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Nature-based learning and development: Maximizing the returns on investment, volume II

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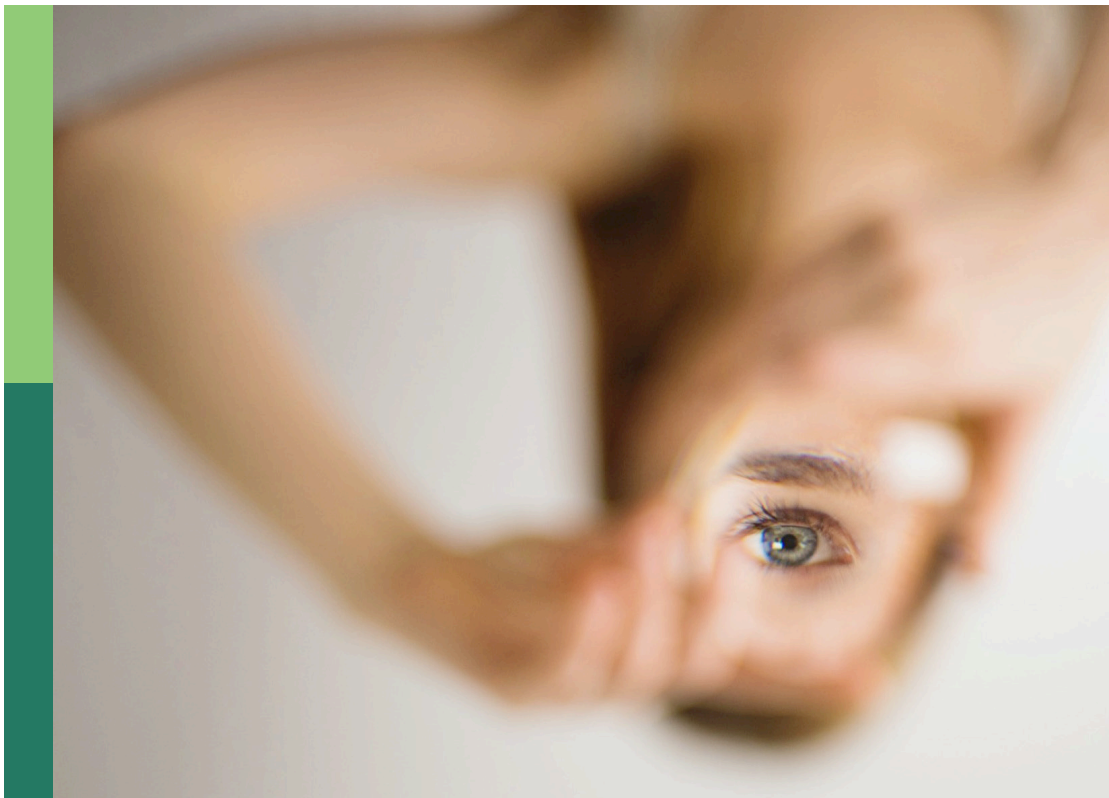

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Nature-based learning and development: Maximizing the returns on investment, volume II

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Editorial: Nature-based learning and development: maximizing the returns on investment, volume II

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Editorial on the Research Topic
Nature-based learning and development: maximizing the returns on investment, volume II

The evidence is in: *experiences with nature promote learning and development*. Findings from upwards of a thousand studies—from fields as disparate as leisure studies, education, landscape architecture, public health, and psychology, and from wilderness backpacking to plants in a preschool to lessons on frogs—show that experiences with nature contribute to learning and healthy development (e.g., Research Topic: The Natural World as a Resource for Learning and Development: From Schoolyards to Wilderness; for review, see Kuo et al.). And in head-to-head comparisons, "nature-based" learning outperforms conventional classroom learning (e.g., Wells et al., 2015). It's time for "nature-based learning" (NBL) to move from research into standard practice.

This Research Topic aims to support that move. We propose that researchers can help move NBL into practice by incorporating a return on investment (ROI) perspective. The articles here illustrate several ROI Best Practices[1]:

- CONVEY THE "ROI." Capturing both costs and benefits of a nature-based intervention in a single sentence helps practitioners decide whether an intervention is feasible and worth implementing, e.g., "a difference of 20% points of green space… is associated with an over 10% lower probability of children using ADHD medication" (de Vries and Verheij). See Traynor et al.'s Figure 1 for a graphical representation of ROI.
- DESCRIBE THE INVESTMENT. Describing interventions in detail (e.g., Traynor et al.) makes it easier for practitioners to adopt them successfully, with less trial and error. Quantifying labor, materials, and other costs aids decision-making about, and preparation for, adoption.
- IDENTIFY THE MINIMUM INVESTMENTS for a desired return. When the minimum investment is small, this information can encourage adoption; when the minimum investment is large, this information can avert underinvestment. Ernst et al. find that incorporating a few nature-based lessons in a traditional curriculum is enough

1 For more ideas on how researchers can increase the impacts of their work on policy and practice, see Kuo (2002).

to yield multiple, important benefits, but that a full nature preschool experience may be needed to specifically boost children's initiative.

- IDENTIFY KEYS TO DESIRED RETURNS. Not all intervention components contribute to desired outcomes; de Vries and Verheij find the relationship between residential nature and ADHD medication usage may depend primarily on overall "greenspace" and not particular "green elements." Identifying the "active ingredients" of an intervention helps practitioners know which must be replicated precisely and which ones practitioners might be able to forgo. Similarly, information about mechanisms helps practitioners know how they might maximize returns. Mateer suggests nature's eudaimonic benefits may stem from experiences of awe and solitude, providing considerably more direction to park designers than the simple exhortation to "provide nature."
- CONSIDER EQUITY, a common and important return on nature interventions. Examining impacts of an intervention separately for different groups enables us to see if a given intervention reduces, exacerbates, or replicates existing inequities—de Vries and Verheij and Hartley et al. do, and find an "equigenic" effect.
- STUDY THE UNDERSTUDIED to provide scientific guidance for policy and practice where little exists. Cosco et al. focus on an understudied population (childcare centers serving low-income families) and an outcome of special importance to that population (fruit and vegetable consumption).
- CONSIDER CONTEXT. Two kinds of contextual factors are important for practitioners: "prerequisites" (conditions needed for an intervention to be fully implemented) and "moderators" (situational factors likely to affect the returns from an intervention, once implemented). "Prerequisites" tell practitioners where an intervention is and isn't feasible—for specific examples, see Beauchamp et al.'s facilitating and limiting factors and Traynor et al.'s "requirements." "Moderators" tell practitioners whether returns are likely to be lower (or higher) in their particular context, and why—see Ellinger et al.'s discussion of potential moderators that might explain why prosocial outcomes typically found in nature failed to appear in their specific context.

The articles here not only illustrate best practices for guiding widespread adoption of NBL but also help us imagine potential returns of that transformation. What if education and environmental design were reshaped to take advantage of nature's powerful effects on learning and development?

Nature-based education

If the nature-based interventions here were extended to multiple developmental stages from preschool to college and adopted at the population level, we might see larger, lifelong, population-level benefits.

A HEALTHIER POPULATION

- If the hands-on gardening in childcare in Cosco et al.'s study was widely adopted and extended into elementary school and beyond, we might see lifelong healthy diets, reducing obesity and disease.
- If the impacts of nature experiences on psychological resilience in both preschoolers and college students found in Ernst et al. and Rakow and Ibes, respectively, were reinforced in K-12 education, we might see future generations better at coping with adversity.
- If nature prescriptions (Rakow and Ibes) were extended to younger-than-college ages and widely adopted, we might see population gains in mental health across the lifespan.

A BETTER-EQUIPPED CITIZENRY—a population with 21st-century skills, more inclined and better prepared to tackle the largest challenges of our time:

- Time in nature appears to foster 21st-century skills and dispositions such as leadership, initiative, communication, collaboration, critical thinking, and creativity (Mann et al.; Ernst et al.; Schilhab).
- Contreras and Krasny find that nature-based projects can empower children as young as pre-k and kindergarteners to be environmental stewards, helping them recognize their capacity to meaningfully contribute to their communities.
- If nature-based science education were the norm, we might expect a more scientifically literate workforce and citizenry, with a stronger foundation in environmental education (for review, see Schilhab).

A MORE JUST AND INCLUSIVE SOCIETY

- Nature-based interventions are often especially effective for underserved populations; see de Vries and Verheij (residential greenspace and low-SES populations) and Hartley et al. (nature-based education and linguistically diverse learners).
- Natural settings seem to afford more inclusive pedagogy—e.g. Beauchamp et al. report teachers incorporating First Nations and Indigenous cultural practices.
- Nature-based interventions can address important outcomes among marginalized populations (e.g. Cosco et al.).

One of the most striking emergent themes in this collection is the difference between two iterations of NBL. NBL 1.0 requires only bringing natural materials into the classroom or bringing lessons outside, and delivers greater *learning*, whereas NBL 2.0 requires a major change in pedagogy, but fosters *development*, including the 21st-century skills that conventional pedagogy and NBL 1.0 fall short on delivering. Chawla points out that such benefits as autonomy, competence, relatedness, and "eudaimonic thriving" require one to be an "active agent" in nature, rather than a passive recipient. Consistent with Chawla's conception, outcomes like communication, flexibility, problem-solving, and leadership/initiative appear almost exclusively in student-centered or student-driven settings in the other articles in this collection (Beauchamp et al.; Contreras and Krasny; Mann et al.; Traynor et al.; Ernst et al.; Hartley et al.). Schilhab discusses barriers to

less structured, more autonomous nature experiences in science learning. In these settings, students are "active agents" and teachers are flexible and responsive.

Nature-based environmental design

Not surprisingly, when we use the findings here to imagine the potential returns of nature-based environmental design, the same themes emerge: health, better-equipped adults, and reduced inequity. If all neighborhoods contained sufficient greenspace, we might see not only less need for ADHD medications but improved academic achievement and greater earnings through the lifecourse for that population—with especially large effects in the neighborhoods most deprived of greenspace (de Vries and Verheij). If parks were designed with "zones" for both outdoor recreation and experiences of awe and solitude, as recommended by Mateer, we might see both hedonic and eudaimonic benefits.

Conclusion

In this Research Topic of 10 empirical articles, one review, and two conceptual pieces, we have attempted to demonstrate the value of a ROI approach and to highlight resulting evidence for best practices to guide wide-spread adoption of NBL. These 13 articles spark a vision for education and environmental design reimagined to leverage the significant demonstrated impact of nature on both learning (NBL 1.0) and development (NBL 2.0).

Author contributions

MK: Conceptualization, Writing—original draft, Writing—review and editing. UD: Conceptualization, Writing—original draft, Writing—review and editing. AF: Conceptualization, Writing—original draft, Writing—review and editing. CJ: Conceptualization, Writing—original draft, Writing—review and editing. NW: Conceptualization, Writing—original draft, Writing—review and editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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References

Kuo, F. E. (2002). "Bridging the gap: how scientists can make a difference," in *Handbook of Environmental Psychology*, eds R. B. Bechtel, and A. Churchman (Hoboken, NJ: John Wiley & Sons, Inc), 335–346.

Wells, N. M., Myers, B. M., Todd, L. E., Barale, K., Gaolach, B., Ferenz, G., et al. (2015). The effects of school gardens on children's science knowledge: a randomized controlled trial of low-income elementary schools. *Int. J. Sci. Educ.* 37, 2858–2878. doi: 10.1080/09500693.2015.1112048

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ORIGINAL RESEARCH
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Comparing the Impact of Nature, Blended, and Traditional Preschools on Children's Resilience: Some Nature May Be Better Than None

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This study examined the effect of nature preschools on the development of key protective factors associated with psychological resilience. The Deveraux Early Childhood Assessment for Preschoolers, Second Edition (DECA-P2), was used to assess the growth in the protective factors of initiative, self-regulation, and attachment in 87 children who attended nature, blended, and traditional preschool classes within the same school district. Study results suggest that nature preschool participation was important in the context of initiative. Blended classes, where some nature-based practices were incorporated into traditional preschool classes, were sufficient in the sense of being more impactful than traditional classes on self-regulation, attachment, and the total protective factors overall. Implications are discussed within the context of the limitations of the study.

Keywords: nature preschools, resilience (psychological), protective factors, initiative, self-regulation, attachment

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INTRODUCTION

In recent years, concerns regarding declining resilience in children have surfaced in the academic and popular literature, alongside concerns regarding increasing stress, anxiety, and depression (Grey, 2013; Masten and Barnes, 2018). Resilience is a particularly relevant psychological construct to explore, especially in light of the coronavirus pandemic. Children have experienced significant stress throughout the pandemic, including quarantining at home, increased screen time, limited access to extended family members and playmates, and the anxiety of caregivers regarding getting sick (American Academy of Pediatrics, 2021). And for some children, the pandemic resulted in stress from financial hardships, fear from increased tensions in households, and grief from the loss of loved ones (Bartlett et al., 2020). While children generally and eventually return to their typical functioning, particularly with responsive and supportive caregivers, some are at risk of developing trauma-related stress, anxiety, and depression (Bartlett et al., 2020).

Psychological resilience is commonly described as the ability to recover from adversity, whether severe and prolonged adversity, such as the pandemic, or on a smaller scale, such as the difficulties that surface as a part of daily life. Resilience is malleable. It is not a characteristic that children either have or do not have; yet, differences in children's personalities and cognitive skills influence adaptive capacity, as do their connections to other people and to external systems (Masten and Barnes, 2018). Benard (2004) defines resilience as being able

to overcome adversity and become competent and caring individuals, and Luthar et al. (2000) positions resilience as the positive, adaptive response in the presence of adversity. With the relatively recent ability to study resilience at the neurobiological level, Masten (2014) describes resilience as embedded within interacting processes and systems, including molecular-level systems within the individual (including epigenetic and immune system processes), social-level systems (families, friends, etc.), community-level systems (schools, emergency service systems, etc.), and macrosystems (such as government-level systems that indirectly influence other systems through policies and regulations). These interacting processes and systems shape the course of children's development and adaptation (Masten, 2014). Consequently, Masten and Cicchetti (2016) conceptualize resilience as the capacity of a dynamic system to adapt to disturbances that threaten the development of the system or its function or viability. For an individual, "resilience reflects all the adaptive capacity available at a given time in a given context that can be drawn upon to respond to current or future challenges facing the individual, through many different processes and connections" (Masten and Barnes, 2018).

Over time, research on resilience has shifted from identifying risk factors to studying what enables children to thrive in spite of adversity, thus transitioning from a problem-based deficit model to a strengths-based model (Masten, 2007). There are protective mechanisms that support successful adaptation to adversity (Benard, 2004). These within-child dispositions and skills, such as problem-solving abilities, initiative, a sense of self-efficacy, self-regulation skills, persistence, and a sense of purpose and belief that life has meaning (Wright and Masten, 2005). Protective factors can involve supports, such as positive relationships with caring and competent adults, effective parenting, positive friendships, effective schools and teachers, and protecting and nurturing brain development (Masten et al., 2008); these have been described as harnessing or restoring the power of human adaptive systems (Masten, 2014).

Somewhat missing, however, in the extensive body of literature regarding protective mechanisms is a solid recognition of the importance of nature exposure and/or positive human connections with the natural world (Wells, 2013; Chawla et al., 2014). This lack of prominent recognition exists in spite of a growing number of studies that connect nature to resilience-related outcomes. For example, Chawla et al. (2014) investigated green schoolyards' impact on children's stress and resilience. The findings from their ethnographic study suggest children experienced not only restoration in their green schoolyards, but also developed feelings of competency and developed supportive social relationships, both of which are considered protective factors relating to resiliency (Chawla et al., 2014). McArdle et al. (2013) investigated the effect of a preschool program that used outdoor free play and intentional efforts to provide nurturing relationships for children who had experienced disruptions in attachments early in life. Their ethnographic study suggests a strengthening of confidence in the face of new challenges, self-control, empathy, motivation, focus, and perseverance (McArdle et al., 2013). A quantitative study by Ernst et al. (2018) found that students enrolled in a nature preschool showed significant strengthening of their total protective factors related to resilience over the course of one school year. Results from Ritchie et al. (2014) suggest the potential for multi-day outdoor adventure trips to influence the resilience and well-being of adolescents, and Buchecker and Degenhardt (2015) found a positive (but modest) relationship between outdoor recreation in nearby nature and urban adults' emotional well-being and resilience. Additionally, there has been some study of single protective factors such as the influence of nature exposure or experiences on self-regulation (Fabor Taylor et al., 2002; McCree et al., 2018; Weeland et al., 2019).

Empirical evidence and theory provide two plausible linkages, or mediating mechanisms, between nature exposure and resilience (Wells, 2013). One of these is that access to nature fosters social interactions and supports the development of social relationships. The potential for green settings to draw people together, thereby foster social interactions, friendships, and social ties is evident in several studies (e.g., Kuo et al., 1988; Coley et al., 1997; Fabor Taylor et al., 1998; Sullivan et al., 2004). The second is that access to nature boosts cognitive functioning. This is grounded in attention restoration theory (Kaplan and Kaplan, 1989), which suggests natural environments can counter directed attention fatigue, as nature engages involuntary attention and thus allows directed attention capacities to recharge. Studies, such as Wells (2000), Fabor Taylor et al. (2001), and Berto (2005), support this association between nature exposure and successful attentional capacity and day-to-day cognitive functioning, both of which help with management of adversity. Social interactions and cognitive functioning are strong predictors of resilience (Masten, 2007), thereby providing the link between nature and resilience.

