

Natural Learning, Naturally Ready: Quantifying Impacts of Nature-Based Preschool on School Readiness

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ABSTRACT

As the nature-based preschool movement in the United States expands, parents and policymakers continue to question nature preschools' effectiveness in terms of preparing children for formal schooling. This study directly assessed the school readiness of 131 children in 10 preschool classes at the beginning and end of the school year using the Bracken School Readiness Assessment, 4th edition (Bracken, 2023). The findings indicate that not only were children in nature-based programs ready for school, but they also experienced growth over the preschool year that exceeded developmental expectations. They were also more ready than their peers in traditional preschools, after accounting for pretest school readiness scores, age, gender, and full v. part-time participation. Results also suggest the effectiveness of nature-based preschools in both public and private settings. This study adds to the growing body of research on the impact of nature-based preschool on children's learning and development, specifically their readiness for kindergarten.

Keywords: nature-based preschool, nature preschool, nature-based early learning, school readiness, kindergarten readiness

The importance of nature play in early childhood is well-established in the research literature, with benefits across developmental domains (Dankiw et al., 2020; McCurdy et al., 2010; Prins et al., 2022; Quintela Do Carmo et al., 2025). This growing evidence base is likely a driver of the surge in nature preschools in the United States, with the number of programs increasing by almost 200% over the last decade (North American Association for Environmental Education, 2023). Yet despite this growing evidence base, one persistent question from parents and policymakers continues to surface relating to nature preschools and nature-based early learning programs more broadly: Will children be ready for kindergarten? (LeFevre, 2025; Sobel, 2022).

Preschools and Their Role in Supporting School Readiness

School-readiness concerns extend beyond nature-based preschool contexts. School readiness is considered a primary indicator of a successful early childhood education program (Office of Head Start, 2015). Research underscores the profound importance of high-quality early education experiences for future academic success, as strong school-readiness skills are associated with higher performance in later schooling, for both cognitive and behavioral outcomes (Donoghue et al., 2017). Yet in the U.S., three out of five children are not ready for school, subjecting them to an "inequality at the starting gate" from which they will not recover (Burkham & Lee, 2002).

Evidence from the U.S. Department of Health and Human Services' Office of the Assistant Secretary for Planning and Evaluation (ASPE) research project, *In the Running for Successful Outcomes: Early Education, Care, and Comprehensive Services* (Halle et al., 2012), underscores the influential nature of school-readiness skills in terms of the level and rate of acquisition of academic and social skills during elementary school. Further, the findings suggest

that children entering school within the normal range (no lower than one standard deviation below the mean) show a greater likelihood of positive linear growth in skills over time (Halle et al., 2012). Yet the study's authors also state that the effects of early academic skills on later achievement are probabilistic rather than deterministic. Accordingly, an important policy and practice implication stemming from this study is that "All children can grow and benefit from early care and education programs. The goal of these programs should be maximizing growth before school entry" (Halle et al., 2012, p. 10).

As such, research has investigated the effectiveness of preschool programs and curricula in supporting growth in early academic skills. For example, findings from a large-scale review of the current state of knowledge on pre-kindergarten effects suggested that academic skill-focused curricula may be more effective in supporting conventional school readiness than whole-child curricula (Jenkins & Duncan, 2017). This coincides with growing emphasis on academic skill development in preschool programs (Bassok, Latham, & Rorem, 2016), as well as higher expectations of the academic skills that make a child "ready" for kindergarten (Brown & Lan, 2015). This emphasis, however, has led to educator concerns (Miller & Almon, 2009) and evidence (Le & Gottfried, 2018) that academic instruction is crowding out opportunities for play-based learning in early learning programs. Of further concern is that this emphasis on early academic skills may come at the expense of children's interest in learning, self-regulation, and social-emotional skills, which are often developed and practiced through play-based opportunities (Christakis, 2016).

Within the same large-scale review that highlighted the effectiveness of academic skill-focused curricula, another key characteristic associated with academic outcomes and school readiness was the use of learning experiences that engaged children's attention (Jenkins & Duncan, 2017). This is consistent with the National Institute for Early Education Research's emphasis on the importance of supporting children's emerging interests (Espinosa, 2002). Play-based learning is known to engage children's interests, curiosities, and attention and is often implicated as a plausible pathway or mechanism for the outcomes associated with nature-based early learning (Johnstone et al., 2022). Nature-based early learning programs provide immersive opportunities in and with different natural spaces and elements that afford experiences to engage in varied forms of play, with positive outcomes across developmental domains (Yogman et al., 2018). With their play-based pedagogy and the affordances of natural environments that can engage children's attention and interests, there is the potential for nature-based early learning programs to also support the early academic outcomes associated with school readiness.

Nature Preschools and School Readiness

Nature preschools are one form of nature-based early learning that provide opportunities for children to have frequent experiences with nature, which not only supports their development across domains, but also helps foster a lasting connection to nature and an environmental ethic (Finch & Bailie, 2015). While nature preschools may vary in the frequency and duration of these nature experiences, they share the central organizing concept of nature; nature is the integrating thread that ties together the preschool's philosophy, methodologies, classroom design, outdoor spaces, and public identity (Larimore, 2016). Additionally, nature preschools are grounded in and guided by high-quality, developmentally appropriate practices of both early childhood education and environmental education; thus, the teaching staff at nature preschools have skills and experience in both early childhood education and environmental education (Larimore, 2016). While a fundamental difference between nature-based and traditional preschools is the amount of time each program spends outdoors and how time outdoors is used, another key difference is the use of an emergent curriculum in nature preschools, where teachers facilitate and scaffold learning experiences based on what is happening in the natural environment and the preschoolers' natural curiosities (Finch & Bailie, 2015).

