 51.13 (2.56) |
| Nature Preschool D[5] | 41.74 (10.59) | 49.37 (9.21) | 55.37 months | 49.54 (2.64) |
| Non-Nature Preschool E[6] | 38.81 (16.75) | 43.69 (16.81) | 52.75 months | 46.64 (2.99) |
| Non-Nature Preschool F[7] | 38.39 (13.19) | 51.50 (13.34) | 59.14 months | 51.60 (2.34) |

[1] Adjusted for the covariates of pretest, age, gender, and prior participation; [2] 48% of participants Male; [3] 53% Male; [4] 64% Male; [5] 52% Male; [6] 50% Male; [7] 53% Male.

To further explore whether or not growth differed between nature and non-nature preschool participants, adjusted posttest means (posttests means when controlling for age, gender, and prior participation) from individual preschools were compared using general liner modelling (univariate analysis of covariance). The between-subjects factor was preschool, and the covariates were age, gender, and prior participation. While the model was significant ($F(9) = 10.43$, $p < .001$, the between-subjects factor (the six preschools) was not a significant variable in the model ($p = .60$); however, as in the previous analysis, both age and pretest level were significant variables ($p = .03$, and $p < .001$ respectively). Follow-up pairwise comparisons yielded similar findings, with no significant pairwise comparisons among any of the preschools. These results suggest there were no significant differences among the posttest means across the six preschools, when controlling for age, gender, and prior participation; none of individual preschools appear to be more or less effective than any of the others in terms of supporting executive skill development. See Table 2 for the means, standard deviations, and adjusted posttest means.

Research Question 3 asked if the executive function growth seen in nature preschool participants different than growth expected from typical, cognitive maturation. To address this question, pretest and posttest means of nature preschool participants were also compared with the data published by Reflection Sciences (2017) of average executive function scores for typically developing children, stemming from a national sample of 14,143 children. The average increase in executive function skills over a 7 month period for children at a similar age as those in this pilot study (average of 50 months at the pretest administration) is about four to five points. Children in the nature preschools (and also in the non-nature preschools as well) had an increase in executive function skills of about 10 points, thus exceeding what would be expected due to cognitive maturation in typically developing children. Participants in the nature preschool had a pretest level of about 42 points, which is slightly higher than the national norm for this age (40 points); however, nature preschool participants had a posttest level of about 52 points, compared to the national norm of 45 points (what would be expected for children who are 57 months in age) This suggests they were close to the normative level of executive function at the start of the preschool year, but by the end of the school year, were higher than what would be expected for typically developing children of a similar age.

## DISCUSSION

The hypothesis for this study, in essence, was that nature play affords opportunities for the development of executive function skills. Like the findings from Carr et al. (2017), children in nature preschools demonstrated

executive function skills; further, the results from this study at hand suggest significant growth in their executive function skills over the course of a nature-play focused school year. While this growth did not exceed that seen in non-nature preschools, the results suggest that nature play does not appear to hinder executive function growth. And with executive function skills as a predictor of school readiness and academic performance, these exploratory results then suggest children who attend nature preschools will be as ready as their peers who attended non-nature preschools (and more ready than the average, typically-developing child, as children in both the nature and non-nature preschools had growth that exceeded what would be expected). But beyond being ready for school, the children who attended nature preschools also will likely be entering Kindergarten with higher levels of creative thinking (Wojciehowski & Ernst, 2018), curiosity (Ernst & Burcak, in press), total protective factors that can be drawn upon in adversity (Ernst, Johnson, & Burcak, 2019), as well as with the other physical, environmental, social-emotional and cognitive benefits that have been found to have associations with time spent in nature as children. Caution, though, is needed in interpretation and generalizations, as the participants in this study were primarily Caucasian and from a higher socio-economic background. Thus, further research investigating the influence of nature play on executive growth in a larger, more diverse sample is needed toward understanding the relationship between nature play and executive function skills.