While these mediating mechanisms proposed by Wells (2013) are in the context of nature and not specifically nature preschool, they provide foundational support for the hypothesized association between nature preschool and resilience. Additionally, in light of research that connects nature preschools to positive social relationships and cognitive functioning (e.g., Cordiano et al., 2019; Ernst and Burcak, 2019; Volpe et al., 2019; Bal and Kaya, 2020; Robinson and Ernst, 2020), it seems reasonable to further study the relationship between nature preschools specifically and resilience. Additionally, further research focusing on young children in the context of resilience is needed. Masten et al. (2008) notes that even though resilience can be supported at every age, there are certain windows of opportunity where supporting the development of protective factors and harnessing the power of protective factors and systems are especially important. One of those critical windows is early childhood and heightened brain plasticity (Center on the Developing Child at Harvard University, n.d.). Additionally, Masten et al. (2008, p. 79) indicate "competence begets competence," and thus, investing early is recommended, and there is a high return on investment in early child development documented by Heckman (2006). Consequently, the study at hand sought to further explore the potential of nature preschools to support the development of protective factors associated with resilience in young children.

MATERIALS AND METHODS

Purpose

The purpose of this study was to investigate whether nature preschool fosters the growth of young children's total protective factors associated with resilience, and how that growth compares with preschool classes where there is less incorporation of nature-based approaches and experiences. The specific research question guiding the study was as follows: When controlling for preschool participants' pretest levels, gender, and dosage of participation, do nature preschoolers have higher levels of protective factors (operationalized as initiative, self-regulation, and attachment) at the end of the school year than their peers in blended and non-nature preschool classes?

Participants

The participants in this study were preschool-aged children enrolled in public preschool classes within one school district, located in a Midwest (United States) suburban area just outside of a major metropolitan area. The school district enrolls approximately 9,000 students from across several cities and townships. The median household income in this community is roughly $100,000, and the community is approximately 90% White (National Center for Education Statistics, 2020). This public preschool system was chosen because of the unique scenario of multiple classes of nature, blended, and traditional preschool programming all within the same school district.

All 17 preschool classes were invited to participate in this study. While initially all teachers expressed interested, as the start of the school year approached and with the uncertainty of the coronavirus pandemic and what the school year would bring, some decided not to participate, resulting in 11 classes who participated in the study. These 11 classes were taught by six teachers, as several teachers had two or three classes, such as a Monday–Wednesday–Friday morning class and a Tuesday–Thursday morning class. Following school district and University Institutional Review Board Approval, all preschoolers in the 11 classes were invited to participate in the study, with the exception of children who were receiving special education and spent the majority of their preschool day not in the preschool classroom. Six teachers taught the 11 participating classes, and there were a total of 87 children with parental consent to participate (see **Table 1**).

Design

A quasi-experimental design (non-equivalent pretest-post-test design) was used in this study. The district offers three types of preschool programming: nature, blended, and traditional. In addition, classes vary by duration ("dosage"), with some being half-day and others being full day; some classes occur 2 or 3 days per week, and others occur 5 days per week. Parents select the type of preschool and the specific class when they enroll their preschoolers, and thus, random assignment was not feasible.

The nature classes were considered the treatment group; the blended and traditional classrooms served as comparison groups. Nature preschool classes were located at two sites (an elementary school and the early learning center) and focused on developing curiosity, a love of learning, and a respect for/connection to nature through playful, unstructured or loosely guided experiences in and with nature. In the nature preschool classes, teachers primarily used child-directed activities, based on the interests of their students and what emerged from their interactions in nature. These classes spent most of their time outdoors in an unmaintained natural setting (3–5 h, depending on half or full day class sections). The nature preschool classes at the elementary site had access to 80 acres of city land designated for wildlife conservation and environmental education purposes. This setting offers several ponds, a stream, prairie areas, forest areas, wetlands, and multiple walking paths. There is also a nature playscape at this site, consisting of a mud kitchen, woodblocks, tree stumps, and other features typical to nature playscapes. The nature preschool classes at the early learning center used a variety of natural space around the perimeter of the school, which allowed for play and exploration in both wooded and grassy areas. The playscape at this site had a mud kitchen, fort-building/sticks, and other natural loose parts (tree cookies, rocks, etc.). The area is about one-quarter acre in size and much of it is a hilly slope covered with sumac and other emergent vegetation just a bit taller than the children. At the base of the hill, there is a paved path, as well as a stump circle for gathering, and a compost bin. There is also a drainage ditch that periodically fills with water and/or ice.

Traditional preschool classes focused on developing early literacy and math skills, through a combination of teacher-directed instruction and child-directed play to prepare children for Kindergarten. The traditional preschool classes were located at the early learning center. Play occurred primarily indoors, with about a half hour of weather-dependent outdoor play (typically on the nearby elementary school playground with occasional use of the nature playscape), as well as use of an outdoor courtyard with riding toys, wagons, plastic trucks, toy figures, etc. While nature was not a focus of the traditional classroom, the children had opportunities to learn about nature, such as using apples or pumpkins in the fall to practice counting and letters and in the context of science (learning about what plants need to grow), for example. Thus, nature was included as subject matter, as opposed to serving as an immersive setting for child-directed play as in the nature preschool classes.

The blended preschool classes were also located at the early learning center. Similar to the traditional classes, the blended classes were focused on Kindergarten readiness, but also had an aim of connecting children to nature. Blended classes balanced teacher-directed instruction and child-directed play, similar to the traditional classes, but also included about an hour of outdoor play in nature and/or teacher-guided outdoor learning. Although the playground and courtyard were used for outdoor play, there was regular use of the nature playscape as well.

While participating preschool classes were already classified as either nature, blended, or traditional, the assignment of teachers to specific classes opened the possibility for a blurring

TABLE 1 | Summary of class and participant data.

Category	Teacher/class	Degree of "Nature-ness"[a]	# of Students	Average Age (mos.)[b]	% Female	Weekly Attendance	Days distance learning due to COVID[c]
Traditional	1/a	22	8	45	63	5 half days	20
	1/b	22	8	55	63	5 half days	20
	2/a	29	7	63	43	5 full days	0
	3/a	29.5	5	58	60	5 half days	0
	3/b	29.5	9	60	44	5 half days	0
Blended	4/a	33	5	42	60	3 half days	0
	4/b	33	8	41	75	2 half days	0
	4/c	33	9	47	44	3 half days	0
Nature	5/a	36.5	8	44	38	3 half days	4
	5/b	36.5	7	54	57	2 half days	5
	6/a	36.5	13	56	54	5 full days	21

[a]*Score on Nature-ness Rubric, ranging from 13 to 39, with higher scores indicating higher levels/more nature-based settings, practices, etc.*

[b]*Age at time of the pretest.*

[c]*All classes had distance learning November 23–34, November 30–December 4; days indicated in column are in additional to program-wide distance learning.*

of lines between the categories (e.g., a teacher with a more traditional preschool teaching philosophy or experience base being assigned to a blended class). For this reason and to confirm the labeling (categorizing) of classes into the treatment and comparison groups, a rubric was developed, building on the work of Bailie (2016) and Larimore et al. (2019), and field tested prior to use in the study at hand (see **Table 2**). The rubric has a total of 13 items covering four traits: curriculum and instructional practices, nature-related curriculum and instruction practices, teacher role, and indoor and outdoor environments. In terms of scoring, for the rows with three cells, points were awarded as follows: three points for the left cell, two points for the middle cell, and one point for the right cell. For rows with two cells, the cell on the left was three points and the cell on the right was one point. If teachers circled two cells, then the points were the average of the two cells, for example, 2.5 if they circled both the left and middle cells in a row. Higher total points indicate higher degree of "nature-ness," with the highest possible level on this rubric being 39 and the lowest being 13.

The six teachers completed this rubric near the end of the academic year, and their "nature-ness" scores were used to confirm the categorization of their classes (See **Table 2**). Based on the completed rubrics, the two teachers with the level of "nature-ness" had a "score" of 36.5; these two teachers taught classes that were labeled by the district as nature preschool classes. The teacher of the three sections of district's blended classes had a "nature-ness" score that was lower than the teachers of the nature sections (a score of 33), and the three teachers of the classes labeled by the district as traditional had the lowest "nature-ness" scores (scores of 29.5, 29, and 22). Thus, while scoring confirmed the general categorization into groups, it is important to note that "nature-ness" or degree of nature-based preschool was more of a continuum, rather than discrete categories. Even the classes in the traditional category had some degree of "nature-ness," as indicated by their rubric scores, likely due to the district being an E-STEM (Environmental, Science, Technology, Engineering and Math) district.

Construct and Measure

The Devereux Early Childhood Assessment for Preschoolers, Second Edition (DECA-P2) (LeBuffe and Naglieri, 2012), was used in this study to measure within-child protective factors central to resilience and social–emotional well-being. This behavior rating scale is completed by teachers and/or parents and evaluates the frequency of 27 positive behaviors (strengths) exhibited by preschoolers during the prior 4 weeks, on a five-point scale from never to very frequently. This instrument includes instructions for those completing the rating form and is designed to be used without specific training. Due to the pandemic and in efforts to not add further stress to parents and families, parents were not asked to complete the DECA-P2 for their children; only the teachers were asked to do so.

The DECA-P2 has three subscales assessing within-child protective factors: initiative, self-regulation, and attachment/relationships, which are described in more detail in the manual (LeBuffe and Naglieri, 2012). The *initiative* subscale contains nine items measuring the child's ability to use independent thought and action to meet his or her needs. Example items within this subscale are "show an interest in learning new things" and "make decisions for him/herself." The *self-regulation* subscale contains nine items that measure the child's ability to express emotions and successfully manage behaviors. Example items include "handle frustration well" and "accept another choice when his/her first choice was not available." The *attachment* subscale contains nine items that measure the child's ability to promote and maintain mutual, positive relationships or connections with other children and adults. Example items include "trust familiar adults and believe what they say" and "seek help from others when necessary." A child's score for each of the subscales is calculated by summing the scores of the nine items within the subscale.

The DECA-P2 assessment has been demonstrated to be reliable and valid; the specific *total protective factors* score has also been described as "the most reliable and valid overall indicator of strengths related to resiliency" relative to its three subscales (LeBuffe and Naglieri, 2012, p. 92). The reported internal reliability coefficient for the overall total protective factors scale

TABLE 2 | Preschool "nature-ness" categorization rubric.

	Nature	Blended	Traditional
1.	Instructional focus is on both environmental outcomes (nature connection, sense of place, respect for nature) and Kindergarten preparation; Kindergarten prep focuses on developing curiosity, love of learning, problem-solving, independence, as well as other social–emotional outcomes	Instructional focus is on Kindergarten preparation, including developing early literacy and math skills and fostering positive in-classroom behaviors, as well as other social–emotional outcomes	
2.	Social and Emotional Learning (as well as other desired outcomes) accomplished primarily through nature play and/or playful, guided outdoor learning, as well as teacher-guided negotiations.	Social and Emotional Learning (as well as other desired outcomes) accomplished through a combination of developmentally appropriate direct instruction, curriculum materials, indoor play, outdoor play, and outdoor play in nature	Social and Emotional Learning (as well as other desired outcomes) accomplished through developmentally appropriate direct instruction and curriculum materials, as well as through play (primarily indoors)
3.	Majority of the day is not teacher-directed	Relatively equal use of teacher-directed activities and child-directed activity	More of the day is teacher-directed than child-directed
4.	Classroom management toward positive behaviors, emphasizes developing empathy and community	Classroom management toward positive behaviors involves a combination of classroom expectations, classroom rules, and developing empathy and community	Classroom management approach oriented toward classroom expectations and rules
5.	Substantial focus on child-directed nature play	Some child-directed nature play encouraged	A small amount of child-directed nature play encouraged
6.	Some teacher-guided nature learning outdoors (with a greater emphasis on child-directed playful learning when outdoors)	Some teacher-guided learning outdoors	Small amount of teacher-guided learning outdoors
7.	Much impromptu nature learning based on what's found outdoors/in nature (including weather-related)	Some impromptu nature learning based on what's found outdoors/in nature (including weather-related)	Infrequent impromptu nature learning outdoors
8.	During outdoor playtime, teacher joins in play, helps set the stage for play, models play skills or behaviors, and/or observes play toward understanding children's interests and play habits	During outdoor play, teacher primarily observes and/or actively guides play, toward maintaining safety and appropriate child behavior and interactions	
9.	Time in the indoor classroom is primarily child-driven. The teacher sets up the indoor classroom with open-ended activities for children to choose from	Inside, teachers lead small and/or large group activities along with providing time for child-directed play	Inside, teachers structure, organize, and often lead activities for children. There is an emphasis on teacher-designed activities for children
10.	Emphasis on respect for nature and others (equal emphasis)	Emphasis on respect for nature and others, with slightly more emphasis on respect for others	Emphasis on a respect for others (and a respect for nature as secondary)
11.	Teachers allow children to work out conflicts on their own as much as possible.	Teachers balance child and teacher negotiation strategies to resolve conflicts.	Teachers provide guided negotiation when conflicts arise.
12.	Indoor environment includes substantial nature content in wall displays, classroom materials, etc. Classrooms softly lit	Indoor environment has some nature content. Classrooms brightly lit	Indoor environment emphasizes other things relevant and of interest to preschoolers. Classrooms brightly lit
13.	Outdoor environment used is primarily an unmaintained, natural setting(s); a maintained natural playspace is also available	Variety of outdoor environments used, including unmaintained natural area, maintained naturalized outdoor play space, and outdoor playground	Outdoor environment used is primarily outdoor playground, with a naturalized outdoor play space and natural environment also available

Rubric builds upon the work of Bailie (2016) and Larimore et al. (2019).

is 0.95 for teachers. For the subscales, the initiative reliability coefficient is 0.92, self-regulation is 0.94, and relationship is 0.85 (LeBuffe and Naglieri, 2012). Content validity was established during development of the test, using a combination of focus groups and literature reviews on social and emotional competence and resilience in young children (LeBuffe and Naglieri, 2012). Criterion validity was established using comparisons across different samples to measure the degree to which the scores on the assessment predict an individual's performance on an outcome (LeBuffe and Naglieri, 2012). Construct validity was established by correlating *T*-scores on the DECA-P2 with standard scores from the Preschool Behavioral and Emotional Rating Scale and the Conners Early Childhood Scale (for more information, see LeBuffe and Naglieri, 2012).

Data Collection Procedures

Teachers were asked to complete the DECA-P2 for each child for whom parental consent had been granted. Teachers were also asked to complete a coding sheet, where children's assessment forms were labeled with a code rather than a child's name, to ensure data confidentiality while allowing for linking the pretest and post-test data. In addition, the following demographic data were collected through the coding system: children's age, gender, and "dosage" of preschool (full day/half-day and days/week). Demographic data regarding socio-economic status, race, and ethnicity were not collected, due to the lack of variation and to avoid being able to identify specific participants. Teachers completed the DECA-P2 on two occasions, at the beginning of the school year (4 weeks into the school year, per DECA-P2 instructions, which suggest a four-week period of getting to know the children prior to completing the assessment), and again at the end of the academic year.

The pre- and post-assessments were scored according to the scoring procedure in DECA User's Guide and Technical Manual (LeBuffe and Naglieri, 2012). The raw scores for the overall total protective factors and three subscales were converted to standard scores (T-scores), using tables provided in the manual. According to LeBuffe and Naglieri (2012), T-scores are classified as a protective factor "strength" (T-score of 60–72), "typical" (T-score of 41–59), or "area of need" (total protective factor T-score of 28–40). As directed by the manual, the T-scores were used in pretest-post-test comparisons at the child- and/or program-levels.

Analytic Strategy

Descriptive statistics were used to compute and summarize the means and standard deviations of the pretest and post-test scores for the total protective factor scores and for the subscales. Because of the lack of random assignment to preschool groups (parents selecting which type of preschool class for their children's enrollment), an analysis of variance test was conducted to determine whether pretest means of the total protective factors scores differed significantly across the three groups (nature, blended, and traditional). Dependent *t*-tests were conducted to determine whether each group had significant growth in total protective factors.

To compare growth in protective factors of nature preschoolers to preschoolers attending blended and traditional classes, general linear modeling was used to investigate whether post-test levels of the protective factors (total score and subscales) significantly differed across groups, when controlling for pretest levels, as well as gender and dosage. In the models, the type of preschool (nature, blended, or traditional) served as the independent variable, and the dependent variable was the within-child protective factor, as measured by the DECA-P2 (initiative, self-regulation, attachment, and the combined total protective factors measure). Pretest scores, gender, and dosage of participation were covariates in the models. Age was not a covariate, per LeBuffe and Naglieri (2012) indicating protective factors do not vary much across the three- to five-year-old developmental period (initial models were run, however to check this; results confirm the decision not to include age into the analyses as a covariate). Nor was socio-economic status, ethnicity or race a covariate in the analyses, due to the lack of variation among participants. For significant models, pairwise comparisons were used to determine which groups had significant differences in adjusted post-test means between them.

In addition to the models where the independent variable was the preschool categorization (nature, blended, and traditional), general linear modeling was used with teacher as the independent variable (with six levels of this factor; these six teachers' classes differed by their level of "nature-ness"). This was done in light of the rubric responses of teachers' and their corresponding "nature-ness" scores, indicating more of a continuum of nature-ness rather than clearly discrete categories, and thus, the possibility that post-test scores differed by degree of nature-ness. It also provided a way to confirm the results from the models where preschool categories served as the independent variable to see whether differences across the groups "held up" or whether instead within-group variation across the teachers/classes was responsible for between-group differences.