When the question of readiness arises in the context of nature preschools, nature preschool advocates often focus on a broad definition of school readiness that highlights a host of interrelated and relevant cognitive and social-emotional outcomes that children can draw on as they enter and progress through school. For example, frequently cited in school-readiness contexts are studies supporting the association between nature-based early learning and executive function (Carr et al., 2017; Ernst et al., 2022), self-regulation (Ernst & Stelley, 2024a; Faber Taylor & Butts-

Wilmsmeyer, 2020), language development (Murakami et al., 2018), peer play and learning behaviors (Cordiano et al., 2019) and critical thinking (Finch & Bailie, 2015).

Another response to school-readiness concerns has been to highlight the importance of social-emotional development in children's school success, while softening the emphasis on early academics. For example, Burgess and Ernst (2020) argue that nature preschools positively influence children's school readiness, particularly when school readiness is conceptualized as children's readiness to interact and engage in positive learning behaviors, rather than specific early academic skills or content knowledge. O'Brien and Murray (2007) and Alme and Reime (2021) further suggest that nature-based early learning programs such as nature preschools and forest kindergartens are uniquely positioned to foster social-emotional competence. Social-emotional competence is widely recognized as the primary foundation for academic success, as well as integral to career and life satisfaction and success (Denham et al., 2012). A strong social-emotional skill foundation in early childhood has been associated with positive long-term academic outcomes, yet early academic skills have not been linked to improved long-term social and emotional skills (McClelland et al., 2000; Snow, 2006). Additionally, the significant social-emotional deficits among many young children entering school (Rimm-Kaufman et al., 2000) signal the importance of prioritizing social-emotional development in early childhood settings, since children who enter kindergarten with underdeveloped social-emotional skills are at a higher risk for academic failure, suspensions, and expulsions as they progress through school (Denham et al., 2012).

Sobel (2022) indicates we are "comfortably down the path to being able to say nature-based early learning does a lot of good for children" (p. 13). However, Sobel (2022) points out that if nature-based early learning is to appeal to the masses, the conventional (early academic) school-readiness aspirations also need to be addressed. Several studies have focused specifically on early academic outcomes of nature-based preschools, with findings suggesting nature preschoolers are as ready for kindergarten as their peers in traditional preschool programs (Cordiano, 2019; Larimore et al., 2019; Larimore et al., 2017; Pikus et al., 2025).

However, a recent systematic review of 36 studies on nature-based early childhood education found evidence of positive links between nature-based programs and children's growth in multiple areas of social, emotional, and cognitive development, but also inconsistent associations (Johnstone et al., 2022). As some studies used measurements that relied on subjective parent/teacher reports or lacked criterion-based and/or norm-referenced measures, and as only 12 of the 36 studies used experimental designs (with only 6 of those controlling for pre-levels of the measured outcomes), the authors suggest more robust research is needed to add strength to the current findings that support the developmental and school readiness outcomes of nature-based early childhood education (Johnstone et al., 2022). Additionally, research comparing nature-based preschools with traditional early childhood programs in terms of school readiness has been specified as a need within the field's coordinated nature-based learning research agenda (Jordan & Chawla, 2019).

Given the importance of early academic skills, school-readiness concerns can impede young children's opportunity to participate in frequent, regular, and sustained nature-based outdoor learning, particularly as regulators and legislators continue to question the safety and effectiveness of such programs. Parents, educators, and policymakers need data regarding effective early learning programs for informed decision-making, particularly given the foundational importance of the early years. Thus, further research quantifying the impact of nature-based early programs on early academics is needed to advocate for the nature preschool movement, but more importantly, to serve the best interests of all children.

STUDY PURPOSE

The purpose of this research was to quantitatively investigate school-readiness outcomes associated with nature-based preschools. The overarching aim was to contribute to the growing body of research surrounding the impact of nature play on children's learning and development, specifically in the context of school readiness. The study was guided by the following research questions:

1. Were children who attended nature-based preschools ready for kindergarten, and how did their growth in school readiness skills across the school year compare with developmental expectations?
2. Were preschoolers who attended nature-based preschools as ready for kindergarten as their peers attending traditional preschools, when controlling for pre-levels of school readiness, age, gender, and full v. part-time attendance?
3. Did the influence of preschool approach (nature-based v. traditional) on school readiness vary by program type (public v. private)?

METHODOLOGY

Design and Participants

This study used a non-equivalent pretest-posttest quasi-experimental design to investigate the school readiness of nature preschoolers. Random assignment to treatment and comparison groups was not feasible, as parents who elect to send their children to preschool enroll them in a private preschool of their choice or in the public preschool program assigned by their neighborhood. The main independent variable of interest was preschool approach (nature-based v. traditional), and a secondary independent variable was preschool type (private v. public). The dependent variable was school readiness, with observations at the beginning and end of the preschool year.