The findings from this study indicated both nature and non-nature preschoolers grew in executive function skills beyond what would be expected from typical cognitive maturation. Because socio-economic status is correlated with executive function skills, it seemed possible that this higher level of growth might be explained by the higher average socio-economic status among the study participants, relative to the reported test norms. However, the study participants were only slightly higher (2 points) than what would be expected at the time of the pretest, yet were 7 points higher by the time of the posttest; this makes it less likely for socio-economic differences to be the sole or primary factor explaining the growth observed in this study. Because there was significant growth in both the nature and non-nature preschool participants, it seems plausible that what might account for this greater than expected growth is their preschool participation.

One prominent shared characteristic between the nature and non-nature preschools is the number of hours spent in unstructured free or loosely guided, child-initiated play. The preschools in this study provided about four to five hours daily of unstructured play for the children who attended full day. The difference was in the location of the play, with the nature preschools utilizing primarily outdoor natural settings, and the non-nature preschools using primarily indoor settings, with about one of the playtime hours outdoors, but in a non-nature setting. Based on the research linking the amount of structured activities inversely related to executive function skills (Barker et al., 2014), it seems then that it is not simply preschool attendance, but more likely the influence of the significant portion of the preschool day spent in unstructured play; unstructured play in both indoor and outdoor settings likely support executive function skill growth. Unstructured play provides ample opportunities for imaginative play, as well as opportunities for children to develop a sense of autonomy, as the play is child-initiated as opposed to teacher-directed. Given the research suggesting imaginative play supports executive skill development, and specifically pretend role-play as a symbolic activity that activates executive function skills (Carlson, 2018), it seems then that perhaps it is not the location of play that was influential on executive function skill development, but the unstructured nature of the play and the longer periods of time provided for unstructured play that allows for play to deepen. It is important to note, though, this is speculation stemming from the results in conjunction with the literature, as opposed to a relationship that was empirically tested; thus, further research is needed to test this new hypothesis in a larger, more diverse sample using a research design that allows for more rigorously testing of and isolating the influence of unstructured playtime on executive function skills.

Another shared characteristic is the focus on holistic development (development across the domains). While this wasn't the focus for the study, and thus not investigated in terms of how this translated into practice, supporting holistic development was part of the philosophies of the participating preschools and was described by the teachers as being their aim and/or focus. Potentially this focus on development across the domains, as opposed to a primary focus on early academics, was influential, in light of Diamond and Lee's research (2011) on the effectiveness of holistic approaches and in light of early childhood neuroscience indicating the highly interrelated nature of the brain and the intertwined nature of cognitive, emotional, social, and language development in the early years (see, for example, *Early Childhood Neurodevelopment*, by the Australian Early Childhood Mental Health Initiative, 2014). A

philosophical focus on holistic development across domains, translated into practice through the provision of unstructured play, could likely be underlying the executive function growth seen in this study at hand, given neuroscience findings that suggest learning through play facilitates the development and activation of interconnected brain processes in children, thereby supporting their capacity to learn (Liu et al., 2017). Similarly, neuroscience research supports the potential influence of a warm and responsive care-giving style of caregivers in healthy brain development (Liu et al., 2017). This caregiving style was experienced by children across all of the participating preschools in the study, and thus may have been influential on executive function skill development.

While more research is needed to better understand for whom and under what conditions unstructured play and specifically nature play can be used to support executive function skill development, these results are encouraging. Through nature preschool participation, children appear to be growing in their skills of cognitive flexibility, inhibitory control, and working memory. Not only will these skills contribute to school readiness and academic performance, studies also suggest they are related to lifelong health, and even likeliness of criminal behavior and financial status (Moffit et al., 2011; Zelazo et al., 2016). Thus, their relevance exceeds far beyond the backdrop for this study of concerns regarding school readiness. And in terms of relevance to environmental education, these executive function skills can be drawn upon in time in the context of environmental behaviors and environmental problem-solving and decision-making.