RESULTS

Descriptive statistics for the preschool categories are reported in **Table 3**. Results of the comparison of pretest levels of total protective factors scores indicate there were no significant differences across nature, blended, and traditional classes, when controlling for gender, $F(2) = 0.99$, $p = 0.37$. This suggests that family-level nature engagement outside of preschool time is less of a concern in terms of interpreting the effects of nature preschool participation. If out-of-school time in nature, particularly by families who chose nature preschool, were influencing protective factors, there likely would have been significant differences across the pretest scores.

Based on the results of the dependent *t*-tests, the total protective factors of nature preschoolers increased over the course of the school year, and this growth was significant, $t(24) = 7.68$, $p < 0.001$. Preschoolers in the blended and traditional classes also had significant growth in protective factors, $t(19) = 5.66$, $p < 0.001$ and $t(35) = 3.65$, $p = 0.001$, respectively.

TABLE 3 | Descriptive statistics for protective factors by category and teacher.

	Initiative		Self-regulation		Attachment/relationships		Total protective factors	
	Pretest M (SD)	Post-test M(SD)	Pretest M (SD)	Post-test M(SD)	Pretest M (SD)	Post-test M (SD)	Pretest M (SD)	Post-test M(SD)
Traditional (Combined Group, *n* = 36)	54.16 (10.41)	55.42 (10.59)	51.68 (8.76)	54.33 (9.50)	49.95 (7.82)	53.75 (7.92)	52.27 (9.35)	55.06 (8.33)
Tchr 1, Classes a,b	45.18 (5.43)	46.53 (6.78)	46.44 (6.90)	47.20 (7.20)	45.43 (5.92)	55.40 (5.34)	44.93 (5.73)	49.60 (5.14)
Tchr 2, Class a	57.28 (6.16)	56.85 (5.08)	53.29 (3.59)	56.71 (2.92)	47.29 (4.82)	45.57 (3.78)	53.43 (5.16)	53.71 (3.15)
Tchr 3, Classes a,b	62.85 (7.92)	64.21 (8.08)	56.85 (9.36)	60.79 (8.74)	56.43 (6.65)	56.07 (9.29)	60.07 (7.72)	61.57 (8.55)
Blended (Combined Group, *n* = 20)	43.14 (9.38)	49.45 (12.68)	46.82 (11.44)	52.45 (11.29)	38.36 (9.42)	52.05 (12.03)	41.91 (9.54)	51.50 (12.03)
Tchr 4, Classes abc	43.14 (9.38)	49.45 (12.68)	46.82 (11.44)	52.45 (11.29)	38.36 (9.42)	52.05 (12.03)	41.91 (9.54)	51.50 (12.03)
Nature (Combined Group, n = 25)	47.46 (6.09)	61.52 (8.16)	50.17 (7.15)	57.16 (8.80)	53.53 (7.54)	61.52 (9.70)	50.64 (6.70)	61.44 (8.36)
Tchr 5, Classes a,b	48.60 (7.22)	58.92 (8.16)	48.73 (7.00)	57.00 (8.78)	49.40 (6.95)	55.23 (8.96)	48.80 (7.62)	58.15 (9.37)
Tchr 6, Class a	46.15 (4.39)	64.33 (7.50)	51.85 (7.25)	57.33 (9.22)	58.30 (5.08)	68.33 (4.49)	52.77 (4.90)	65.00 (5.50)

The adjusted post-test means (post-test means when controlling for the pretests scores, gender, and dosage of participation) for each of the dependent variables from the general linear modeling analyses are reported in **Table 4** (for both the group-level and teacher-level modeling). **Table 5** provides a summary of the significant differences in the adjusted post-test means of the protective factors by group and teacher.

TABLE 4 | Summary of adjusted post-test means[a] by group and teachers.

	Initiative Estimated Mean (Standard Error)	Self-Regulation Estimated Mean (Standard Error)	Attachment/ Relationships Estimated Mean (Standard Error)	Total Protective Factors Estimated Mean (Standard Error)
Traditional	51.41 (1.23)	52.97 (0.98)	52.71 (1.35)	52.65 (1.02)
Tchr 1, Classes a,b	50.50 (1.85)	50.12 (1.50)	57.43 (1.91)	53.56 (1.61)
Tchr 2, Class a	50.16 (2.73)	54.42 (2.14)	46.33 (2.73)	50.36 (2.27)
Tchr 3, Class b	52.92 (2.36)	55.62 (1.59)	50.82 (2.14)	52.69 (1.88)
Blended	55.60 (1.71)	54.79 (1.37)	58.31 (2.12)	57.42 (1.49)
Tchr 4, Classes a,b,c	55.60 (1.71)	54.79 (1.37)	58.31 (2.12)	57.42 (1.49)
Nature	62.37 (1.49)	57.25 (1.23)	58.02 (1.78)	60.12 (1.26)
Tchr 5, Classes a,b	59.44 (1.88)	58.21 (1.55)	54.45 (2.10)	58.49 (1.63)
Tchr 6, Class a	67.15 (1.98)	56.02 (1.62)	61.79 (2.38)	62.14 (1.73)

[a]*Controlling for Pretest Mean, Gender, and Dosage of Participation.*

Initiative

Regarding the protective factor of initiative, there was a significant difference across preschool categories, $F(2) = 15.22$, $p < 0.001$, which corresponded to a large effect size (partial eta squared = 0.29). The pairwise comparisons indicated significant differences between the nature and traditional preschool categories (mean difference 11.00, SE = 2.00, $p < 0.001$) and between the nature and blended categories (mean difference = 6.77, SE 2.33, $p = 0.01$). The difference in adjusted initiative post-test means between the nature-lite (blended) and traditional categories was not significant (Mean Difference = 5.59, SE = 2.19, $p > 0.05$).

When the analysis was run with teacher as the independent variable, there was a significant difference across teachers, $F(5) = 10.58$, $p < 0.001$, which corresponded to a large effect size (partial eta squared = 0.42). The class of teacher six (categorized by the district as nature; nature-ness score of 36.5) had a significantly higher adjusted post-test mean than all of the other classes ($p < 0.001$). The two combined classes of teacher five, also categorized by the district as nature and a nature-ness score of 36.5, had a significantly higher adjusted post-test mean than the classes of the three teachers in the traditional preschool category, with their nature-ness scores of 22, 29, and 29.5, respectively ($p = 0.001$, $p = 0.01$, $p = 0.04$, respectively), but not significantly higher than the teacher's classes that were classified as blended by the district and had nature-ness score of 33 ($p > 0.05$). The three teachers' classes in the traditional category did not significantly differ among themselves ($p > 0.05$) nor did the teacher's combined classes that were categorized as blended differ from teachers' classes in the traditional category ($p > 0.05$).

Self-Regulation

Regarding the protective factor of self-regulation, there was a significant difference across preschool categories, $F(2) = 3.65$, $p = 0.03$, which corresponded to a medium to large effect size (partial eta squared = 0.09). The pairwise comparisons indicated

TABLE 5 | Summary of significant differences in the adjusted post-test means of the protective factors by group and teacher.

	Nature v. Traditional		Nature v. Blended		Blended v. Traditional	
	Evidence of Significant Difference from Comparisons of Categories	Evidence of Significant Difference from Comparisons of Classes of Teachers	Evidence of Significant Difference from Comparisons of Categories	Evidence of Significant Difference from Comparisons of Classes of Teachers	Evidence of Significant Difference from Comparisons of Categories	Evidence of Significant Difference from Comparisons of Classes of Teachers
Initiative	Yes	Yes	Yes	Yes	–	–
Self-Reg	Yes	Yes	–	–	–	Yes
Attachment	Yes	Yes	–	–	Yes	Yes
Total Protective Factors	Yes	Yes	–	–	Yes	Yes

significant differences between the nature and traditional preschool categories (mean difference 4.28, SE = 1.60, p = 0.01). The difference in adjusted self-regulation post-test means between the nature and blended categories was not significant (mean difference = 2.18, SE = 1.75, p > 0.05) nor was it significant between the blended and traditional categories (Mean Difference = 1.92, SE = 1.64, p > 0.05).

When the analysis was run with teacher as the independent variable, there was a significant difference across teachers, $F(5) = 3.06$, $p = 0.02$, which corresponded to a large effect size (partial eta squared = 0.17). The classes of teachers six and five (which were categorized by the district as nature; nature-ness scores of 36.5) had a significantly higher adjusted post-test mean than the classes of teacher one, who was classified as traditional by the district and a nature-ness score of 22 ($p < 0.001$, p = 0.01, respectively). The adjusted post-test means of the combined classes of teacher four (categorized as blended, with a nature-ness score of 33) and the combined classes of teacher three (categorized as traditional, with a nature-ness score of 29.5) were also both significantly higher than teacher one ($p = 0.02$ for both).

Attachment

Regarding the protective factor of attachment, there was a significant difference across preschool categories, F(2) = 4.46 $p = 0.02$, which corresponded to a medium to large effect size (partial eta squared = 0.11). The pairwise comparisons indicated significant differences between the nature and traditional preschool categories (mean difference 5.31, SE = 2.21, p = 0.02) and between the blended and traditional categories (mean difference = 5.56, SE 2.56, $p = 0.03$). There was not a significant difference between the nature and blended categories (mean difference = 0.23, SE = 2.90, $p = 0.94$).

When the analysis was run with teacher as the independent variable, there was a significant difference across teachers, F(5) = 6.06, $p < 0.001$, which corresponded to a large effect size (partial eta squared = 0.29). The classes of teachers five and six (categorized by the district as nature; nature-ness scores of 36.5) were significantly higher than the class of teacher two (categorized as traditional; a nature-score of 29), p = 0.02 and $p < 0.001$, respectively, and the combined classes of teacher four (categorized as blended; nature-ness score of 33) were also higher than the class of teacher two, $p = 0.001$. The class of teacher six and the combined classes of teacher four were both significantly higher than the combined classes of teacher three (categorized by the district as traditional with a nature-ness score of 29.5), $p = 0.02$ and $p < 0.001$, respectively. There was also significant within-category variation. The combined classes of teacher one (traditional; nature-ness score of 22) were significantly higher than the classes of teachers two and three (traditional; nature-ness scores of 29 and 29.5), p = 0.001 and p = 0.03, respectively. The combined classes of teacher five (nature) were significantly higher than the class of teacher six (nature), p = 0.02; both teachers had nature-ness scores of 36.5.

Total Protective Factors

When the subscales (individual factors of initiative, self-regulation, and attachment) are combined into the measure of total protective factors, there was a significant difference across preschool categories, $F(2) = 11.25$ $p < 0.001$, which corresponded to a large effect size (partial eta squared = 0.23). The pairwise comparisons indicated significant differences between the nature and the traditional preschool categories (mean difference 7.46, SE = 1.63, $p < 0.001$) and between the blended and traditional preschool categories (mean difference 4.82, SE = 1. 85, $p = 0.01$). There was not a significant difference between nature and blended (mean difference 2.92, SE = 1.91, $p = 0.13$).

When the analysis was run with teacher as the independent variable, there was a significant difference across teachers, $F(5) = 5.87$, $p < 0.001$, which corresponded to a large effect size (partial eta squared = 0.29). The classes of teachers five and six (categorized by the district as nature; nature-ness score of 36.5) were significantly higher than the classes of teachers three, two, and one (categorized by the district as traditional; nature-ness scores of 29.5, 29, and 22, respectively), $p = 0.02$ for teacher five across the comparisons with the traditional classes, and $p < 0.001$ for teacher six across the comparisons with the traditional classes. The combined classes of teacher four (categorized by the district as blended; nature-ness score of 33) were significantly higher than the class of teacher two (categorized as traditional; nature-ness score of 29), $p = 0.02$.

DISCUSSION

Limitations

It is important to consider these findings within the context of the study's threats to validity. In light of lack of random assignment limiting internal validity, it is difficult to attribute results solely to participation in the type of preschool. While pretest scores were incorporated into the analyses to account for possible pre-existing differences and despite participants being from within the same school district, cautious interpretation and generalization is warranted. Also, while the DECA user manual was followed regarding guidance regarding age and gender in the statistical modeling, it is important to note that the sample from this study was different from the national sampling and analyses conducted by the test authors toward the normed data and recommendations regarding use of covariates. Another limitation stems from the "nesting" of data (children within classes within teachers within categories). The analysis approach used was selected in place of multi-level modeling because of an insufficient sample size at the program level and due to the groups being a fixed rather than random factor, per recommendations by Garson (2013) and Huta (2014). However, there is the possibility of inaccurate statistical estimates from not accounting for the hierarchical structure of the data and the resulting risk of partitioning variance incorrectly (Woltman et al., 2012).

Construct validity is limited due to the single measure of total protective factors associated with resilience and also due to the potential for hypothesis guessing, particularly when teachers were associated with both the independent and dependent variables. Construct validity is also limited from mono-operation bias, as there were not multiple classes for two of the teachers. Additionally, these two teachers had fewer students overall for both observing students and completing the research instrument, further threatening construct validity. Similarly, there was only one teacher for the three classes in the blended category and thus only one "rater" completing the DECA instrument. Further, the self-report nature of the measure of teachers' levels of "nature-ness" is another threat to the construct validity of the study. In addition, teachers may have varied in their level of childhood teaching experience, degree and licensure/emphasis, and experience with nature-based practices; these may have impacted not only how their curriculum and instruction, but also how they completed the DECA research instrument, particularly since there is no training for using the DECA.

External validity is limited given the voluntary participation and also the lack of variation in terms of race, ethnicity, and socio-economic status of the sample at hand. Additionally, it is important to restate this study was conducted during a pandemic, which further limits the external validity of the study. While pretest levels of participants' protective factors were within the normative range reported in the DECA manual, the conditions children experienced throughout the school year likely negate comparisons with published test norms and perhaps limit the external validity of this study beyond pandemic times. It is unclear from the findings at hand whether the growth in total protective factors among the nature preschool participants was further influenced by children having transitioned out of a time period in which they were primarily homebound with potentially elevated stress levels within households. Thus, the immersion in nature and the opportunities for unstructured outdoor play may have been even more salient, thereby strengthening the efficacy of nature preschools beyond what might occur during non-pandemic times. These limitations, individually and collectively, are important to consider when drawing implications from the study's findings.

Discussion of Findings

These results overall suggest that nature and blended preschool classes were effective in supporting growth in total protective factors. Thus, when goals for young children include fostering the protective factors children can draw upon in times of adversity, the incorporation of nature-based practices and experiences into preschool programming appears to be an effective approach. Nature preschools seem particularly effective, as children's protective factors at the end of the preschool year corresponded with the descriptor, "strength," whereas the preschoolers in the blended and traditional sections had protective factors at the level of "typical" for their age, per guidelines in the DECA User's Guide and Technical Manual (LeBuffe and Naglieri, 2012). However, in light of some variations in the results pertaining to the protective factors individually, it may be useful to consider the factors individually toward guiding practice and further research.

Regarding initiative, results suggest it is being furthered through nature preschool, more so than traditional preschool, and likely more so than blended preschool. In other words, the degree of nature-ness of the participating teachers/classes seemed to impact initiative, and if the goal is increasing or maximizing the protective factor of initiative in young children, nature preschool appeared be most effective. Blended preschool in this study seemed to be no more effective than traditional preschool in terms of supporting initiative in preschool-aged children.

Regarding self-regulation, results suggest it was supported through nature preschool, more so than through traditional preschool. Additionally, the degree of nature-ness in the participating teachers/classes appeared to influence the effectiveness on self-regulation, with a greater degree of nature-ness being more effective than a lesser degree of nature-ness, particularly when comparing blended and traditional classes.

Regarding attachment/relationships, results suggest both that nature and blended preschool classes were more effective in supporting it in young children than traditional classes. In light of the within-category variation in attachment levels, there was likely some other teacher and/or programming characteristic that was influencing attachment, other than the degree of nature-ness; whether this other characteristic was as influential as nature-ness is unknown.

These results also suggest the greatest impact of nature preschool on initiative, as this individual protective factor had the greatest effect size relative to the others. This also was

the only protective factor with evidence suggesting nature preschool was even more effective than blended preschool. One possible explanation could be attributed to the less-structured approach within the nature preschool category; the majority of the day is not teacher-directed, and there is a substantial focus on unstructured, child-directed nature play. Thus, students have more autonomy and free choice to choose the activities they want to take part in, and to participate (regardless of what that looks like or entails) takes initiative. The natural spaces for children to explore in nature often lead to less supervision and increased distance from teachers, which affords opportunities to problem solve on their own, rather than relying on a teacher for help (Alme and Reime, 2021). Grey (2013) positions increasing anxiety and declining resilience as resulting from the dramatic decline in children's opportunities to playfully explore and pursue their own interests away from adults. In nature preschool, children are more responsible for coming up with ideas regarding what to play, for solving problems when they arise, assisting each other as they encounter and initiate challenging activities, rather than relying on teachers for things they can do for themselves. Additionally, the dynamic nature of natural outdoor settings continuously affords opportunities for children to constantly adapt and problem solve, which prompt the opportunity for initiative (Alme and Reime, 2021).