Nature-based preschools, the “treatment” in this study, were early childhood programs for 3–5-year-old children that used an immersive approach, putting nature at the heart of the program to foster children’s holistic development, including their environmental literacy and connection to nature (Larimore, 2016). The nature-based preschools emphasized environmental outcomes, as well as kindergarten preparation in the form of developing curiosity, positive attitudes toward learning, independence, and other social-emotional outcomes, through unstructured nature play and loosely guided, playful outdoor learning. Children spent a significant portion of time outdoors (in some cases, all of the instructional time) in their nature playscapes and in wild natural areas that Merrick (2019) refers to as “areas beyond the fence.” Teachers used a child-centered, play-based approach emerging from and guided by children’s interests, abilities, cultures, and their natural surroundings. The teacher’s role in children’s learning was primarily one of facilitation and scaffolding play, aiming to encourage and support children’s competence, autonomy, and initiative. Teachers observed play to understand children’s interests and document learning. They set the stage for play and scaffolded play based on children’s interests, curiosities, and peer interactions, as well as on the affordances of their surroundings; they also facilitated play planning and reflection.

Traditional preschools were the comparison group in the study at hand. Although high-quality nature-based and traditional preschools share cognitive, social-emotional, and physical developmental goals for children, traditional preschools tend to have a stronger focus on early academics and kindergarten readiness through more teacher-directed activities, rather than on a dual focus on environmental literacy through a child-led, emergent approach. In these traditional preschools, more of the day was teacher-led direct instruction or guided play, with free play periods of shorter duration and mostly indoors through “centers” (i.e., the play kitchen/dramatic play area, the block area, the reading corner, the arts area, etc.). Outdoor time was more limited (less than an hour per day) and occurred in playground settings in ways that reflected what Pikus et al. (2025) described as a break from learning rather than an intentional way to enhance children’s learning and capitalize on their interest in the outdoors. The teachers’ role tended to be one of structuring, organizing, and leading activities for children.

In the study at hand, participating preschools were categorized as nature-based preschools or traditional preschools based on their participation and categorization in previous studies (i.e., Ernst & Stelly, 2024a; Ernst & Stelly, 2024b). In these prior studies, a rubric was used for preschool program categorization (see Table 2 for the Preschool Nature-ness Rubric in Ernst & Stelly, 2024a). This rubric covers curriculum and instructional practices, nature-related teaching and learning practices, teacher roles, and indoor and outdoor environments; collectively, the items provide general descriptions of what it means for a program to be categorized as a nature-based preschool versus a traditional preschool program. Researcher familiarity with the participating programs, alongside conversations with the lead teachers/program directors regarding continuity from previous years in terms of teaching staff, curriculum,

and setting, allowed for confirming program categorization into their respective approaches without asking teachers to complete the rubric again.

Ten preschool programs participated in the study. Six of the 10 participating programs were nature-based preschools. Of these six, five were privately operated, licensed nature preschools, and one was an integrated public preschool-Head Start program that was nature-based. Of the four non-nature preschools participating in the study, two were private preschools, and two were public preschool-Head Start programs. As such, preschool type (private v. public) was also investigated as a second independent variable in this study. It is important to note that this study variable, while labeled as preschool type, actually represents a combination of preschool type and socio-economic status (SES). Public preschool, for the study at hand, refers to publicly funded preschool programs in which most children served are of lower SES backgrounds. Private preschool refers to preschool programs that are not publicly funded and serve students primarily from middle or higher SES backgrounds. While private programs may have scholarship options or offer a sliding fee scale, the majority of children tend to be from families who can afford the tuition. The participating public and private preschool programs operated under the same mandated teacher-to-child ratio of 1 teacher for every 10 children.

The public preschool-Head Start programs participating in this study were located within the same school district. All 10 public and private preschools in the study were located in a small metropolitan area in the upper Midwestern region of the United States. Members of this community are 89% White, with the remaining percentages relatively evenly distributed across other racial categories. One hundred thirty-one children from across 10 preschool programs participated in this study. The average age of participants at the beginning of the study was 52 months; 53% of participants were male, and 47% were female. Racial and ethnic data, data relating to participant qualifications for special education services, and data relating to multi-language learners were not collected to protect individual and program privacy, given the small and highly homogeneous groups within program approaches and types. Individual-level SES data and data relating to prior participation were also not collected, due to collinearity with preschool type and preschool age, respectively. See Table 1 for a summary of participating programs and participants.

Table 1. *Summary of Preschool and Study Participant Data*

Approach	Program	Type	# of Participants	Participants' Average Pretest Age (mos.)	Participants' Pretest Age Range (mos.)	% of Participants Female
Nature	a	Private	14	51	40-60	43
	b	Private	16	49	36-64	50
	c	Private	17	49	36-59	24
	d	Private	14	55	47-63	64
	e	Private	19	51	38-63	53
	f	Public	11	49	37-60	46
	Subtotal	-	91	51	36-64	46
Traditional	g	Private	9	56	48-65	66
	h	Private	11	57	50-63	36
	i	Public	10	51	43-63	50
	j	Public	10	51	40-60	50
	Subtotal	-	40	53	40-65	50
Total			131	52	36-65	47