Overall, these findings add evidence to the growing literature base suggesting the benefits of nature preschools. Nature preschool participants in this study developed executive function skills at the same rate as high quality, non-nature preschools, thereby helping address and alleviate parents' hesitations regarding nature preschools and school readiness. Further, climbing trees, playing in the snow, building forts, and stomping in mud puddles are arguably more developmentally appropriate and healthier forms of interventions in support of executive function development than targeted trainings and curriculum-focused, directed instruction. Further, as these children are outside in nature, they are likely growing in their affective connection to the natural world (Ewert, Place, & Sibthorp, 2005; Moore, 2014). With these deepened connections to the natural world alongside their ability to plan and execute goal-oriented behaviors, the findings from this study provide another opportunity for thinking about young children's contributions to a more sustainable future.

**REFERENCES**

Ackerman, D. J., & Friedman-Krauss, A. H. (2017). Preschoolers' executive function: Importance, contributors, research needs and assessment options. *ETS Research Report Series*, *2017*(1), 1-24. https://doi.org/10.1002/ets2.12148

Banning, W., & Sullivan, G. (2011). *Lens on outdoor learning*. St. Paul, MN: Redleaf Press.

Barker, J. E., Semenov, A. D., Michaelson, L., Provan, L. S., Snyder, H. R., Munakata, Y., (2014). Less-structured time in children's daily lives predicts self-directed executive functioning. Frontiers in Psychology, 5(593), 1-16.

Brussoni, M., Olsen, L., Pike, I., & Sleet, D. (2012). Risky Play and Children's Safety: Balancing Priorities for Optimal Child Development. *International Journal of Environmental Research and Public Health,9*, 3134-3148.

Carlson, S. (2018). Batman and brain development – how imagination can help children develop self-control. Bridging Research and Practice, May/June.

Carlson, S., & Philip, Z. (2016). *Measure What Matters* (Rep.). Reflection Sciences.

Carr, V., Brown, R. D., Schlembach, S., & Kochanowski, L. (2017). Nature by Design: Playscape Affordances Support the Use of Executive Function in Preschoolers. *Children, Youth and Environments, 27*(2), 25-46.

Center on the Developing Child at Harvard University (2011). *Building the Brain's "Air Traffic Control" System: How Early Experiences Shape the Development of Executive Function: Working Paper No. 11*. Retrieved from www.developingchild.harvard.edu.

Diamond, A., Barnett, W., Thomas, J., and Munro, S. (2007). Preschool program improves cognitive control. *Science* 318, 1387-1388.

Diamond A., & Lee, K. (2011). Interventions shown to aid executive function development in children 4-12 years old. *Science* 333, 959-964.

Ernst, J., Johnson, M. & Burcak, F. The nature and nurture of resilience: Exploring the impact of nature preschools on young children's protective factors. Intl. J. of Early Childhood Env. Ed. 2019, 6(2), 7-17.

Ernst, J. and Burcak, F. (in press). Young Children's Contributions to Sustainability: The Influence of Nature Play on Curiosity, Executive Function Skills, Creative Thinking, and Resilience. Sustainability, Vol X, p X.

Ewert, A., Place, G., & Sibthorp, J. (2005). Early-Life Outdoor Experiences and an Individual's Environmental Attitudes. *Leisure Sciences,27*(3), 225-239.

Executive Functioning Performance Tests, Assessments Apps. (2017). Retrieved from http://reflectionsciences.com/

Holmes, J., Gathercole, S., and Dunning, D. (2009). Adaptive training leads to sustained enhancement of poor working memory in children. Devolpment Science, 12, 915.

KidsMatter Australian Early Childhood Mental Health Initiative. (2014). *KidsMatter Early Childhood: Early childhood neurodevelopment.* Retrieved from https://bishopkingdom.com/wp-content/uploads/2019/02/fTzgsjIBJO0bDeFUB3Kh.pdf

Larimore, R. A. (2016). Defining nature-based preschools. *International Journal of Early Childhood Environmental Education*, *4*(1), 33–37.

Larimore, R. (2011). Nature-based preschools: A powerful partnership between early childhood and environmental education. *Legacy*, 8-11.