For self-regulation, attachment, and the combined measure of total protective factors, results suggest that some incorporation of nature experiences and practices is better than none and that nature preschool may not lead to even stronger outcomes than blended approaches. In a study by Kochanowski and Carr (2014), child-directed nature play was associated with an increase in self-regulation. Their study suggested nature's open-ended structures and loose parts challenged children's physical boundaries; consequently, children often displayed their courage and determination through continued attempts to succeed. The study authors speculate that through these experiences, children often experienced a mix of emotions including frustration and anger, and by continuing to not give up, students exercised and developed skills related to self-regulation. Perhaps, since open-endedness and loose parts were features of play in both nature playscapes and unmaintained natural settings and since children in the blended preschool classes had the opportunity to play in playscapes, it is reasonable to expect some growth in self-regulation for both blended and nature sections. This illustrates that depending on the desired outcome at hand, the dosage of "nature" (whether that be in terms of setting, time, or time proportional to another type of activity) likely matters.

The possibility that incorporating some nature-based practices can be influential, whether that be on self-regulation and attachment or other outcomes, is noteworthy. Not all preschools can or want to become nature preschools. An incremental shift for programs might make more sense for programs wanting to experiment with the feasibility and impact of integrating nature-based experiences and settings into their programming. Also important to note, though, is that it is unlikely that self-regulation or attachment, nor even protective factors associated with resilience overall, would be the sole aim for a preschool program. Thus, while blended approaches (incorporating some nature-based approaches and settings) may suffice for fostering attachment or self-regulation, there are likely other important developmental outcomes that perhaps may be impacted less so without the full degree of nature-ness in the program. This study suggests initiative is one of those outcomes.

What does this mean for policy makers and funders? The study at hand is encouraging, as it suggests that for relatively little investment, meaningful and timely impacts (strengthening of protective factors relating to resilience) might be gained. For example, in this study, children playing on a shrub/vegetation-covered slope with access to loose parts appear to have had increases in self-regulation and attachment over the course of the school year. While this unstructured play was daily, it was not for unreasonably lengthy periods of time (about an hour a day). However, the nature play was consistent; it was not dependent on weather or seasons. Thus, perhaps rather than large financial investments, funding organizations could encourage this type of play through small grants to support small-scale projects to naturalize school grounds, or through other means, such as helping preschools identify places on their school grounds where outdoor play with natural loose parts could happen. Or perhaps the investment comes in the form of outdoor clothing or footwear that makes outdoor play more feasible in a range of weather conditions and seasons. Another investment, for example, may be along the lines of fostering among preschool teachers the receptivity, motivation, and commitment toward daily outdoor play with natural elements as well as skills for navigating barriers that arise (perhaps through networks or mentors who can help "troubleshoot" challenges that arrive). Or perhaps the investment comes in the form of early learning and care policies that encourage rather than discourage outdoor play in nature. At the same time, it is important to be both mindful of the range of relevant early childhood learning and developmental outcomes and intentional in action, investing in strategies, materials, and settings that match the desired outcome at hand.

Implications for Further Research

Due to the pandemic and the University's restrictions on face-to-face data collection, observation data were not collected. Nor were parents asked to complete the DECA-P2, to avoid adding further stress in the midst of the uncertainties surrounding the upcoming school year. Future research might entail incorporating multiple sources of data such as these toward a more complete understanding of the impact of nature preschool on total protective factors. Also in light of the study being conducted during the pandemic, future research exploring the impact of nature preschool on total protective factors during non-pandemic times would lend insight into a potential association between nature preschools' efficacy and the presence of adverse conditions. With growing evidence of risks to health and well-being posed by adverse life experiences that occur during critical developmental periods, particularly when

adversities are prolonged or cumulative (Masten and Barnes, 2018), this research direction could have significant implications for practice, particularly if an association were found.

Additionally, while these results show a positive relationship between nature preschool participation and fostering protective factors related to psychological resilience, there are areas where further research is necessary. For example, within the subscale of attachment, results suggest there is likely an equally strong or stronger influence on attachment other than degree of nature-ness, particularly with the higher levels of attachment within teacher one's traditional preschool classes. A possible explanation could be that the role of the adult/teacher in a traditional classroom is more hands-on and teacher-directed, whereas in nature sections, there is much child-directed free play and potentially less interaction with teachers. Showing preference for and seeking help from an adult are indicators of attachment, and therefore, differences in the degree of teacher-directed interactions may provide at least a partial explanation. Also, attachment seems potentially most likely to have been affected by quarantine and distance learning due to COVID-19. Thus, more research is needed to explore not only attachment, but more generally, investigating what about nature preschools has a positive influence on protective factors, individually and collectively, and investigating the durability of these gains beyond the preschool year.

Chawla et al. (2014) and Ernst et al. (2018) speculate as to what about nature preschool may prompt these positive findings, yet given the importance of resilience, research that allows for more than speculation on the mechanisms is critical toward guiding practice (both teacher professional development and nature preschool implementation). The design of this study limits the ability to attribute the positive impact to any particular program characteristic; nor is it clear from this study whether nature preschools are responsible for the increase in protective factors or if instead, for example, they are an effective vehicle for providing time for children to be in nature, with time in nature being the source of positive impact. Since pretest levels of protective factors did not significantly differ across the groups, it would reason that family nature engagement and/or time in nature is not solely responsible for the findings at hand. Further research, though, is needed to better understand which program characteristics are most influential and how program characteristics interact to support the development of protective factors (e.g., is it the frequent and sustained periods of time in nature, or is it the unstructured play and child-directed interactions, or is it the interactions with preschool peers afforded by nature play?). Future studies might incorporate additional comparison groups, such as child-directed, play-based preschool programs (e.g., Montessori preschool programs) or "drop-in" nature play programs for parents and preschool-aged children that do not have the structure and format of a nature preschool. Future studies might also benefit from including the amount of time children spend in nature outside of the preschool day as a covariate in the analyses.

Another direction for further research relates to investigating whether the effectiveness of nature preschool on protective factors varies based on race, ethnicity, and socio-economic status. This would be helpful toward establishing external validity of the study. Furthermore, research has found that economic hardship severely and adversely impacts child development, learning, and quality of life and that not all races experience adverse childhood experiences equally (Sacks and Murphey, 2018). While black non-Hispanic children experience the most occurrences of adverse childhood experiences (Sacks and Murphey, 2018), they are among the least represented within nature preschools [North American Association for Environmental Education (NAAEE), 2017]. Understanding the effectiveness of nature preschools on children's protective factors across races and ethnicities could have urgent implications for diversity, equity, and inclusion-related concerns within the nature preschool movement, particularly if it is determined that nature and/or blended preschools are effective or even more effective for races and ethnicities currently underrepresented in the current nature preschool movement. As such, the potential exists for nature preschool to further educational and developmental disparities, especially when lack of research exists on possible treatment by demographic interaction effects and in light of lack of representativeness within the nature preschool movement.

CONCLUSION

This research sought to examine the impact of nature preschool on the growth of protective factors associated with resilience and the impact relative to that in blended and traditional preschool classrooms. Given the prevalence of adverse childhood experiences, the pandemic that children have just experienced, and the range of day-to-day adversities encountered in life, resilience is a relevant and significant construct to support within young children. The results of this study suggest that when we invest in nature-based early learning and integrate child-directed nature play into the preschool day, the returns are not only significant growth in total protective factors, but protective factors that are above typical for this age level and at a level corresponding with being considered "strengths." Further, this study's findings suggest that we can maximize the return on investment, particularly in the case of the protective factor of initiative, through nature preschools, yet for furthering self-regulation and attachment, some incorporation of nature-based practices may also be effective. Considering these results alongside existing literature, this study adds to the evidence base supporting the use of nature-based practices and settings for supporting children's well-being and opens the door for encouraging programs to incorporate even some aspects of nature-based practices toward helping children develop the skills for navigating the challenges that may lie ahead. However, as this study was exploratory, future research is needed to confirm associations, as well as to untangle moderating and mediating factors, toward identifying which elements of nature preschool need to be studied further in order to more precisely articulating the return associated with nature preschools.

DATA AVAILABILITY STATEMENT

The datasets presented in this article are not readily available because this data is regarding young children, and parents were not asked to consent to inclusion of their children's data in a dataset that may be shared with other researchers. Requests to access the datasets should be directed to jernst@d.umn.edu.

ETHICS STATEMENT

This study involved human participants and was reviewed by the University of Minnesota Institutional Review Board. Written informed consent to participate in this study was provided by the participants' parent or legal guardian.

AUTHOR CONTRIBUTIONS

DS and JE were the principal investigators and designed and provided oversight for the study. HJ was the graduate student research assistant and responsible for the literature review, scoring of the assessments, and data entry; this study was completed as her master's thesis. JE was responsible for data analysis and led the manuscript preparation. DS and HJ contributed to the manuscript writing and review. All authors contributed to the article and approved the submitted version.

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REFERENCES

Alme, H., and Reime, M. A. (2021). Nature kindergartens: a space for children's participation. *J. Outdoor Environ. Educ.* 113–131. doi: 10.1007/s42322-021-00081-y

American Academy of Pediatrics. (2021). Interim guidance on supporting the emotional and behavioral health needs of children, adolescents, and families during the COVID-19 pandemic, https://services.aap.org/en/pages/2019-novel-coronavirus-covid-19-infections/clinical-guidance/

Bailie, P. (2016). "Nature preschools: The cross fertilization of early childhood and environmental education," in *Nature Preschools and Forest Kindergartens: The Handbook for Outdoor Learning*. ed. D. Sobel (St. Paul, MN: Redleaf Press), 45–58.

Bal, E., and Kaya, G. (2020). Investigation of forest school concept by forest school teachers' viewpoints. *Int. Electron. J. Environ. Educ.* 10, 167–180.

Bartlett, J., Griffin, J., and Thomson, S. (2020). Resources for supporting children's mental well-being during the COVID-19 pandemic. Children Trends, Available at: https://aisa.or.ke/wp-content/uploads/resources/health-and-wellbeing/wellbeing-resources/resources-for-supporting-childrens-emotional-well-being-during-the-covid-19-pandemic-290320.pdf.

Benard, B. (2004). *Resiliency: What We Have Learned*. San Francisco, CA: WestEd.

Berto, R. (2005). Exposure to restorative environments helps restore attentional capacity. *J. Environ. Psychol.* 25, 249–259. doi: 10.1016/j.jenvp.2005.07.001

Buchecker, M., and Degenhardt, B. (2015). The effects of urban inhabitants' nearby outdoor recreation on their well-being and their psychological resilience. *J. Outdoor Recreat. Tour.* 10, 55–62. doi: 10.1016/j.jort.2015.06.007

Center on the Developing Child at Harvard University. (n.d.). Resilience, https://developingchild.harvard.edu/science/key-concepts/resilience/.

Chawla, L., Keena, K., Pevec, I., and Stanley, E. (2014). Green schoolyards as havens from stress and resources for resilience in childhood and adolescence. *Health Place* 28, 1–13. doi: 10.1016/j.healthplace.2014.03.001

Coley, R., Sullivan, W., and Kuo, F. (1997). Where does community grow? The social context created by nature in urban public housing. *Environ. Behav.* 29, 468–494. doi: 10.1177/001391659702900402

Cordiano, T., Lee, A., Wilt, J., Elszasz, A., Damour, L., and Russ, S. (2019). Nature-based education and kindergarten readiness: nature-based and traditional preschoolers are equally prepared for kindergarten. *Int. J. Early Childhood Environ. Educ.* 6, 18–36.

Ernst, J., and Burcak, F. (2019). Young children's contributions to sustainability: The influence of nature play on curiosity, executive function skills, creative thinking, and resilience. *Sustainability* 11:4212. doi: 10.3390/su11154212

Ernst, J., Johnson, M., and Burcak, F. (2018). The nature and nurture of resilience: exploring the impact of nature preschools on young children's protective factors. *Int. J. Early Childhood Environ. Educ.* 6, 12–26.

Fabor Taylor, A., Kuo, F., and Sullivan, W. (2001). Coping with ADHD: The surprising connection to green play settings. *Environ. Behav.* 33, 54–77. doi: 10.1177/00139160121972864

Fabor Taylor, A., Kuo, F., and Sullivan, W. (2002). View of nature and self-discipline: evidence from inner city children. *J. Environ. Psychol.* 22, 49–63. doi: 10.1006/jevp.2001.0241

Fabor Taylor, A., Wiley, A., Kuo, F., and Sullivan, W. (1998). Growing up in the inner city: green spaces as places to grow. *Environ. Behav.* 30, 3–27. doi: 10.1177/0013916598301001

Garson, G. D. (2013). *Hierarchical Linear Modeling: Guide and Applications*. Thousand Oaks, CA: SAGE Publications.

Grey, P. (2013). *Free to Learn: Why Unleashing the Instinct to Play Will Make our Children Happier, More Self-Reliant, and Better Students for Life*. New York: Basic Books.

Heckman, J. (2006). Skill formation and the economics of investing in disadvantaged children. *Science* 312, 1900–1902. doi: 10.1126/science.1128898

Huta, V. (2014). When to use hierarchical linear modeling. *Quant. Methods Psychol.* 10, 13–28. doi: 10.20982/tqmp.10.1.p013

Kaplan, R., and Kaplan, S. (1989). *The Experience of Nature: A Psychological Perspective*. New York: Cambridge University Press.

Kochanowski, L., and Carr, V. (2014). Nature playscapes as contexts for fostering self-determination. *Child. Youth Environ.* 24, 146–167. doi: 10.7721/chilyoutenvi.24.2.0146

Kuo, F., Brunson, L., Sullivan, W., Kuo, F., and Coley, R. L. (1988). Fertile ground for community: inner-city neighborhood common spaces. *Am. J. Community Psychol.* 26, 823–851.

Larimore, R., Pikus, A., Skibbe, L., and Sobel, D. (2019). "Development of the Nature-Based Education Rating Scale (NABERS) for K-3 Education." in *Poster Presented at the Nature-Based Early Learning Conference, Manchester, NH*.

LeBuffe, P., and Naglieri, J. (2012). *Devereux Early Childhood Assessment for Preschoolers, Second Edition: User's Guide and Technical Manual*. Villanova, PA: Devereux Center for Resilient Children.

Luthar, S. S., Cicchetti, D., and Becker, B. (2000). The construct of resilience: a critical evaluation and guidelines for future work. *Child Dev.* 7, 543–562. doi: 10.1111/1467-8624.00164

Masten, A. (2007). "Competence, resilience, and development in adolescence: Clues for prevention science," in *Adolescent Psychology and the Developing Brain: Integrating Brain and Prevention Science*. eds. D. Romer and E. Walker (New York: Oxford University Press), 31–52.

Masten, A. (2014). Global perspectives on resilience in children and youth. *Child Dev.* 85, 6–20. doi: 10.1111/cdev.12205

Masten, A., and Barnes, A. (2018). Resilience in children: developmental perspectives. *Children* 5, 98–116. doi: 10.3390/children5070098

Masten, A., and Cicchetti, D. (2016). "Resilience in Development: Progress and Transformation," in *Developmental Pyschology*. ed. D. Cicchetti (New York: Wiley), 271–333.

Masten, A., Herbers, J., Cutuli, J., and Lafavor, T. (2008). Promoting competence and resilience in the school context. *ASCA Prof. School Couns.* 12, 76–84. doi: 10.5330/PSC.n.2010-12.76

McArdle, K., Harrison, T., and Harrison, D. (2013). Does a nurturing approach that uses an outdoor play environment build resilience in children from a challenging background? *J. Adventure Educ. Outdoor Learn.* 13, 238–254. doi: 10.1080/14729679.2013.776862

McCree, M., Cutting, R., and Sherwin, D. (2018). The hare and the tortoise go to Forest School: taking the scenic route to academic attainment via emotional wellbeing outdoors. *Early Child Dev. Care* 188, 980–996. doi: 10.1080/03004430.2018.1446430

National Center for Education Statistics. (2020). Education demographic and geographic estimates. https://nces.ed.gov/Programs/Edge/ACSDashboard/2730060.

North American Association for Environmental Education [NAAEE]. (2017). *Nature Preschools and Forest Kindergartens: 2017 National Survey*. Washington, DC: NAAEE.

Ritchie, S., Wabano, M., Russell, K., Enosse, L., and Young, N. (2014). Promoting resilience and wellbeing through an outdoor intervention designed for Aboriginal adolescents. *Rural and Remote Health.* 14:2523 doi: 10.22605/RRH2523.

Robinson, E., and Ernst, J. (2020). Beyond traditional school readiness: how nature preschools help prepare children for academic success. *Int. J. Early Childhood Environ. Educ.* 7, 1–33.

Sacks, V., and Murphey, D. (2018). The prevalence of adverse childhood experiences, nationally, by state, and by race/ethnicity. Child trends, #2018-03. Available at: www.childtrends.org/publications/prevalence-adversechildhood-experiences-nationally-state-race-ethnicity/

Sullivan, W., Kuo, F., and Depooter, S. (2004). The fruit of urban nature: vital neighborhood spaces. *Environ. Behav.* 36, 678–700. doi: 10.1177/0193841X04264945

Volpe, M., Derr, V., and Kim, S. (2019). "And it made me feel good inside:" initial evidence and future methods for evaluating nature school effectiveness. *Children Youth Environ.* 29, 5–27. doi: 10.7721/chilyoutenvi.29.2.0005

Weeland, J., Moens, M. A., Beute, F., Assink, M., Staaks, J. P. C., and Overbeek, G. (2019). A dose of nature: two three-level meta-analyses of the beneficial effects of exposure to nature on children's self-regulation. *J. Environ. Psychol.* 65:101326. doi: 10.1016/j.jenvp.2019.101326

Wells, N. (2000). At home with nature: effects of "greenness" on children's cognitive functioning. *Environ. Behav.* 32, 775–795. doi: 10.1177/00139160021972793

Wells, N. M. (2013). "The Role of Nature in Children's Resilience: Cognitive and Social Processes," in *Greening the Red Zone*. eds. K. Tidball and M. Krasny (Boston, MA: Springer), 95–109.