Research Instrument

The study's dependent variable was the posttest level of school readiness, as measured by the BSRA-4, the Bracken School Readiness Assessment, Fourth Edition (Bracken, 2023), available through Pearson Assessments. This assessment conceptualizes school readiness as a child's comprehension of foundational academic and social-emotional concepts that children have traditionally needed to know to be prepared for early formal education. This BSRA-4 is aligned with early childhood state standards and consists of six subtests: colors, letters, numbers/counting, sizes/comparisons, shapes, and self- and social awareness. The assessment yields a school readiness composite score from the six subtests combined, which represents "conceptual knowledge that is closely aligned with early childhood educational experiences and curricula" and serves as "an indicator of the academic preparation a child has received before beginning formal schooling" (Bracken, 2023, p. 57). Among stated uses for this assessment are determining the extent to which a child has acquired the academic and social-emotional concepts needed to be successful in formal education and assessing academic progress after an educational intervention, program, or instruction has occurred (Bracken, 2023).

During its development, items on the BSRA-4 were reviewed for potential bias and cultural sensitivity issues by a panel of school psychologists, special educators, and speech-language pathologists with expertise in the assessment of diverse populations, and items were further reviewed statistically to detect differential item functioning across diverse populations. Standardization research for the BSRA-4 and the development of normative information through inferential norming are detailed in the testing manual (Bracken, 2023). The assessment has a reported reliability of .98 for the school readiness composite score, with further reliability evidence suggesting it is a reliable measure for children from diverse populations in the United States in terms of parent education level, race and ethnicity, gender, and region, as well as for children of varying abilities, including children diagnosed with developmental or language delay or identified as gifted (Bracken, 2023). Evidence of validity was established through a literature review, user surveys, and content, bias, and item reviews, as well as through empirical and qualitative examination of response processes during the test's development. The testing manual (Bracken, 2023) reports a correlation of .74 with the WIAT-4, the Wechsler Individual Achievement Test, Fourth Edition (Breau, 2020), an achievement test for use in clinical, educational, and research settings that measures early listening, speaking, reading, writing, and math skills, which provides further evidence of its validity as a school readiness assessment.

Data Collection

After site permission from the participating preschool programs and with approval from the University's Institutional Review Board for the Social and Behavioral Sciences, parent consent was obtained for participating children. Additionally, teachers from the 10 preschool programs were asked to complete a demographic summary sheet regarding participants' age in months, gender, and full v. part-time attendance (in several of the programs, parents can enroll children in less than full-time attendance).

The researcher administered the BSRA-4 to children individually, at the beginning of the preschool year (mid to late September, after school routines were established) and again at the end of the preschool year (mid to late May). The BSRA-4 is a receptive measure that is untimed, taking approximately 15 minutes to administer per child, based on a child's proficiency and how far they advance through the items, as well as on their personality/temperament and how quickly they proceed through the items. Administration continues until a child reaches a discontinuation point (an incorrect or no response on three consecutive items) on each of the subtests. For the nature-based preschools, administration occurred outdoors, slightly away from the group to avoid disruption, while remaining within visual sightlines of the teacher. The administration of the BSRA-4 primarily occurred indoors for the traditional programs, although there were several instances across the programs where the researcher administered the assessment to several children on the playground; for these programs, the testing location was similar in that it was away from the activity at hand, but within the view of the teacher.

Scoring Procedures and Interpretation of Scores

Raw scores were recorded for each subtest and then summed for a school readiness composite raw score. The testing manual (Bracken, 2023) indicates the composite score is to be used, rather than individual subtest scores, because it is more psychometrically sound as a total entity, providing a more even distribution of scores than the individual subtest distributions. Further, it is a stronger predictor of school readiness and school success than individual subtests (Panter & Bracken, 2000). The school readiness composite raw scores were then converted to a norm-referenced standard score through age-based conversion tables provided in the testing manual.

The school readiness composite standard score is distributed across a scale with a mean of 100 and a standard deviation of 15. Standard scores ranging between 85 and 115 correspond to one standard deviation below and above the mean, which is considered the range of average performance for that age group nationwide; within this range, the development target is met, with the child having mastered the expected number of basic concepts required for successful entry into school for his or her age group (Bracken, 2023). Standard scores below this range are interpreted as below average or delayed. A standard score of 86 or above (less than one standard deviation below the mean of the normative group) suggests a lack of delay in a child's knowledge of foundational concepts such as colors, letters, numbers, sizes, shapes, or self-awareness (Bracken, 2023). The child has demonstrated the necessary baseline skills to enter a standard early-childhood or kindergarten classroom without triggering a need for immediate corrective intervention (Bracken, 2023). In other words, a standard score of 86 or higher (≥ 86) indicates a child is ready for kindergarten or, for a child who will not be entering kindergarten the subsequent year, he or she is on track to be ready for kindergarten. This operationalization of school readiness is consistent with guidance in Halle et al. (2012) that suggests children entering school within the average range (no lower than one standard deviation below the mean) show a greater likelihood of positive linear growth in skills over time.