Lawson, G. M., Hook, C. J., & Farah, M. J. (2017). A meta-analysis of the relationship between socioeconomic status and executive function performance among children. *Developmental Science*, (November 2014), 1–22. https://doi.org/10.1111/desc.12529

Liu, C., Solis, S. L., Jensen, H., Hopkins, E. J., Neale, D.,Zosh, J. M., Hirsh-Pasek, K., & Whitebread, D. (2017). Neuroscience and learning through play: a review of the evidence (research summary). The LEGOFoundation, DK.

Meuwissen, A. S., & Carlson, S. M. (2015). Fathers matter: The role of father parenting in preschoolers' executive function development. *Journal of Experimental Child Psychology,140*, 1-15.

Moffitt, T. E., Arseneault, L., Belsky, D., Dickson, N., Hancox, R. J., Harrington, H., . . . Caspi, A. (2011). A gradient of childhood self-control predicts health, wealth, and public safety. *Proceedings of the National Academy of Sciences,108*(7), 2693-2698.

Marcovitch, S., Jacques, S., Boseovski, J. J., & Zelazo, P. D. (2008). Self-Reflection and the Cognitive Control of Behavior: Implications for Learning. *Mind, Brain, and Education, 2(3),* 136-141.

Moore, R. (2014). *Nature Play & Learning Places. Creating and man- aging places where children engage with nature*. Raleigh, NC: Natural Learning Initiative and Reston, VA: National Wildlife Federation,Version 1.2.

Moreno, A. J., Shwayder, I., & Friedman, I. D. (2016). The Function of Executive Function: Everyday Manifestations of Regulated Thinking in Preschool Settings. *Early Childhood Education Journal,45*(2), 143-153

Nesbitt, K. T., Farran, D. C., & Fuhs, M. W. (2015). Executive function skills and academic achievement gains in prekindergarten: Contributions of learning-related behaviors. *Developmental Psychology*, *51*(7), 865–878. https://doi.org/10.1037/dev0000021

North American Association for Environmental Education (NAAEE). (2017). Nature preschools and forest kindergartens: 2017 national survey. Washington, DC: NAAEE.

Shaul, S. & Schwartz (2013). The role of the executive functions in school readiness among preschool-age children. *Reading and Writing*. 27(4), 749-768.

Sobel, D. (2014). Learning to walk between the raindrops: The value of nature preschools and forest kindergartens. *Children, Youth and Environments*, *24*(2), 228–238. http://doi.org/10.7721/chilyoutenvi.24.2.0228

Steenbergen-Hu, S., Olszewski-Kubilius, P., & Calvert, E. (2017). Protocol: The Direct and Indirect Effects of School-Based Executive Function Interventions on Children and Adolescents' Executive Function, Academic, SocialEmotional, and Behavioral Outcomes: A Systematic Review [Review]. *Campbell Collaboration*, 1-63.

United States Department of Education. (2017). Early Learning: Initiatives. Retrieved from https://www2.ed.gov/about/inits/ed/earlylearning/initiatives.html

Vitiello, V. E., & Greenfield, D. B. (2017). Executive functions and approaches to learning in predicting school readiness. *Journal of Applied Developmental Psychology*, *53*(August), 1–9. https://doi.org/10.1016/j.appdev.2017.08.004

White, R. Prager, E., Schaefer,C., Kross, E., Duckworth, A., & Carlson, S. (2017). The "Batman Effect:" Improving perseverance in young children. *Child Development*. Online doi: 10.111/cdev.12695

Wojciehowski, M. & Ernst, J. Creative by nature: Investigating the impact of nature preschools on children's creative thinking. Intl. J. of Early Childhood Env. Ed. 2018, 6(1), 3-20.

Zelazo, P.D., Blair, C.B., and Willoughby, M.T. (2016). Executive Function: Implications for Education (NCER 2017-2000) Washington, DC: National Center for Education Research, Institute of Education Sciences, U.S. Department of Education.

Jenna Zamzow is a lead teacher at Little Hawks Discovery Preschool in Holland, Michigan. She can be reached at jenna@outdoordiscovery.org.

Julie Ernst is a Professor of Environmental Education at the University of Minnesota Duluth. She can be reached at jernst@d.umn.edu.