Woltman, H., Feldstain, A., MacKay, J. C., and Rocchi, M. (2012). An introduction to hierarchical linear modeling. *Tutorials Quant. Methods Psychol.* 8, 52–69. doi: 10.20982/tqmp.08.1.p052

Wright, M. O., and Masten, A. S. (2005). "Resilience Processes in Development: Fostering Positive Adaptation in the Context of Adversity," in *Handbook of Resilience in Children*. eds. S. Goldstein and R. B. Brooks (Kluwer Academic/Plenum Publishers), 17–37.

Wright, M. O., Masten, A. S., and Narayan, A. J. (2013). "Resilience Processes in Development: Four Waves of Research on Positive Adaptation in the Context of Adversity," in *Handbook of Resilience in Children*. eds. S. Goldstein and R. Brooks (Boston, MA: Springer), 15–37.

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REVIEW
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Nature Experiences in Science Education in School: Review Featuring Learning Gains, Investments, and Costs in View of Embodied Cognition

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This review examines the didactic use of nature experiences in science education, in primary and secondary school (7–16 years) globally. From the perspective of embodied cognition the review explores the types of nature experiences used in science teaching. Focus is on returns when we invest in nature-based science learning, such as specific academic achievements in the form of long-term effects on learning and memory and how we maximize those returns. The review also addresses challenges and barriers, such as costs and labour involved when using nature experiences in science teaching. Initially, 3,659 articles were selected, with the initial screening leading to the inclusion of 159 studies. Of these articles, 34 studies forming the corpus in this review investigated the effect of using nature experiences as an intervention. These studies are divided into four themes: content understanding, environmental education, teaching scientific methods, and costs and challenges to teaching science outdoors. Informed by the perspective of embodied cognition, the review addresses the returns in terms of learning and academic achievements, the mode of action of the intervention, the investment, costs in the form of labour, challenges, and gaps in the theoretical underpinning of the field. Based on the review, using nature experiences in science education seems promising regarding increasing content knowledge, insight into science methodologies and pro-environmental behaviours. Interventions exploiting the schoolyard, school gardens, or nearby park areas are particularly promising due to the simultaneous strengthening of local engagement at low costs. However, using nature experiences as an alternative to traditional in-class teaching depends on profound didactic deliberations and preparations, which are difficult for the individual teacher to address single-handedly. The review also reveals an urgent need for research that thoroughly explores the connections between teaching practices and theoretical foundations to consolidate the field. To that end, it is noteworthy that a few studies also reported on prior pilot studies demonstrating the need for testing the entire design before conducting the actual research. Teachers seldom experience the opportunity to preview their teaching strategies before performing in front of their students.

Keywords: nature experience, science education, primary and secondary school education, content knowledge, environmental education (EE), review (article), nature connectedness, embodied cognition

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INTRODUCTION

Science is the term for school subjects that deal with natural phenomena and the scientific exploration of them. Science in school draws on astronomy, physics, chemistry, geology, geography, and biology. Such disciplines share the assumption of a real-world defined by space and time accessible to the senses at large and therefore readily available in direct experiences.

Historically, the so-called scientific revolution in the Renaissance argued for observation and concrete experiences of natural phenomena as a basis for knowledge and theory formation about the world (Chalmers, 2013). Galileo Galilei who is known for his observations of Saturn's rings, and who advocated the modern heliocentric worldview, has been hailed as the promoter of the modern scientific method.

Hence, in the natural sciences, observations of natural phenomena and justifications for scientific finds follow from experiences with the natural world (Føllesdal et al., 2005). Unfortunately, science education in school often happens in built environments like in class or laboratories (Braund and Reiss, 2006; Rios and Brewer, 2014). Why is this the case? Are there no differences between learning from direct experiences in nature and traditional learning, or are the challenges too costly?

The latest advances within the cognitive sciences termed "embodied cognition" emphasise the role of direct experiences in learning and meaning-making, including advanced academic achievements (Barsalou, 2010; Rowlands, 2010); Glenberg, 2015). Also, multimodal activation during learning typically supports improved memories for the particular learning episode.

Accordingly, science learning benefits from natural, authentic environments, affording pupils' direct experiences with scientific content (e.g. Amin et al., 2015). Unfortunately, the embodied cognition inspired use of nature experiences in teaching science in school is currently under-researched, which is a shame since the embodied cognition framework could prove valuable in detailing to what extent learning processes differ between learning in nature and class. A recent review by Ayotte-Beaudet et al. (2017) encompassed 18 articles published between 2000 and 2015 relating to learning science outdoors. The review was primarily concerned with research emphasising proximity and ease of access and therefore concentrated on outdoor science in schools' immediate surroundings, and the results were not related to the embodied cognition approach.

Hence, this review, based on a systematised search strategy that initially involved 3,659 articles, is motivated by the embodied cognition frame and concerned with locating examples on the use of nature experiences in science education in primary and secondary school globally (pupils aged 7–16 years). At the outset, the aim is to scout for the didactic use of nature experiences in science learning to review the extent to which their modes of action harmonise with the percepts of embodied cognition theories. Given the novelty of the embodied cognition approach, it is unlikely that the didactic research on nature experiences in science learning embraces this perspective openly. Hence, the aim is not to search the literature for research adhering to the embodied cognition tradition but to identify research on embodied cognition compatible teaching practices and the benefits and drawbacks in this approach. The embodied cognition compatible teaching practices could contribute to the conceptualisation and theorising of the nature-based learning field (e.g. Schilhab, 2017a; Shapiro and Stolz, 2019). Hence, the research literature is analysed for types of nature experiences in science teaching and thematised and interpreted in terms of the embodied cognition perspective. Focus is on which interventions exist, the modes of actions involved as suggested by the reported results, and the investment, returns and challenges.

Definition of Nature Experiences the Natural Environment and Embodied Cognition Aspects

Following embodied cognition studies (e.g. Barsalou, 2009, 2010; Glenberg, 2015), the understanding of academic material is facilitated when using the surroundings and the body (e.g. Fuchs, 2017); Ionescu and Vasc, 2014) as concrete placeholders for meaning-making; a process known as cognitive offloading (Wilson, 2002). For example, children who interact with concrete entities to simulate the meaning of a text when reading (combing hair when reading "'combs") form deeper and longer-lasting memories of the material (e.g. Kiefer and Trumpp, 2012; Glenberg, 2011).

This method resembles how children acquire language by learning the meaning of concepts from direct experiences (firsthand learning) with the original referent (Klomberg et al., 2022). Unfortunately, most formal learning is not based on direct experiences but on descriptions of experiences (secondhand knowledge), in which pupils interpret descriptions of experiences in the absence of the original referent (e.g. Shapiro and Stoltz, 2019). When using nature experiences to teach science, the teacher uses direct experiences to facilitate meaning-making in pupils. Here, "experience" refers to a combination of all the processes that happen in us in every moment. Barrett (2009) describes the mental "now" as an amalgamation of *1*) the sensory influences such as sounds, colours, temperatures, and events; *2*) our inner sensory experiences such as the experience of hunger, sadness, joy, body position, muscle tension, fatigue, and mood; and *3*) our memories and past experiences.

In every mental now, the number of processes is overwhelming. Imagine for example, how the sound of rain, the smell of soil, the desire to taste, the foot's feeling of the wet sock in the leaky rubber boot, the childhood memory of the blackberry bush in the garden, and the sight of the bee on the flower creates your experience of a blackberry bush (Sheckley and Bell, 2006; Schilhab et al., 2018a). The experience also consists in the social context we participate in when experiencing the bush with parents, friends or teachers and the community's expression of the value of blackberry bushes (Schilhab and Esbensen, 2019).

Hence, a nature experience consists in the many levels from our present and our previous experiences and the natural space and its observable qualities such as biodiversity, types of water bodies, the density of deciduous trees etc. (Schilhab and Esbensen, 2019).

In this review, the nature experiences of interest should typically involve observations of and interactions with concrete natural phenomena, natural processes, and the effects of natural laws, as they occur in natural surroundings such as forests, beaches, lakes, meadows, and parks (Stevenson et al., 2019; Schilhab et al., 2020). However, small animals in a schoolyard, the mixture of cultivated trees and naturally occurring weeds in a distant corner of the school area, the human-made reconstructions of biotopes in a botanical garden, and the life cycle of farm animals are also included. Hence, the term natural environment refers to green or blue surroundings and natural phenomena available to the senses. Of essence, when smaller animals or weeds manage to survive in human-made areas, they do so due to natural processes and life processes. Though a tree is cultivated and pruned in a park or a botanical garden, the short-lived human influence does not remove the tree's character of following the laws of nature. The "natural" appears from the fact that the tree unfolds an autonomous life extensively adapted to the laws of nature. In that perspective, the reason why it grows in a particular location and that it started life in a nursery is unimportant. Central to the concept of nature is the processes that make growth possible in the first place – a mechanism that reaches far beyond any human intervention.

These considerations entail that human-made environments involving natural phenomena such as zoos, public aquariums, green "wedges" in the landscape, farms, and school gardens are included in this review. In a few instances, the location is secondary to the experience of particular natural phenomena such as precipitation, waterfalls, and gravity.

However, the presented review excludes nature experiences inside school buildings, e.g. school laboratories, with terrariums in the classroom, or computer simulations. Teaching not including the school and for other stated purposes than teaching (e.g. play and social events) are also excluded.

METHODS

Study Design and Review Protocol

This review assumes that teachers use nature experiences to facilitate learning about science by firsthand learning to promote meaning-making. Therefore, the review selects studies seeking nature experiences to enrich the learning episode by sustaining relevant associations of embodied and conceptual processes (Kiefer and Trumpp, 2012; Schilhab, 2017a; Glenberg, 2011). Accordingly, "nature experience" is used in this strict sense, which refers to the embodied cognition literature not usually implied by the nature-based learning literature (Jordan and Chawla, 2019). Hence, the initial search in databases was guided by the following three research questions:

1) How are nature experiences used in science teaching in primary and secondary school?
2) Does the scientific literature describe the types of natural phenomena or topics particularly suitable/effective for science teaching in primary and secondary school?
3) What are the challenges of using nature experiences in science teaching?

The primary goal is to provide an overview of existing research. This involves describing the prevailing assumptions, characterising themes, and the theoretical and methodological approaches. The secondary goal is to identify the interventions' modes of actions in terms of embodied cognition, as well as to describe investment, returns and challenges.

The initial search was conducted by librarian and information specialist Anne-Marie Klint Jørgensen using the EPPI reviewer tool developed and curated by the EPPI Centre, at the Institute of Education, University of London, United Kingdom. At first 3,659 articles were selected based on the following search strings: ("Science learning" OR "Learning science" OR "Learning natural science" OR teaching of Science) and ("informal environments" OR "Outside the Classroom" or "outdoor" OR ("Experiential education and (outdoor or nature or natural")). International searches were conducted in the ERIC database, Education database, Australian Education database, British Education database, Science Citation Index, and Dissertation abstracts. The searches were defined by the following boundaries:

- Publications published exclusively in Danish, English, Norwegian, or Swedish.
- Publications published without specific period requirements before August 1, 2020.
- Publications that deal with comparable school systems (i.e. OECD and EU countries).
- Publications addressing primary and secondary school (pupils aged 7–16 years).

The Scandinavian search was performed in: Bibliotek.dk (DK), The Danish research database (DK), Oria (NO), Norart (NO), Christin (NO), Libris (SE), DIVA Portal (SE), and Swepub (SEE). References derived from references were also included. All abstracts meeting the search criteria were screened based on the following inclusion and exclusion criteria:

Inclusion

I) The study deals with one or more of the research questions, and II) Only peer-reviewed academic documents such as theoretical considerations, conference papers, and empirical studies are included.

Exclusion

I) Wrong document type: Editorials, comments, policy documents, biographies, theses, master's and bachelor's theses; II) Wrong age group: The review only concerns teaching at primary and secondary school level; III) Wrong educational area: The study only examines the use of nature experiences in science teaching in primary and secondary school; IV) Wrong language: The study (full text) was not published in Danish, Norwegian, Swedish, or English; V) Wrong focus: The study does not focus on the use of

nature experiences in science teaching in primary or secondary school; and VI) Insufficient information: The study does not clarify which educational area, age group, or country/countries the material is based on.

This screening process and nine references derived from references led to 159 studies, of which 150 was uploaded to EPPI by academic assistant Markus Noach Brauner and read in full by the main researcher. Studies were condensed according to the following categories: I) purpose of the research, II) research questions, III) characterisation/definition of the nature experience, IV) research findings, V) approach used (theoretical, methodical, empirical, other), VI) context in which the work is carried out (country, science discipline), VII) contributions to the field, and VIII) quotes of particular relevance.

Research questions and the protocol were drafted by the main researcher and qualified by Anne-Marie Klint Jørgensen. The studies were not divided based on course duration because that information was not always clear–even though some studies suggest this influences the size of the effects (e.g. Braun and Dierkes, 2017). After a second screening by the main researcher, 45 papers were excluded. Therefore, the review involves a total of 114 studies (see **Supplementary Table S1** for bibliographic details and abstracts).

Analysis

The condensing process revealed that studies of developing practices and theoretical studies dominate the literature. An obvious reason is that the field is somewhat new and therefore preoccupied with proof-of-concept studies (*see* Barsalou, 2010).

Thus, the 114 peer-reviewed studies were categorised into theoretical articles, articles with practical instructions for teaching authored by teachers, and 34 *empirical* studies examining the facilitative effects of nature experiences on science learning. Here, nature experiences are interventions with effects measured qualitatively or quantitatively, and therefore of particular relevance to the embodied cognition interpretation. A fourth category, "other," did not fit the former categories. The review analyses the empirical studies, which are presented in **Table 1**. Following the review by Ayotte-Beaudet et al. (2017) **Table 1** provides information about *authors*, *years of publication*, *geographic origin of data*, *school grades*, *type of data*, *research methodologies*, *instruments*, *participants*, *investigated outcomes, and category*.

Guided by the first and second research question: *How are nature experiences used in science teaching in primary and secondary school?* and *Does the scientific literature describe the types of natural phenomena or topics particularly suitable/effective for science teaching in primary and secondary school?* the studies were divided into three major categories: *content understanding*, *environmental education*, and *teaching of scientific methods.* The third research question *What are the challenges of using nature experiences in science teaching?* guides the analysis of the last category which draws on knowledge from all 114 papers, *Investment, costs and challenges when teaching science outdoors*.

RESULTS AND INTERPRETATIONS

Before presenting the categories in more detail, general themes that emerged from the material on the different cross-national interpretations of the field are presented.

General Overview of the Field

A significant part of the international research in the field originates from the United States, where nature experiences in science teaching commonly take place in "science camps" outside school hours in collaboration with recognised institutions such as NASA (e.g. Barker et al., 2014). Here, the science teacher rarely plans and handles the teaching during the school year. Instead, nature-based science teaching are conducted as short-term collaborations with researchers and science centres during excursions (e.g. Cwikla et al., 2009; Nadelson and Jordan, 2012; Allison et al., 2017). Similar characterisations apply to science teaching in Australia and Europe (Ballantyne and Packer, 2009; Aydede-Yalçın, 2016). One example is an annual school trip focusing on the local area in Flanders, Belgium (Boeve-de Pauw et al., 2019).

These teaching initiatives differ from the Scandinavian outdoor school tradition, defined by repeated teaching led by the same science teacher and organised according to the primary school's curricular goals (Mygind, 2007, 2009; Bentsen and Jensen, 2012; Bølling et al., 2018, 2019; see also Christie et al. (2016) for a similar version in Scotland; Ottander et al., 2015 for the outdoor school tradition in the Swedish context; and Jordet, 2003, for a Norwegian perspective). As research on outdoor schooling often focuses on increasing students' motivation, physical and psychological well-being, and feeling of equality (e.g. Dettweiler et al., 2015; Stevenson et al., 2018; Bølling et al., 2019), these studies are included in this review to the extent that they address the use of nature experiences in the strict sense in science teaching.

In the research literature, a relatively large number of environmental education studies, which examine connections with nature, originate from Turkey, where the environmental education of 4th–8th-grade students in more informal pedagogical arenas has enjoyed great national attention since 1999 (Aydede-Yalçın, 2016). This focus has increased interest in environmental education as a research topic in education science and pedagogy in Turkey (Genc et al., 2018; Çobanoğlu and Kumlu, 2020).

The driving force behind using nature experiences in science teaching also varies by country. In Turkey, as noted above, nature experiences are justified by a national commitment. By contrast, in countries such as the United States and England, it is more often the individual teacher who, driven by enthusiasm and ideals for teaching, initiates using nature experiences to teach science (Scott et al., 2011). In such instances, the teaching develops as the result of passionate souls' insights and inspirations rather than institutionalised teaching goals (e.g. Cwikla et al., 2009). Therefore, many external actors are often needed to implement the initiative, including parents, older primary school students, university students, and local residents (e.g. Cole, 2004; Rye et al., 2012).

TABLE 1 | Nature experiences in science education in school – An overview of the empirical research articles.