Comparing standard scores over time indicates whether the child improved at the same rate as, or faster or slower than, same-age peers in the nationwide normative sample; a standard score change from pre- to posttest indicates a change in relative normative standing, not a change in how many new concepts were mastered since the pretest. To determine if there is a statistically significant change in test performance over time, the testing manual indicates that a comparison of the confidence intervals of the pre- and post-levels of a child's composite standard scores should be used (Bracken, 2023). Test performance significantly differs from pre- to post-scores if the confidence intervals do not overlap (Bracken, 2023). Non-overlapping confidence intervals with a positive shift in standard scores indicate significantly greater growth than expected, where a child is acquiring foundational concepts at an accelerated developmental trajectory. In other words, the child's development of school readiness skills is outpacing age-related developmental expectations. This greater-than-expected growth, also phrased as growth that exceeds typical developmental expectations, is interpreted as a treatment effect, particularly in study designs that rule out other external variables and when there is sufficient time between the pre- and post-administrations to rule out a practice (testing) effect.

RESULTS

Nature-Based Preschoolers' School Readiness

To address the first research question regarding nature-based preschoolers' school readiness, the standardized school readiness composite scores of the 91 children in the nature-based preschools were analyzed using descriptive statistics to determine how many had posttest scores of 86 or higher. As noted in the prior section, a standard score of ≥ 86 reflects less than one standard deviation below the mean of the normative group, suggesting a lack of delay in a child's knowledge of foundational concepts such as colors, letters, numbers, sizes, shapes, or self-awareness (Bracken, 2023). A child with a score of ≥ 86 has demonstrated the necessary baseline skills to enter a standard early-childhood or kindergarten classroom without triggering a need for corrective intervention; they are kindergarten-ready, or on track to be ready by their kindergarten year (Bracken, 2023). Results from the study at hand suggest preschoolers finished their year of nature-based preschool on track in terms of school readiness, with 88 of the 91 nature-based preschoolers (96.7%) having posttest scores at or exceeding a standard score of 86; see Table 2.

To investigate how nature-based preschoolers' growth in school readiness across the preschool year compared with developmental expectations, descriptive statistics were used to summarize the percentage of nature-based

preschoolers with non-overlapping confidence intervals for their pre- and post-school readiness composite standard scores. Non-overlapping confidence intervals reflect a significant difference in the child's test performance from pre- to post-scores, indicating the child made progress above and beyond what is typically expected for developmental growth for their age over that time frame (Bracken, 2023). Of the 91 nature-based preschoolers, 88 of the 91 (96.7%) experienced greater growth than would be typically expected; see Table 2. To address this question of growth in school readiness relative to developmental expectations from another angle, the confidence levels for the pre- and posttest means were calculated using the standard errors of the means. Similar to the interpretation for individual-level data, non-overlapping confidence intervals indicate a statistically significant change in pre- to posttest scores for the group, which again is interpreted as growth that exceeds typical developmental expectations. When the confidence intervals for the nature-based preschoolers' pretest and posttest means were compared, they were non-overlapping, signaling an accelerated developmental trajectory; see Table 3. Collectively, this provides evidence in support of the effectiveness of nature-based preschool for children's school readiness, as not only were children ready, but their growth also exceeded developmental expectations.

Table 2. *Percentage of Nature-Based Preschoolers Demonstrating School Readiness and Growth that Exceeded Developmental Expectations*

	% Entering the preschool year with pretest scores of $\geq 86^a$	% Finishing the preschool year with posttest scores of $\geq 86^a$	% With growth that exceeded developmental expectations ^b
Nature-Based Preschoolers (n = 91)	65.9	96.7	96.7

^aA standardized composite score of ≥ 86 is less than one standard deviation below the mean of the normative group and indicates a child is on track in terms of school readiness for their age (Bracken, 2023).

^bNon-overlapping confidence intervals for pre- and posttest scores indicates a statistically significant change in relative normative standing and is interpreted as an accelerated developmental trajectory (Bracken, 2023).

Table 3. *Summary of the Standardized Composite Means, Standard Errors of the Means, and Associated Confidence Intervals for Nature-Based Preschoolers^a*

	Mean	Standard Error of the Mean	95% Confidence Interval for Mean Scores
Pretest	90.24	1.28	87.73 - 92.75
Posttest	106.07	1.43	103.27 - 108.87

^an=91.

School Readiness of Nature-Based Preschoolers Relative to Peers in Traditional Preschools

The second research question investigated whether preschoolers who attended nature-based preschools were as ready for kindergarten as their peers attending non-nature preschools. A one-way analysis of covariance was used to determine whether post-test levels of school readiness differed significantly across the preschool approaches, when controlling for pretest levels of school readiness, age, gender, and full v. part-time attendance. In the model, the preschool approach (nature-based or traditional) served as the independent variable, and the dependent variable was post-test level of school readiness; pretest scores, age, gender, and participation (full v. part-time) were the covariates. While the standardized scores account for age through the age-based norms, age was included as a covariate to account for the within-bracket age effect from groups that may have different age distributions. The Levene's Test of Equality of Error Variances was not significant, $F(1,129) = 3.08$, $p = .08$, suggesting the data met the assumption of homogeneity of variance. The overall model was significant, indicating the variables collectively explained a significant amount of the variance in posttest levels of school readiness, $F(5,125) = 73.98$, $p < .001$, partial $\eta^2 = .75$. There was a significant main effect of preschool approach, $F(1,125) = 59.68$, $p < 0.001$, which corresponded to a large effect size (partial $\eta^2 = 0.32$). The difference between the two groups' adjusted standardized posttest means was 12.70 (SE = 1.65), with posttest scores for nature-based preschoolers significantly higher than those in the traditional preschools; see Table 4 for adjusted means and standard errors. These results suggest preschoolers who attended nature-based programs were not only as ready as their peers in non-nature programs,

but significantly more ready for kindergarten, when accounting for pre-levels of school readiness, age, gender, and full v. part-time attendance.