Authors (year of publication)	Geographic origin	School grades	Research methodologies	Instruments	Participants	Investigated outcomes	Corpus category
Aydede-Yalçın, (2016)	Turkey	Sixth, seventh and eighth grade	Quantitative Qualitative Quasi-experimental pre-/post-test	Surveys Observations	17 pupils	Pupils' perceptions of environmental problems	Scientific process skills Environmental Content knowledge
Boeve-de Pauw et al. (2019)	Belgium	Fifth and sixth grade	Quantitative Pre-/post-test	Surveys	484 pupils 24 teachers	Novelty, preparation and environmental learning outcomes Experienced affective connection	Environmental education Novelty effects
Braun and Dierkes, (2017)	Singapore	First to 11th grade	Quasi-experimental Pre-/post-tests	Questionnaires	601 pupils	Nature connectedness Importance of the duration of intervention	Environmental education
Carrier et al. (2014)	U.S.A.	Fifth grade	Quantitative pre/post assessments Qualitative	Surveys Interviews Observations	49 Pupils One Principal Two Teachers	Science knowledge Environmental attitudes Outdoor comfort levels	Content knowledge Environmental education
Christie et al. (2016)	Scotland	Eighth to 10th grade	Mixed methods	Observations Questionnaires Focus group interviews	150 pupils 10 teachers	Students' Science learning Teacher perceptions	Critical thinking opportunity Scientific methods
De Dominicis et al. (2017)	Italy	Third to sixth grade	Quasi-experimental Study one between-subjects 2by2research design Study two pre/post research design	Surveys Surveys	497 pupils 248 pupils 92 parents	Promotion of students' pro-environmental attitudes and behaviors	Environmental education
Demirbas, (2017)	Turkey	Seventh grade	Quantitative pre/post assessments No statistics applied	Word association test	21 pupils	Environmental knowledge	Environmental education
Dhanapal and Lim, (2013)	Malaysia	Third grade	Mixed methods	Quiz tests Questionnaires	24 pupils	Student perceptions of and comparison between the impacts of indoor and outdoor learning	Content knowledge
Dieser and Bogner, (2016)	Germany	Fourth and fifth grade	Quasi experimental pre/post retention assessments	Multiple choice test Questionnaires	289 pupils	Cognitive knowledge achievements	Content knowledge
Djonko-Moore et al. (2018)	U.S.A.	Third to sixth grade	Mixed methods Pre/post narrative inquiry	Tests Focus group interviews Journals Student work samples	34 pupils	Urban children's science knowledge and engagement	Environmental knowledge
Drissner et al. (2014)	Germany	Fifth grade Third and fourth grade	Quantitative Test and control group	Essay Drawings	Study 1 104 pupils Study 2 121 pupils	Knowledge of especially small animals Emotions towards small animals in our own environment	Content knowledge
Fančovičová and Prokop. (2011)	Slovakia	Fifth grade	Quasi-experimental Pre/post retention assessment Control group	Questionnaire	34 pupils	Pupils' attitudes towards and knowledge of plants	Environmental education
Fägerstam and Blom, (2013)	Sweden	Seventh and eighth grade	Mixed methods Quasi-experimental Pre/post retention assessment Control group	Essay-type question about content knowledge Interviews	85 pupils	Cognitive as well as affective effects of outdoor teaching	Content knowledge Environmental education

(Continued on following page)

TABLE 1 | (*Continued*) Nature experiences in science education in school – An overview of the empirical research articles.

Authors (year of publication)	Geographic origin	School grades	Research methodologies	Instruments	Participants	Investigated outcomes	Corpus category
Gencet al. (2018)	Turkey	Seventh grade	Quantitative One group pre-/post-test design Qualitative	Surveys Interviews	30 pupils	Attitudes towards the environment and animals	Environmental education
Ghadiri Khanaposhtani et al. (2018)	U.S.A.	Fifth to eighth grade	Qualitative	Natural inquiry Drawing activities Questionnaires Interview Field-observations	Seven pupils	Cognitive and affective impacts	Content knowledge
Glaab and Heyne, (2020)	Germany	Third grade	Quasi-experimental Pre/post retention assessment Test and control group	Surveys	268 pupils	Pupil's science learning	Content knowledge
Golob, (2011)	Slovenia	Fourth grade	Mixed methods	Surveys Interview	468 pupils 62 teachers	Pupils' attitudes and/or actions towards environmental phenomena	Environmental education
Heras et al. (2020)	Spain	Sixth grade	Qualitative	Focus group interviews	22 pupils	Pupil's perceptions and pro-environmental behavior	Content knowledge Environmental education
Hiller and Kitsantas, (2014)	U.S.A.	Eighth grade	Quasi-experimental Pre-/post-test Test and control group	Surveys	86 pupils	Citizen science project impact on science learning and pupil's career motivation	Content knowledge
Hammarsten et al. (2019)	Sweden	First to third grade	Qualitative	Walk-and-talk interviews	28 pupils	Pupils's perspectives on forest gardens	Environmental education
Jesus-Leibovitz et al. (2017)	Portugal	Second to fourth grade	Mixed methods Pre-/post-test	Surveys Interviews Personal mind maps	164 pupils Nine teachers	Pupils' understanding about biodiversity and scientific procedures	Content knowledge
Kelemen-Finan et al. (2018)	Austria	Third to 12th grade	Quantitative	Surveys	428 pupils	Citizen science project effects on learning outcomes	Environmental education
King and Ginns, (2015)	Australia	Ninth grade	Qualitative	Field notes Audio and video recorded conversations, Interviews Student journals Classroom documents	26 pupils	Environmental education	Scientific methods
Kossack and Bogner, (2012)	Germany	Sixth grade	Quantitative Pre/post retention assessment Test and control group	Surveys	239 pupils	Connectedness with nature	Environmental education
Kärkkäinen et al. (2017)	Finland	Third to sixth grade	Qualitative and quantitative	Annotated drawings	26 pupils	Students' understandings of environmental issues	Environmental education
Lee, (2014)	U.S.A.	Fifth grade	Mixed methods Photography research	Photographs Interviews	27 pupils	Memories *via* photographs during an environmental science field trip experience	Scientific methods
Lehrer and Schauble, (2017)	U.S.A.	First/ second, third and sixth grade	Qualitative	Individual Interviews	26 pupils	Pupils' understanding of sampling in science	Scientific methods
Magntorn and Helldén, (2007)	Sweden	Third to fourth grade	Qualitative	Interviews Concept maps	23 pupils	Ecological understanding	Scientific methods
Nadelson and Jordan, (2012)	U.S.A.	Sixth grade	Mixed method Retention test	Surveys Annotated drawings	111 pupils	Pupil's perception of field trip	Content knowledge
Randler et al. (2005)	Germany	Third and fourth grade	Quantitative Pre/post retention assessment Test and control group	Surveys	46 pupils	Pupil's understanding and retention of science learning	Content knowledge

(Continued on following page)

TABLE 1 | (*Continued*) Nature experiences in science education in school – An overview of the empirical research articles.

Authors (year of publication)	Geographic origin	School grades	Research methodologies	Instruments	Participants	Investigated outcomes	Corpus category
Scott and Boyd, (2016)	England	Fifth and sixth grade	Quantitative Pre/post retention assessments Test and control group	Surveys	379 pupils	Pupils' ability to write about ecology	Content knowledge
Smeds et al. (2015)	Finland	Fifth grade	Mixed methods Pre/post retention assessment	Interviews Assessments	106 pupils	Impact of learning environments on science learning	Content knowledge
TaŞ and Gülen, (2019)	Turkey	Seventh grade	Mixed methods Pre/post retention assessment	Multiple choice test Interviews	19 pupils	Students' academic achievement Permanence of information	Content knowledge
Ting and Siew, (2014)	Malaysia	Fifth grade	Quasi-experimental Pre/post retention assessments	Surveys	119 pupils	Pupils' science process skills and scientific curiosity	Scientific methods

The teaching can also be part of a larger initiative led by local foundations that support initiatives encouraging students to gain a greater local knowledge and understanding of nature through teaching based on nature conservation (Bingaman and Eitel, 2010). This partly explains the large proportion of US research literature that arises because researchers have developed and implemented a science course in collaboration with dedicated science teachers.

The purpose of nature experiences in science teaching also differs by country. Typical purposes include to facilitate learning and consolidate content knowledge through multimodal activities, familiarise students with scientific working methods, and support students' affective and emotional processes (Kilty and Burrows, 2020).

In the United States, the use of nature experiences in science may have a clearer political and social justification than that seen in the corresponding Nordic research literature. Here, nature experiences in science education may be used "for establishing culturally relevant experiential learning opportunities to engage underrepresented children in science" (Djonko-Moore et al., 2018, p. 137).

Similar considerations about the importance of social class in connection with nature experiences in science teaching are also found in Turkey (Taş and Gülen, 2019). However, the more politically motivated use of nature experiences in science teaching is beyond the scope of this review. Further, although the use of nature experiences in science teaching varies by country, studies that deal explicitly with physics are scarce (*see* Alberghi et al., 2007; Aspinall, 2016).

Summary of the Corpus

In the empirical studies, nature experiences are typically treated as interventions that can last from half a day to courses extending over several years with multiple experiences (Drissner et al., 2010; Golob, 2011). Such studies tend to measure the effect of the intervention using various qualitative and quantitative methods that test for the learning of scientific content, the attitudes towards nature or nature connectedness, such as multiple choice tests, Likert scale tests, word association tests, personal meaning mapping tests, interviews, observations, student work samples and annotated drawings. In most studies, the performance of the intervention group is compared with that of a similar control group that received instruction on the same content in a more traditional setting (textbook and blackboard instructions, Internet searches, and PowerPoint presentations in the classroom).

According to the literature, students exposed to nature make observations that spontaneously stimulate their wonder – even without encouragement. During longer stays in nature, they gain a greater knowledge of the variation of natural phenomena and can more easily develop expectations and predictions (e.g. Bosse et al., 2009). However, the scientific observation of natural phenomena can still be greatly improved. Some studies therefore describe that the teacher can help sharpen students' observational abilities (e.g. Parrott, 2004; McBride and Brewer, 2010). Although observations constitute an essential aspect of the scientific method, focus is also placed on the formation of hypotheses, ability to reason scientifically, and ability to argue and incorporate background knowledge.

Studies on Content Understanding in the Corpus

A US study of the use of nature experiences in science teaching for a 5th-grade class showed significant differences in students' scientific knowledge and connection to nature after a year (Carrier et al., 2013). The study developed a year long snapshot of one school's science experiences with using the outdoors for science instructions. Here, students' knowledge was measured both before and after the intervention using a 48-question multiple choice test divided into four main areas: ecosystems, weather, force and motion, and landscape forms. The improvements in the content knowledge of experimental students were significant for all four themes compared with 5th-grade students who had only received classroom instruction. Similar cognitive effects were demonstrated in a quasi-experimental study by Fägerstam and Blom (2013). Here, 85 Swedish pupils in four classes (grade 7 and 8) were taught about ecology and diversity of life in several lessons. Half of the pupils were taught outdoors and the other half indoors. 21 pupils were interviewed

5 months later. According to Fägerstam and Blom, pupils taught outdoors would refer differently to the science experience (2013, p. 71): "Five months after the course they could tell a story about themselves doing science, compared with the pupils who were taught indoors who instead talked about what the teacher did." Also, content knowledge between the experimental and the control classes differed to a significant extent. The researchers report (p. 63): "In the outdoor classes the pupils used more course-related words (e.g. plants, animals, leaf, bird, adaption, Darwin, food web, consumers, photosynthesis, carbon dioxide) than in the indoor classes."

The study by Nadelson and Jordan (2012) examines 6th-grade students' memories of nature-related topics 1 month after conducting a day visit to a nearby park with various science activities (presentations, demonstrations, and interactive sessions) organised by a high school teacher and his 3rd-grade students to support students' non-formal science teaching. Using a single-page questionnaire including annotated drawing, the researchers measured the type of activity students most often recalled. Of the activities (tree planting, recycling and waste management, blindfolded walk in a nature area in the park, orienteering, a simulated fox and rabbit game, water quality demonstration, and presentation of animals from a zoo), the orienteering race stood out. The activity was remembered three times more often than the water quality experience, which was remembered the second greatest number of times. The researchers stated that the hands-on element, and situatedness made it particularly easy to remember. Additionally, the orienteering could easily be associated with students' theoretical knowledge of maps and compasses, which anchored the classroom knowledge in concrete experiences. Apparently, the teaching benefitted from pairing the theoretical and embodied approach with the direct experience, including manipulatives such as maps and compasses illuminating the conceptual understanding already introduced in class (Clements, 2000; Hutchins, 2005).

In a Turkish study by TaŞ and Gülen from 2019, 19 pupils from 7th grade were enrolled in an outdoor program consisting of activities to teach them about e.g. the needs of living beings, food chains in nature, and species under threat. The content knowledge was assessed in a pre-/post-/retention test design and pupils were interviewed about their perception of the educational program. Whereas pupils showed significant changes in content knowledge from their pretest to posttest performance, there were no significant difference between posttest and permanence test results assessed 6 weeks after the intervention. However, this study did not involve a comparison group.

The cognitive benefits of teaching content knowledge as part of more coherent experiences were also demonstrated by Randler et al. (2005). In a German study with 3rd- and 4th-grade students and a control group, the researchers investigated how concrete experiences in nature help students understand abstract concepts such as biodiversity. The study focused on five species of amphibians (toads, salamanders, and frogs). The intervention involved a class-based course with the participation of both experimental and control groups. All students were first introduced to the topic through a radio-transmitted story about toads' life cycle. Then, they were divided into groups of four. These groups carried out a series of activities such as using biological identification keys and lifelike plastic models of five toad species. During toads' annual migration to their breeding grounds, the 26 experimental students were guided by college students to count all the toads they encountered. They were then taught about toads' life cycles, habitat requirements, predators, and nature conservation conditions in the classroom. Both before the intervention and 1 week and 6 weeks after, all students were tested on their ability to identify six toads at the genus and species levels using a coloured sheet with the toads. Both the experimental and the control groups showed significant improvements in their ability to identify the toads, but the experimental group performed significantly better than the control group, both 1 week and 6 weeks after the intervention.

The gains of swapping between class-based instructions and experiential hands-on activities outside class compared to the traditional pedagogical approach are reflected in significantly better scores in the follow-up achievements tests. The authors assert that since biodiversity is a rather ill-defined, abstract and complex construct, outdoor ecological education that introduces students to basic knowledge about identification and the life history of a single species is particularly potent in establishing a conceptual understanding of biodiversity.

The didactic framing of nature experiences in a 1-day environmental course was the exact focus of a quasi-experimental German study. 268 pupils in 3rd grade took part in an educational program about the life conditions of wild cats, defined as either teacher centered, guided learning, or free learning. A fourth group attended the wild life park without any instruction and formed the control group. All pupils completed knowledge questionnaires (multiple-choice tests) 1 week before, right after, and 6–8 weeks after the intervention answering questions like "How does the wildcat hunt its prey?" and "which paw print belongs to the wildcat?" In all intervention groups, knowledge scores increased significantly from pre-to post-test and from pre-to retention test compared to the control group. However, pupils who participated in teacher centered or guided learning at work stations showed significantly more content knowledge from pre-to post test. It is noteworthy, that this difference between intervention groups vanished when tested in the retention test months later. The researchers comment that (p. 149–150): ". . . we assume, that the stronger presence of an educator leads to a better cognitive outcome at the out-of-school learning setting, regardless whether the educator guides the whole learning process instructively or just phases . . . Moreover, the short-term learning advance does not persist into the medium term, where no significant differences between all approaches can be discerned. We assume a lack of follow-up instructions within the weeks following our instructional unit to play a role in this outcome."

In a Finnish paper by Kärkkäninen et al. (2017), work at the school before and after the field trip was actually implemented as a major part of the entire intervention. In this study, 26 pupils

from 3rd to 6th grade were taught about the complexity of landscape changes in an educational program that spanned both school work, work at a visitor centre in a national park, and a field trip. Before and after the intervention, pupils were asked the question "Which factors shape the landscape" and answered using annotated drawings. There was a significant shift in the amount of depicted non-human induced and human induced landscape changes.

However, compared with the majority of the studies presented, the actual nature experience reported in Kärkkäninen et al. seemed to play a reduced part of the entire intervention. This characterisation also applies to the Malaysian study by Dhanapal and Lim (2013) which compared the impacts of indoor and outdoor learning about a particular science theme in improving students' academic achievements. The study found that indoor and outdoor learning complement each other in improving students' academic performance.

In a Finnish study by Smeds et al. (2015), three learning environments that differed by the degree of authenticity were compared. 106 pupils were to learn about the route of milk and were either taught in the classroom (traditional learning), classroom and the farm (mixing traditional with authentic learning), or farm (authentic learning). The interventions were sequenced into three 2 h sessions including a 15 min break over a period of 14 days. Pupils were tested before, immediately after and 5 months after in assessments addressing five concepts relating to the route of milk. In the post test, classroom + farm group and the farm group scored significantly higher than the pure classroom group but did not differ from each other. Five months after the interventions, both farm groups scored significantly higher than the pure classroom group, while not displaying any internal differences.

Significance of the Intervention Duration

Across studies, the effectiveness of an intervention that aims to build content knowledge seems to some extent to depend on the duration of the educational program. For example, several studies show that short-term courses have fewer desirable effects than longer-term courses. In Turkey, Aydede-Yalçın (2016) examined whether a 5-day course consisting of environmentally oriented fieldwork in two national parks for 6th-to 8th-grade students affected their general science understanding, insights into scientific working methods, and environmental science understanding. Students were tested early on the first and last day of the course. Students showed significant improvements in both their scientific and their environmental knowledge, but not in their understanding of scientific procedures.

Similar results were observed in a study by Braun and Dierkes (2017). Here, students' nature connectedness was measured as a function of an outdoor education program. 194 students participated in a 5-day residential ecology program outdoors, whereas 182 pupils participated in a 1-day program outdoors. The control group of 225 pupils had no outdoor sessions but took ecology lessons using pictures, short films and texts for either 1 or 5 days. All participants were measured for grade of connectedness with nature, 2 weeks before, just after, and 6 weeks after the intervention. Both experimental groups showed a significant rise in their nature connectedness immediately after the intervention, whereas this measure did not change within the control groups. However, when tested 6 weeks after the field trip, participants in the 5-day outdoor learning session demonstrated significantly higher nature connectedness than students who participated for only 1 day.

A Spanish qualitative study reporting about a 1-day nature field trip to a protected area, used semi-structured interviews of 22 pupils from sixth grade conducted 1 month after to investigate the cognitive and emotional outcomes of the intervention (Heras, et al., 2020). Although all informants liked to participate in the field trip reporting positive emotions, the cognitive effects seemed much less convincing. When asked the question "what have you learnt," the factual answers showed inaccuracies and mistakes, and pupils experienced difficulties in remembering them. The researchers assert, that although the pupils claimed to have learned a lot, it was difficult for them to verbalise or clearly identify the learning.

However, a Portuguese study found that 2nd, 3rd, and 4th graders who worked as marine biologists for a day showed a significantly better understanding of the complexity behind biodiversity (Jesus-Leibovitz et al., 2017). In a so-called "personal meaning map" centred on biodiversity topics, intervention students distinguished far more relevant relationships both between types of living organisms (plants, mammals, and birds) and between specific animal species. The same effect was seen in personal meaning maps focusing on scientific work. After the intervention, the quality of students' personal meaning maps increased considerably, demonstrating more relevant concepts for both people and places (e.g. fieldwork) as well as more concrete examples of scientific procedures (e.g. experiments, exploration, discoveries, observations, learning, study, thinking, and discussion).

Durability of Cognitive Effects. When the primary goal of teaching is to enhance cognitive effects, the durability of the effects becomes particularly interesting. Even short interventions can be efficacious. In the German study by Dieser and Bogner (2016), who examine the cognitive effect of a week-long course in a nature park, 298 4th- and 5th-grade students were tested with a multiple-choice questionnaire before, immediately after, and 4–6 weeks after the intervention. The intervention involved hands-on activities such as a barefoot experience of different types of soil, tracing of tree species, interaction with different types of domestic animals, and ecologically oriented tasks in wetland, forest, and meadow areas such as examining a squirrel's storage strategies and the function of national parks. By comparison, 60 students who instead received classroom instruction were used as control. Both the short-term and long-term test showed that intervention students had significantly more comprehensive content knowledge about the experience-based topics and better memory about it than the control group. Also, Fančovičová and Prokop (2011) reported significant retention of knowledge compared to the control group after 3 months.

A Slovenian mixed method study on what 4th grade pupils remember about school induced nature experiences in earlier

periods of their school education, shows that more lasting experiences of observing life in water was significantly linked to better knowledge of smaller organisms like insect larvae, tadpoles, pond skaters, and algae (Golob, 2011). See also Drissner et al. (2014) referring to significant long-term effects (up to 5 years) after an intervention lasting half a day.

Use of Nature Experiences to Support Environmental Education

In a Turkish study (Demirbas, 2017), 21 7th-grade students participated in field studies focusing on environmental education. Before and after the five weekends of fieldwork, students completed a word association test on key environmental education concepts such as air, soil, and water pollution, biological diversity, urbanisation, and recycling. Students were given 1 min to associate new concepts with each word. The number of relevant association concepts increased from 82 before to 1,230 after the intervention. Most increase was seen in the key concept of biodiversity (by 63 words), while the number of associations to air pollution *only* increased by 20 words. However, this study did not apply statistics. Hence, nominal increases of associated words are provided.

Also, studies measuring changes in nature-connectedness and attitudes towards nature as a result of direct experiences can be identified. In a study by Genc et al. (2018) 30 7th grade students were participating in an educational program dealing with the natural environment such as water pollution, natural habitats, recycling and biodiversity in a natural setting over a period af 11 days. The students' attitudes towards nature were tested in at pre/posttest design measuring e.g. attitudes towards living organism and the environment. According to the researchers (p. 333): "At the end of the program, it was revealed that, for the 7th grade students, attitudes towards the environment, and living organisms and the affective tendency were shown to be more highly developed than before the program."

An Italian study by De Dominicis et al. (2017) tested 3rd to 6th grade students proenvironmental attitudes and behaviours after participating in a program that promotes informal activities in natural environments. The research paper reports on two separate quasi-experimental studies involving respectively 419 and 248 pupils. One parameter of interest to the first study was the impact of place of residence. Apparently, effects were larger for children living in large urban context than for children living in smaller cities. The second study was a longitudinal pre-post quasi-experimental aiming at assessing the long-term effects of participating in the environmental program. The study showed that pupils' general pro-environmental attitudes and self-reported behaviours were significantly affected by the intervention.

In a German quantitative study by Kossack and Bogner (2012) 123 6th grade students participated in a 1-day module involving both self-directed indoor and outdoor learning in nearby woods. Hence, the learning swapped between group presentations of seasonal rhythms indoor and "touching trees" outdoor focussing on the individual relationship with forests. Students (116 pupils) and a control group were tested for nature connectedness 2 weeks before, immediately after and 7 weeks after projects participation. The researchers concluded that the 1-day module influenced the significant shifts in connectedness with nature found in the intervention classes, which were not found in the control group.

Citizen Science Projects

Citizen science projects are projects in which students work with researchers to solve real-world problems by, for example, reporting the occurrence of certain species/pollution and solving research tasks locally. Citizen science projects often rely on large amounts of data (Almeida et al., 2006; Rogers and Steele, 2014), which demands that citizens such as science students contribute to the research. Such projects typically strengthen students' local knowledge and connection to their local area (Parrott, 2004; Bingaman and Eitel, 2010). At the same time, it is assumed that students gain self-efficacy and control, which is considered to be essential to enhance their environmental awareness.

This was demonstrated in an Austrian citizen science project (Keleman-Finan et al., 2018) in which 428 students and 21 teachers from 16 primary schools participated in two tasks : *1*) identifying eight key butterfly species and eight other selected butterfly species and *2*) identifying eight key bird species and 12 other selected bird species. Students were tested using a questionnaire that revealed their level of knowledge about biodiversity, assessment of their ability to identify species, and motivation to both learn about animals and contribute to science as well as their self-reporting on helping species in the garden. After the intervention, 309 out of 428 participating students responded to the questionnaire, with the highest number of responses to motivation to learn about animals, while the response level for biodiversity was the lowest. The researchers found that the favourite research activities were the identification of birds and butterflies. The results also showed that the youngest students scored highest on motivation to learn more and helping species in the garden as well as on their assessment of their ability to identify species.

An improved self-assessment of mastery was also observed in a US citizen science study in which two classes of 8th graders were recruited to register daggertails at the beach (Hiller and Kitsantas, 2014). Students were trained, as is often standard for citizen science projects, in data collection. The intervention also provided lectures on the life cycle, form, and function of daggertails as well as their biomedical significance. Students took part in a laboratory activity to test a condensate based on the copper-rich blood of daggertails, which can be used to detect bacteria. After the laboratory visit, they visited a nature centre to learn to handle small daggertails. To facilitate data collection, students were taught how to measure daggertails, assess their age based on colour, and determine their gender. They worked in teams of two or three and were initially monitored by researchers to answer questions and assuage any uncertainty about the task. As the day progressed, students worked more independently and collaborated to calibrate their abilities. Pre- and post-intervention tests revealed their level of knowledge and self-assessment of abilities to perform the task. A control group of students who learned about daggertails in class using the same PowerPoint show as the intervention group was similarly

tested. The self-assessment test for skills in science consisted of a questionnaire based on a Likert scale from "strongly agree" to "strongly disagree" and the test of content knowledge was generated from the PowerPoint presentation previously presented to both groups. The results on the knowledge increase and self-assessment of abilities showed a significant difference in favour of the intervention group.

In citizen science projects, the teachers typically rely on the expertise and labour of the involved researchers. In such cases, the workload related directly to the teaching might be less demanding than in traditional school settings since any training of data collection practices with students is the responsibility of the researchers. However, implementing citizen science projects into the science education in school may challenge teachers' balancing of curricular demands in terms of the time spent on the project and its subsequent relevance to the national testing scheme in science (e.g. Carrier et al., 2013).

Garden-Based Science Learning

According to the research literature, when students are asked about ecosystems often plants are underestimated (Carr, 2010) even though plant diversity plays a decisive role in the health of ecosystems both through productivity and through nutrient cycles (Fančovičová and Prokop, 2011). Such "plant blindness" includes the inability to notice plants in the environment, inability to recognise the importance of plants for the environment and human affairs, inability to recognise plants' aesthetic and unique biological properties, and tendency to underestimate plants in favour of animals (Strgar, 2007).

In a school garden project in Slovakia, Fančovičová and Prokop (2011) investigated how teaching a garden course affected 5th-grade students' attitudes towards plant knowledge. They also explored whether student access to their own garden affected learning. Among the topics taught, students learned about organisms such as animals, plants, and fungi in ecosystems such as meadows, forest and water areas, and cultivated fields. The 34 students were divided into an intervention group and a control group. Together with experts, the intervention group planted trees on the school grounds while learning about the life cycle of the forest and amenity value of trees. In addition, they were taught botany on a meadow next to the school. Students worked together in groups of four or five on different tasks such as botanical research methods, the collection of plants, and plant determination using keys as well as discussed plant names and roles in specific ecosystems. The tree planting and botany course lasted 6 months, corresponding to six lessons. The control group did not participate in the tree planting and meadow teaching, but instead received conventional biology teaching in class. However, they were given access to the meadow in which they practiced sports for a period corresponding to the intervention group's stay on site.

Two days before, 3 days after, and 3 months after the intervention, students' knowledge of and attitude towards plants were tested using a questionnaire. In the attitude test, they had to answer 45 statements such as "plants in the city are a problem because they cause allergies," "plants are very important for medical knowledge" and "I enjoy going to plant exhibitions." In the knowledge test, students were asked 13 in-depth questions about the meadow ecosystem such as "what is not an abiotic factor in the ecosystem: temperature, human activity, wind direction?" and "draw all the components of the meadow ecosystem." The responses correlated with age, gender, grades in biology, and access to one's own garden. Significant differences in both the attitude and the knowledge tests were found between the intervention and control groups but there was no correlation with gender or access to one's own garden. The researchers concluded that students' awareness of the importance of plants can increase through carefully planned courses with plants as a focus.

Also an understanding of the insects and smaller mammals found in students' immediate environment is overlooked (Hagevik, 2003; Dominguez et al., 2013; Spring and Harr, 2014). The media generally focus on birds and exotic vertebrates, while small animals, if mentioned at all, often arouse disgust. According to Drissner et al. (2014), this creates major problems for the understanding of environmental problems. The researchers investigated a "green classroom" project in a German botanical garden in which teaching and hands-on experiences sought to sharpen students' attention to invertebrates and insects in their immediate environment. In the botanical garden, the animals live in their natural habitats such as meadows, forests, and lakes, and students from visiting schools received direct answers to their questions while observing the animals. Students were also allowed to handle and physically examine the animals under controlled conditions to learn to treat them with caution and show them respect. The intervention built on the assumption that students only learn to care for insects and smaller mammals if they build concrete relationships that provide emotional attachment to these organisms.

The researchers' study involved 121 3rd- and 4th-grade students divided into an intervention group and a control group. Intervention students visited the botanical garden for 1 day 9 months before, while control students did not (Drissner et al., 2010). Back at school, both groups of students were asked to draw an ordinary forest with the typical plants and animals they knew. The researchers then evaluated the drawings according to the number of *1*) small animals (insects and invertebrates) such as butterflies, beetles, spiders, snails, and millipedes, *2*) large animals (vertebrates and mammals) such as birds, foxes, hedgehogs, and deer, and *3*) different kinds of species (animals only). The intervention group drew twice as many small animals and indicated more different species than the control group. The girls in the intervention group drew almost twice as many invertebrates as the boys as well as more distinct species than the boys. According to the researchers, time spent on drawing could have been the cause of the gender difference observed.

The demonstration of the effect of teaching 9 months after an intervention that lasted half a day is in line with the same researchers' study of 5th–9th-grade students who showed significantly different attitudes and emotions towards small animals several years after the intervention (Drissner et al., 2010). The results of that study are supported by a qualitative

forest garden intervention in Sweden in which students highlighted that concrete experience had changed their attitudes towards, for example, spiders and dragonflies (Hammarsten et al., 2019; *see* also; Short, 2013).

Use of Nature Experiences to Support Teaching Scientific Methods

Empirical Studies on Scientific Methods in the Corpus

Spontaneous stimulation of scientific methods was investigated in a Malaysian study of 5th-grade students. Here, the intervention group was taught using an "eco-hunting" task over four to 6 weeks, while the control group received comparable teaching in the classroom using textbooks, smartboards, and presentations (Ting and Siew, 2014). The experimental group practiced their observational skills when asked to look for animals and plants in the schoolyard. They were also introduced to performing prediction and derivation procedures when dealing with themes such as "animals with and without parental care" and "plant dispersal strategies." Before and after the intervention, the experimental and control groups conducted a multiple-choice test consisting of 20 questions on scientific research methods such as observation, classification, the ability to derive, predict, and communicate, and control variables. In subsequent lessons, teachers focused on food chains and the importance of the relationship between the number of primary producers and consumers. Both groups showed significant improvements in their ability to apply scientific methods, but the improvements of the intervention group were significantly greater than those of the control group. Within the intervention group, the main improvement centred on classification and observation skills. The researchers explained that the outdoor environment improves students' senses of hearing, sight, feeling, and taste considerably.

A Scottish qualitative outdoor school study focusing on the subjects of geography and mathematics highlights how nature experiences support students' critical thinking (Christie et al., 2016). The researchers followed 150 11–14-year-old students and 10 teachers for a year to understand their learning processes through the use of nature experiences in science teaching. The researchers observed that students, as a result of their observations of and experience and interaction with the outdoor environment as well as the discussions that the experiences initiated, asked themselves questions such as "why do some rivers freeze in winter when others do not?" This questioning helped students interpret intentions, understand context, recognise hidden values and emotions, clarify motives, detect bias, and conclude concisely and suitably.

Learning in a natural environment can also stimulate conversations (Kirsh, 2010), as demonstrated by an Australian qualitative study in which a class of 9th graders received science lessons at the local stream over an 11-week period (King and Ginns, 2015). The teaching centred on measuring and comparing water quality, flora, fauna, and pollution in three places. Students were divided into groups of five that rotated around different sub-activities. The researchers observed so-called "spontaneous teaching episodes" in which the teacher seized the opportunity for deeper conversations on an environmental topic with students. These were conversations about habitat, the difference between living and extinct species, water quality, organism adaptations, food chains, species populations, native and invasive plant species, plant reproduction, and the erosion of the edges of the stream. The interactions took the form of a spontaneous question/answer dialogue, beginning with the teacher asking 11 students at the stream if they had seen water insects. The teacher and students brainstormed together in such a way that different students first provided examples such as water striders and dragonflies and then began to discuss their observations of larger animals. The teacher seized the opportunity to ask the group if they expected to see fish in the area. One student said that the water was not sufficiently clean to see fish. In response, the teacher used the concept of pollution and then introduced the concept of habitat. The teacher then asked students what habitat they expected the fish in the area would prefer.

In this way, he made students grasp the concept, reason, direct their attention towards stones, and at the same time point to places in the stream where the fish accumulated. As the next step in the ongoing dialogue at the stream, the teacher asked if there is anything else behind which fish prefer to hide. Another of the students mentioned seaweed and pointed to the stream to illustrate. "Yes, seaweed," the teacher replied and then asked "What about along the edges?" One student answered, "Plants hanging down in the creek." The teacher confirmed and continued the brainstorming by commenting that plants hanging down the stream are probably also a good area, thus encouraging students to search for small animals around the vegetation as they put on waders and moved around in the stream. In conclusion, he summed up that "things not only live in the water; they also live in the area around and above it."

The spontaneous teaching episodes that frequently occur during fieldwork are an expression of a special class and teacher–student dynamic. Such an environment both encourages and supports longer dialogues in which the teacher can make students familiar with scientific hypothesis formation, derivative thinking, and reasoning based on what they have in common (Rennie et al., 2003; Eshach, 2007; Lewis and O'Brien, 2012; Heras et al., 2020).

Scientific Systematics

The scientific method also involves a special systematics in relation to the collection and handling of empirical data (Çapkınoğlu and Yilmaz, 2018). In a project on nature conservation in the United States, 5th-grade students acquired basic and essential fieldwork skills (e.g. updating a logbook; Bingaman and Eitel, 2010). They also learned to introduce date, time, and location, organised measurements on sheets with appropriate headings, outlined observations, found precise names for them, and categorised information.

Some parts of the science approach are not intuitive for elementary school students. In a US study, 26 1st-, 3rd-, and 6th-grade students from a rural area were interviewed about the relationship between sampling and the possibility of deriving

causal relationships (Lehrer and Schauble, 2017). Over a year, the students had collected data and conducted comparative studies of nearby local ecosystems, including ponds, prairies, and forests. Through their experiences with sampling in the field, they became indirectly aware of biodiversity and began to associate species variation with variations in biotopes. The researchers aimed to uncover students' understanding of the concept of sampling, ways of collecting sensible samples, potential sources of error in sampling, the relationship between cause and randomness in explanations of variability, ideas about larger sample sizes, how a single sample can represent the whole ecosystem, and variations in sample quality.