Table 4. *Adjusted^a Standardized Posttest Means and Standard Errors by Preschool Approach*

Preschool Approach	Adjusted Posttest Mean (SE) ^a
Nature-Based (n=91)	107.65 (.84)
Non-Nature (n = 40)	94.95 (1.34)

^aAdjusted for pretest mean, age, gender, and full v. part-time participation.

School Readiness by Preschool Approach and Type

Descriptive statistics for the preschool categories (approach by type) are reported in Table 5. A two-way analysis of covariance was used to evaluate the effects of preschool approach (nature-based or traditional) and preschool type (public or private) on school readiness, with covariates of pretest, age, gender, and full v. part-time participation. This analysis addressed the third research question regarding whether the influence of preschool approach (nature v. non-nature) on school readiness varied by program type (public v. private). The Levene's Test of Equality of Error Variances was not significant, $F(3,127) = 1.31$, $p = .28$, suggesting the data met the assumption of homogeneity of variance. The overall model was significant, indicating the variables collectively explained a significant amount of the variance in the outcome variable of school readiness, $F(7, 123) = 52.08$, $p < .001$, partial $\eta^2 = .75$. There was a significant main effect for preschool approach (nature v. non-nature), $F(1, 123) = 42.07$, $p < .001$, partial $\eta^2 = .26$, but not for preschool type (public v. private), $F(1,123) = .08$, $p = .77$, partial $\eta^2 < .01$. The interaction between preschool approach and preschool type also was not significant $F(1, 131) = .06$, $p = .81$, partial $\eta^2 < .01$. See Table 6 for the adjusted posttest means and standard errors.

These results suggest school readiness at the end of the school year significantly varied by preschool approach (nature-based v. non-nature) but not by preschool type (public v. private), when taking into consideration pretest levels of school readiness, age, gender, and participation. Further, and in the context of the research question at hand, the influence of nature-based preschool on school readiness did not vary by preschool type (public v. private); nature-based preschools appeared to be more effective than non-nature preschools in terms of supporting an accelerated trajectory of school readiness growth in both public and private settings. In other words, nature-based preschoolers in both public and private settings were not only as ready for kindergarten as their peers, but more ready, when accounting for age, gender, full v. part-time participation, and pretest level.

Table 5 *Standardized School Readiness Means and Standard Deviations by Preschool Approach and Type*

Preschool Approach	Preschool Type	Pretest Mean ^a (SD)	Posttest Mean ^a (SD)
Nature-based	Public (n = 11)	81.82 (11.32)	98.91 (13.58)
	Private (n = 80)	91.40 (11.96)	107.06 (13.47)
Non-Nature	Public (n = 20)	84.25 (13.67)	89.15 (16.40)
	Private (n = 20)	105.35 (14.11)	107.90 (11.91)

^aUnadjusted means.

Table 6 *Adjusted Standardized School Readiness Posttest Means and Standard Errors by Preschool Approach and Type*

Preschool Approach	Preschool Type	Adjusted Posttest Mean ^a (SE)
Nature-based	Public	106.74 (2.52)
	Private	107.79 (.93)
Non-Nature	Public	94.82 (1.90)
	Private	95.00 (2.06)

^aAdjusted for pretest, age, gender, and full v. part-time attendance.

DISCUSSION AND IMPLICATIONS

In the context of the study's purpose, which aimed to quantify school-readiness outcomes associated with nature-based preschool, the findings are quite encouraging. Young children's school readiness skills matter for the acquisition of academic and social skills during formal schooling (Daily et al., 2010). The better a child's skills are when he or she enters school, the better his or her skills are likely to be in elementary school and beyond; further, children with stronger school readiness skills upon kindergarten entry tend to maintain their advantage over time, and there are clear long-term developmental benefits of helping children reach and exceed the normal range (Halle et al., 2012).

Nearly all the nature preschoolers in this study had posttest scores indicating school readiness (a standard score that was less than one standard deviation below the mean of the normative group). On average, they ended the year with unadjusted standard scores of 106, which falls near the upper end of the range of average performance (85-115) for that age group nationwide; scores within this range indicate the developmental target is met. Also noteworthy is that in the nature-based preschools, more preschoolers ended the preschool at this developmental target relative to the number who were at this developmental target at the beginning of the school year (there were children who were not on track at the beginning of the year, but gained ground and ended the year on track in terms of school readiness). Also noteworthy is that the growth in school readiness among the nature-based preschoolers outpaced age-related developmental expectations. Not only was their growth statistically significant, but this growth in school readiness also has great practical significance considering the U.S. Department of Health and Human Services' recommendation for maximizing growth before school entry (Halle et al., 2012). Further, the findings from this study suggest that nature-based preschools may not only be as ready as, but more ready than, their peers, when accounting for pre-levels of school readiness. This, too, has great practical significance, given that play rather than direct instruction is used in nature-based preschools to engage children in learning (Merrick, 2019).

While direct instruction has long been thought to be the key to achieving school readiness and other curricular objectives expected by parents, school leaders, and policymakers, a recent systematic review and meta-analysis of 39 studies indicated that guided play had a greater positive effect than direct instruction on early math skills, shape knowledge, and task switching; for literacy, guided play and direct instruction appeared to be similarly effective (Skene et al., 2022). It is possible that a playful, guided approach to learning places less stress on a child, thus allowing their brains to more effectively process information and build new neural connections. Neuroscience evidence from Whiting et al. (2021) suggests that in the midst of stressful learning environments, children are more distracted by superficial features of their surroundings and find it harder to engage in response planning and voluntary attentional control; they also experience reduced efficiency of executive functions and are more likely to engage in habitual behaviors that can interfere with the learning potential at hand. Relatedly, in a study comparing children in highly academic preschools with children in settings with less emphasis on formal academics, Hirsh-Pasek et al. (1990) found that children from the highly academic environments had not only higher anxiety, but also lower self-esteem and poorer attitudes toward school than children who had been enrolled in a less academically oriented preschool. Further, as play in nature-based preschools often occurs in natural settings, it is possible that learning is optimized even more fully through the stress-reducing qualities of time in nature. Natural environments can counter directed attention fatigue, as nature engages involuntary attention, allowing directed attention capacities to recharge (Kaplan & Kaplan, 1989). Thus, guided play in natural settings may be particularly effective in boosting cognitive functioning due to reduced stress and restored attentional capacity.

Alternatively or additionally, positive associations between guided play and children's academic and socioemotional outcomes, including spatial language production, vocabulary development, and prosocial skills, such as those noted in studies by Coplan et al. (2010), Ferrara et al. (2011), Han et al. (2010), possibly may be explained by guided play's position of middle ground between free play and direct instruction. Sylva (1984) suggests learning during guided play is inherently engaging and meaningfully rich due to greater opportunities for both active participation and self-reflection (Sylva, 1984). In guided play, the teacher stands back a bit, observing a child's play to determine if, when, and/or how to intervene to support the child's learning (Bruce, 2015). Perhaps it is in this middle ground of guided play where children experience just the right amount of "productive struggle" necessary for academic skill-building, while receiving the right amount of support at the appropriate times to keep the learning at hand from becoming

too easy or too frustrating and consequently leading to disengagement (Young et al., 2025). Through guided play, learning emerges from children's engagement with their environment and then is supported by the teacher in ways that ultimately move the child beyond the possibilities of independent play (Hannikainen & Munter, 2018).

While nature-based preschools use guided play, free play is a hallmark of nature-based programs. Free play is child-directed, voluntary, and flexible and is intentionally used in nature-based preschools to support social-emotional development, as well as learning and development more broadly. The meta-analysis by Johnstone et al. (2022) suggests natural environments offer more variation in space and elements, affording more diversified free play, thereby enhancing a range of outcomes, including prosocial interactions. Free play is associated with higher levels of self-control and fewer disruptive behaviors (Veiga, Neto, & Rieffe, 2016), as well as with motivation, task persistence, and agency, particularly when children are provided sufficient time and autonomy (Skene et al., 2022). According to Thompson and Goodman (2009), children who are eager to learn and have a high level of task persistence may enjoy the challenge afforded by academic content, which in turn can further enhance their interest and confidence in learning new content and skills, particularly when they master the challenging new skills or content at hand. As such, Skene et al. (2022) suggest that it may be that free play fosters outcomes such as children's regulation, motivation, task persistence, and enjoyment; guided play then scaffolds onto those outcomes, extending learning beyond what the child might achieve on their own. Le et al. (2019) also describe a leveraging of social capabilities by young children when in academic learning environments. Perhaps the social capabilities that nature preschoolers are developing through free play are being leveraged during guided play, making them ready and receptive to encounter and engage with school readiness concepts and skills when they emerge in their play environments. Thus, it may be that the combination of free play and guided play in nature-based preschools offers a uniquely effective pathway to children's school readiness – a confluence that opens space for emergent and supported, meaningful, and deep learning across domains, including early academics and other school readiness skills.

Another potential explanation for this study's findings may be related to the increased physical activity associated with free play in natural settings (Ernst et al., 2021). There is some evidence to suggest physical activity may influence cognitive school readiness through self-regulation; physical activity is associated with the activation of the prefrontal cortex, which is the same part of the brain responsible for self-regulatory behaviors, and self-regulation has a positive association with school readiness (Bai et al., 2021). Relatedly, research by Howard and Vasseleu (2020) suggests advanced learning in preschoolers was predicted by socio-demographic factors, executive function, and cognitive aspects of self-regulation. This is salient given research indicating association among nature play, executive function, and self-regulation (Carr et al., 2017; Ernst et al., 2022; Ernst & Stelley, 2024a; Faber Taylor & Butts-Wilmsmeyer, 2020). Perhaps the play in nature-based preschool is supporting executive function and self-regulation, which in turn support cognitive school readiness.

Implications for Practice and Policy

One practical implication of these findings is that school readiness can happen through nature-based preschools, despite their lack of teacher-directed, academic-focused instruction. Combinations of free and guided play can be an avenue for academic readiness. Halle et al. (2012) indicate that children who enter school with both strong process skills (i.e. higher levels of executive functioning and approaches to learning) and strong early academic content knowledge and skills are more likely to experience academic and behavioral success during their school years; "children need to develop a constellation of school readiness skills to have a better chance of being successful in elementary school and beyond" (p.61). Thus, the findings of school readiness among nature preschoolers in this study are especially meaningful when paired with prior research relating to nature preschools' effectiveness in supporting process skills (Carr et al., 2017; Cordiano et al., 2019; Ernst et al., 2022), offering a more holistic picture of outcomes associated with nature-based preschools. It appears these nature play-based programs may be weaving together process skills, early academic content knowledge, and social-emotional skills, helping effectively prepare young children for school success. Further, this evidence regarding nature preschools' ability to support early academics and conventional school readiness can help counter the notion that it is an "either-or" scenario (a choice between early academic outcomes that set children up for school success or a host of broader outcomes that can

be drawn upon as children begin and proceed through school); nature-based preschools appear to be able to do both.

A second important implication relates to the effectiveness of nature-based preschools in both private and public settings. Particularly as the public programs in this study were integrated preschool and Head Start programs with a generally lower level of SES among participants, it is meaningful to see that this accelerated trajectory of school readiness growth was not limited to private nature-based preschools with children of higher SES backgrounds. As noted by Lee and Burkham (2002), if children from less-advantaged backgrounds are systematically placed in lower-quality preschools, existing inequalities in children can widen, particularly upon school entry and in future academic success. Nature-based public preschools expand the accessibility of the nature preschool movement to a broader range of demographics, thus making the constellation of positive outcomes associated with nature-based preschools, including school readiness, within the reach of more families and their children.

Limitations and Opportunities for Further Research

While this study used a quasi-experimental design, had pre- and post-observations, and used a norm-referenced measure, thereby addressing shortcomings Johnstone et al (2022) noted in their systematic literature review on outcomes associated with nature-based early learning, there are study limitations to note. First, it is important to recognize that the overall sample was relatively small ($N = 131$) and homogeneous in terms of race and ethnicity; this decreases the generalizability of findings. Further, the sample size of nature preschool participants was larger relative to the sample size of non-nature preschool participants; likewise, the sample size of private preschool participants was larger relative to public preschool participants. While the data suggested equal variances across the groups, statistical tests can become less robust with unequal group sizes, with a reduction in statistical power. Additionally, the lack of random assignment limits internal validity, making it difficult to attribute results solely to participation in the respective preschool approaches.

Another limitation stems from the “nesting” of data (children within classes within teachers within categories) unaccounted for in the analysis. The analysis approach used was selected because of an insufficient sample size at the program level for multi-level modelling and due to the groups being a fixed rather than random factor, per Huta (2014), with a possibility of inaccurate statistical estimates from not accounting for the hierarchical structure of the data. Relatedly, differences in teachers’ background (licenses, years of experience, etc.) and specific teacher-staff ratios were not accounted for in the study, and thus could have influenced the study’s findings. Further, the specific dosage and combinations of free play, guided play, and direct instruction were not measured at the program level, but described in a general way at the preschool approach level; nature-based preschools likely varied in their specific dosage of free and guided play, as well as in the balance of each relative to the other.

As a result of these limitations, future research with a larger and more diverse sample, as well as research investigating specific attributes of nature-based preschools associated with school readiness, including teacher characteristics, is warranted to more conclusively confirm the influence of nature-based preschool on school readiness. Additionally, future research investigating how the combination of free and guided play, along with other moderating and mediating factors, contributes to school-readiness outcomes would be useful to guide future programmatic, pedagogical, and policy decisions. This is needed to confirm the literature-based speculations noted earlier regarding the potential role of free and guided play in explaining the superior growth in school readiness observed in the nature-based programs.

As a further research implication, future studies should continue to incorporate the variable of preschool type (public v. private settings and/or SES). While in this study, nature-based preschool seemed effective in both public and private programs, preschool type (public v. private) has been influential in other recent studies on nature-based preschool (i.e., Ernst & Stelley, 2024b; Ernst et al., 2022), and thus its influence could likely vary based on the outcome of interest. Thus, without considering preschool type, subsequent findings might mask potential or, conversely, over-generalize the effectiveness of nature-based preschool programs.

CONCLUSION

School readiness concerns are relevant in nature-based and traditional preschool contexts, as strong school-readiness skills are associated with higher performance in later schooling, for both cognitive and behavioral outcomes (Donoghue et al., 2017). This study provides supporting evidence to aid in reassuring parents and policymakers when school readiness concerns surface. Additionally, it provides quantitative evidence in response to the question posed to the field by scholars Jordan and Chawla (2019): "How do nature-based preschools and kindergartens compare with conventional early childhood programs that emphasize indoor learning in terms of preparing children for school readiness?" (p. 5). With quantitative data from an established, norm-referenced measure that suggest not only are nature preschoolers ready for school and progressing at a rate that exceeds developmental expectations, but also that they are more ready than peers in traditional programs, these findings can help move the field's response from a qualified "yes" to a more confident "yes" when school readiness concerns arise. Additionally, as the pendulum in education in general swings toward "back to basics," alongside a trend that has already been growing regarding what Sobel (2022) calls "the academification of preschool," this research is important toward continued support for and momentum in the nature preschool movement, helping ensure nature-based early learning remains an option among early learning and care programs.

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