The researchers expected that the repeated opportunities to collect, interpret, and reason about data would increase children's understanding that samples acquired in the same place vary, that some phenomena in the sample occur more often than others, and that one's opportunity to predict what appears in subsequent samples increases with the number of samples. The results varied by age. The 1st-grade students perceived samples as concrete parts of the ecosystem and expected that more samples would better describe species diversity because they gained an overview of a larger concrete part of the system. Those students placed less emphasis on the fact that methods of obtaining data affect which data one has access to. By contrast, 3rd-grade students were more aware that the systematic implementation of the same method, maintained in the same place, is necessary for sample reliability. The significance of occasional coincidences for the outcome of a sample was rarely included in the interviews. In the 6th grade, on the contrary, there was a strong presumption that samples varied over time. The explanations, however, were most often backed up by concrete experiences with sampling and only rarely with considerations of the principled randomness in sampling. During the ecology course in mathematics teaching, both 3rd- and 6th-grade students had been taught the concept of chance without having it explicitly related to data collection. Only 30% of the younger students referred to ideas of randomness to account for variations in random sampling, while this figure increased to 43% in the older students.

In a Swedish qualitative study by Magntorn and Helldén (2007), 23 3rd to 4th grade pupils were taught ecology by focussing on individual specimens of a species such as the freshwater shrimp to help students *read nature* in a river ecosystem. From the ecology of the freshwater shrimp, the students' perspective was broadened to focus on interrelations between organisms and the relationship between biotic and abiotic factors. During the intervention, seven lessons of a duration from 80 to 200 min, pupils were interviewed three times when they were presented with a tray of objects from the ecosystem. The task was to name and describe the objects and potential links between them. The researchers report how the progression of the course supported the concept development and students' understanding of the complex notion of ecosystem.

Technology-Based Nature Experiences in Science

The scientific emphasis on observations is traditionally linked to the use of technology (e.g. magnifying glass, binoculars, microscope, telescope, oscilloscope, seismograph), which either expands or amplifies the senses (Lewis and O'Brien, 2012).

The ability to stimulate scientific attention through sensory-expanding technology is described in the US study by Ghadiri Khanaposhtani et al. (2018). The qualitative study examined the effect of a 4-day stay in a so-called soundscape ecology camp that recorded and processed the sound of nature areas on the ability of seven 5th–8th-grade students to ask scientific questions and prepare research projects. Students learned to "*see*" the surroundings through soundscape technology. They learned how to compare and contrast sound universes in different ecosystems, how soundscape ecologists record sound universes and analyse them to answer research questions, and how the students themselves could answer questions by collecting and analysing acoustic data. The researchers conducted a drawing and writing activity with the seven students in a questionnaire with six open-ended questions such as "why do animals make sounds?" After the intervention, students showed signs of a deeper understanding of sound universes and how they can be used as a scientific tool to investigate both the state of an ecosystem and the importance of human activity for this ecosystem.

Similar observations about mixing nature experiences and use of technology to teach science are found in the British study conducted by Scott and Boyd (2016). Here, 379 pupils from 5th and 6th grade took part in an intervention in which their class teacher chose a local habitat for a half-day fieldwork session. Selected habitats were the school playing fields and gardens, a school pond, a local woodland, and local rocky shore. Children were encouraged to thoroughly explore the area and use charts to identify all the plants and animals they encountered, and encouraged to photograph species of their own choice, write down field notes about appearance and location, and to write down questions that the encounter with the organism had inspired.

The day after the fieldwork session, pupils were asked to use computers to construe a field guide targeting other children visiting the site based on their photographs and field notes. They were encouraged to look up the answer to their questions on the internet and to add wow facts that had amazed them while learning. The comparison classes did not participate in the field work session but were taught in the classroom about the same habitat and types of organisms.

Two weeks before and 6 weeks after the intervention, pupils' scientific knowledge was assessed. For example, pupils were asked to identify a herbivore, or from drawings of organisms describe which was a predator of which, or provide an answer to a question like "Some children collected animals from a pond. They found a lot of animals amongst the water plants, why was this?"

The study results show that pupils who took part in the intervention scored significantly higher in the mean level of academic achievement. However, the researchers add that the intervention classes also scored higher in the pretest assessments. They hypothesise that the better pretest scores are the result of the intervention classes being told beforehand that they were to participate in ecological fieldwork, and may have started to "think like a scientist" (Scott and Boyd, 2016, p. 668).

In a US study focusing on ecosystems, Lee (2014) describes how categorising 5th-grade students' experiences with photo

documentation from fieldwork benefitted their recall and understanding of the subject. In the project, each student was encouraged to photograph what they found interesting. The excursion involved longer walks in wild terrain and teaching at several museums. After the intervention, students were interviewed about their pictures. The photographs were classified into "documentation images," where the student documented a view or something beautiful, and "observation images," where the student zoomed in on a phenomenon or characteristic of what was observed. Others were classified as "cause-and-effect images," where the student illustrated a cause-and-effect relationship (e.g. images of the location of rocks as a result of being pushed from a glacier), and "wonder images," where the student found the photographed image mysterious and in need of explanation (e.g. what an animal skeleton could reveal about the living animal). The study revealed that students photographed far more documentation images on museum visits than on walks (72.8 versus 50.1%) and far more cause-and-effect images on walks than at museums (26.1 versus 2.6%). The researchers conclude that nature experiences stimulate the need to ask questions and predict events whereas museum visits support scientific curiosity (*see* also Hammarsten et al., 2019).

INVESTMENTS, COSTS AND CHALLENGES WHEN USING NATURE EXPERIENCES IN SCIENCE TEACHING

According to the research, there are administrative, financial, and practical challenges to conducting science teaching in nature.

Excursions and longer stays require financial support and more teachers. For example, outdoor teaching is often carried out in collaboration with nature centres, researchers, students, and volunteers.

Also, teaching in a natural environment typically follows a more open course because the outdoor space varies in terms of its organic environment. If organisms are not in the pre-planned location, this might obstruct the teaching (Schilhab and Lindvall, 2017; Glaab and Heyne, 2020). However, this open-ended quality allows teachers to stimulate students' commitment and curiosity. It could be argued that thise lack of control creates the different teacher–student interactions that make the natural environment valuable (King and Ginns, 2015). The teacher may decide to grasp spontaneous learning opportunities, but at the same time feel pressured because they are supposed to strengthens students' abilities when tested. In the study by Carrier et al. (2013), two US teachers remarked that too tight a timeframe is allowed for science teaching and pointed out that science teaching should be the equivalent of mathematics and reading from a political standpoint. They also demanded more subject-related courses that could equip them to teach outdoors. The perception of time constraints and heavy content demands are shared by the Scottish teachers in the study by Christie et al. (2016).

Pupils' attitudes towards the environment also constitute a barrier. Children unaccustomed to being outdoors require more attention to behave appropriately. A typical problem is inappropriate clothing that makes the stay cumbersome. Students often need to be instructed in how to behave during their stay. Articles on examining plant and animal species in school gardens or nearby areas emphasise that caution with poisonous, stinging, and burning plants is necessary (Magiante, 2009; Dominguez et al., 2013). At the same time, the importance of teaching students' etiquette in connection with their stay in nature is highlighted. Students must develop responsibility and care and learn to treat the environment with respect (Drissner et al., 2010, 2014). The teacher's attitude also affects nature experiences (Carrier et al., 2013). Eshach (2007) posits that the teacher's personal interests, preparation, actions in the field, and handling of the fieldwork after the course is completed all affect students' attitude towards the course, both immediately after and in the long run (*see* also Strgar (2007) for the importance of the teacher in emphasising the importance of plants).

The literature points to another barrier that teachers typically encounter. School leaders, school politicians, and parents may be sceptical about the learning potential of completing science subjects in nature. Most inspirational articles therefore have a section that deals with the importance of convincing the pedagogical leader and gaining permission for the project.

DISCUSSION AND CONCLUDING REMARKS

Across the studies in the corpus, typical research methodologies are mixed methods, quasi-experimental, pre-/post- and retention test setups, compared to those of a control group. Exceptions exist. In one study, using measurements statistics is not applied, and in few others, the number of participants is limited, or control groups are missing. The measurements are typically based on instruments like questionnaires and multiple-choice tests to assess the level of knowledge from the number of correct answers. However, quantitative measures of students' knowledge acquisition and retention also encompass probing memories in interviews based on student photos, annotated drawings, personal meaning maps, word association tests, essays, and student work samples. The effects that are measured include cognitive and emotional changes as well as attitudes towards nature and living organisms, and degree of nature connectedness.

In a handful of studies, methodologies are purely qualitative relying on interviews, observations, student work samples or annotated drawings.

Thus, the majority of scientific content knowledge studies, environmental studies and scientific systematics studies (the three categories used here) all assume and are primarily interested in demonstrating quantitatively that cognition, emotions, and attitudes are influenced by nature experiences to a significant extent.

Unsurprisingly, the empirical literature consists of articles written by the researchers affiliated with the intervention projects, implying that projects with less researcher involvement may face difficulties getting published. The

researcher involvement likely impacts how to organise the courses and which elements to develop. For example, researchers could be biased towards designing interventions that favour effect measurements. However, school teachers would design interventions governed by pedagogical criteria of quality (e.g. Rennie et al., 2003).

Relatedly, the expectations of this review study were to find the application of nature experiences across several scientific disciplines ranging from physics and chemistry to geology, and astronomy. In the field as such - the 114 studies – a number of articles fall within this broader scope. Surprisingly in the corpus, almost all studies are concerned with the biological sciences, such as the interconnectedness of nature, adaptational issues, and sustainability issues.

It would be interesting to investigate the effects on learning of for example the demonstrating of watersheds in students' own environments (described by Endreny, 2007). Here, the teacher invited students to walk through the landscape right outside the door. They had access to both a stream and a larger wetland and learned to recognise the relevant physical phenomena. They were also shown their connection with the landscape and taught how to read topographical maps of watersheds as graphic tools and symbolic representations of the phenomena. Hence, it could be argued that observations of actual phenomena and nature experiences could be implemented in a much wider ranges of natural science disciplines (e.g. Townsend, 2010).

In terms of embodied cognition, the research on content knowledge does reflect an appreciation of learning being both embodied and immersed. When content knowledge is gained exclusively through linguistic constructions, its success depends on how well the student works with and imagines linguistic information (Schilhab, 2007; Schilhab, 2011; Schilhab, 2017a; Schilhab, 2017b; Schilhab, 2018; Shapiro and Stolz, 2019)). However, the didactic choice of swapping between firsthand learning and secondhand learning (concepts and theories) are present in many of the studies. Concretisation through direct experience clarifies the meaning of the concepts at two levels (King and Ginns, 2015; Allison et al., 2017; Schilhab and Lindvall, 2017) by *1*) adding experiential content to the conceptual understanding (i.e. something in the world which feels in a particular way corresponds to the concept), and *2*) identifying aspects essential to the concept through the action practices of which the phenomenon is part (Hasse, 2016). At the second level, content knowledge includes knowledge about how to talk and reason about science and nature, contextualised through the experience of these phenomena, related practices, and the theoretical concepts one uses about them (Schilhab and Esbensen, 2019).

The bias towards environmental issues mentioned above, explains why a large part of the research is categorised as environmental education. Here, the research is primarily concerned with environmental issues measuring students' attitudes towards nature and organisms and their feelings of attachment to nature, e.g. their nature connectedness. In several of these studies, the underlying assumptions are that when students gain knowledge about nature, they feel more connected to nature. This may not necessarily be the case.The studies may find a concurrent increase in measures of academic achievements and nature connectedness. However, measures of correlations are not measures of causality.

In terms of embodied cognition, the environmental studies endorse the idea that meaning-making is situated. According to the embodied cognition approach, learning and knowledge formation cannot be dissociated from lived life. On the contrary, cognisers' minds are always embodied, embedded, enacted, and extended (Rowlands, 2010; Menary, 2010; see also; Rietveld et al., 2018), and an adequate understanding of cognitive processes in meaning-making activities is therefore concerned with cognisers' bodies, surroundings, and continuous exchanges with those surroundings (Walter, 2009; Fuchs, 2017). These factors pertained to the experience of the blackberry bush in the introduction. Along those lines, as students *experience* nature, nature starts making sense. That nature experiences related to science in childhood can have long-term effects that may even show up in the choice of a science-related profession has been demonstrated with field geologists (LaDue and Pacheco, 2013). For over half of respondents, early nature experiences in geological areas in which informants lived or had visited in childhood were a decisive reason why they pursued a career as a geologist as adults. Hence, disregarding effect measures, nature experiences have life-long impacts affecting who studies nature professionally.

Research on how the natural environment creates an optimal backdrop for eliciting observations and derived reflections central to scientific inquiries relates to the gains of the formative swapping between instructions and experiential hands-on activities (discussed in relation to content knowledge). With very little investment, such as exposing students to investigating birds at a feeding board or plant development in a select plot, and encouraging spontaneous teaching episodes, teachers tune their students to observe the natural world and through that explore the essence of scientific thinking and reasoning.

Among these studies, some argue for the use of technology in conjunction with nature experiences in science, systematically investigated in a recent review by Kilty and Burrows (2020). The study uncovered how science teachers typically use mobile devices for teaching purposes. Of the 45 selected peer-reviewed articles, the researchers found that mobile devices are most often used to support observations, data collection, and knowledge sharing (44%) and gain content knowledge (49%). However, the use of mobile devices to support observations and hypothesis formation were less well represented.

Contemporary students already use digital learning tools and the Internet as part of their daily lives (Schilhab, 2017c; Schilhab et al., 2018b). The Danish project Natural Technology has demonstrated how smartphones engage disadvantaged children in nature experiences and explorative investigations of natural phenomena (Schilhab et al., 2020; Schilhab and Esbensen, 2021).

In terms of embodied cognition, it could be argued that studies using nature experiences to stimulate pupils' understanding of scientific procedures and methodologies assumes that cognisers' minds are always enacted, and extended (Rowlands, 2010). Also,

when using smart technologies in observations and note taking we extend the mind with the tool as thinking-aid. This claim also pertains to notebooks with PIN codes and telephone numbers, road signs, and chalk lines on the wall indicating how many times the sun has risen. When we use objects and surroundings as a placeholder for our thinking - we externalize thought processes that would otherwise taxour cognitive resources.

Though most studies in the corpus were not discussing the investments, costs and challenges, the teacher papers among the 114 papers did. An exception is Randler and colleagues who comment that (2005, p. 50): ". . .residential outdoor programs are expensive and often linked with traveling. . .", therefore "Schools should provide their students with local outdoor ecological programs."

Obviously, not every school has access to or can afford to send their students to nature parks, the seaside or wetlands. In this regard, interventions exploiting the schoolyard, school gardens, or nearby park areas are particularly promising. First, the closeness of the empirical site reduces the costs in terms of time, extra helpers and expenses spent on transportation. Also, projects based on easy access can support science teaching on an ongoing basis. This point seems noteworthy since all learning activities seem to benefit from prolonged interventions and subsequent repetitions.

Second, in local areas the science learning effortlessly pivots around the importance of insects, plants and smaller mammals often neglected at the expense of more "attractive" however non-local species. Learning to care about commonly underrated organisms and environments nearby, because they belong to your neighborhood, seem to stimulate pro-environmental behaviours. In local areas, students are also already familiar with the environment, reducing the risk of a negative impact of novelty, and making it safer for younger students to navigate without supervision.

An insight gained from studying the corpus worth emphasising is that the gains from using nature experiences in science learning fundamentally depends on the educators' preparations and didactic reflections. Albeit nature experiences appear "natural" the framing of these within an educational context is far from given. This factor became apparent from the fact that many of the studies included in class preparations and postintervention debriefing in the learning module. The swapping between firsthand and secondhand experiences and the shift between free learning and teacher centered learning needs to be organised by didactic goals. Hence, when considering the gains and costs of implementing nature experiences in science learning, it is important to address the extra working hours on the part of the teacher involved in conceptualising the interventions as useful didactic alternatives to class-based education. To that end, it is remarkablethat a few studies also reported on prior pilot studies demonstrating the need for testing the entire design before conducting the actual research. Teachers seldom experience the opportunity to preview their teaching strategies before performing in front of their students. What this suggests is the necessity to develop educational programs that allow teachers to seamlessly adopt these practices in their everyday routines.

An extremely important metafinding from this review is that science education seems central for remedying the extinction of experience in students, and if exposure to nature is a prerequisite for learning to care abot nature, for providing opportunities for students to learn to care about nature (e.g. Soga and Gaston, 2016). Provided, that time is allowed to develop courses, and that extra manpower is made available, science education seems to be *in a unique position* for incorporating nature experiences into the curriculum. Such actions will boost students' understanding of and maybe also attitudes towards nature. Hence, science educators in primary and secondary schools should be made aware of the gains of using nature experiences in science learning and receive support to reduce the obvious costs if they were to explore this educational approach further.

Very few studies in the present review have touched upon the effect of using nature experiences in science learning regarding disadvantaged children or youth, children of color, children from low-income households, and children with emotional, behavioral, or cognitive disabilities. Results reported by De Dominicis et al. (2017) seemed to suggest that particularly for children living in urban environments like Rome, nature experiences proved useful for developing pro-environmental attitudes and behaviors. Future research should further elaborate on the potential of nature experiences to include disadvantaged children and youth in science education.

Regardless of these limitations, importantly, the material suggests that using nature experiences in science education increases content knowledge and nature-connectedness, and expands insight into scientific methods and inquiry strategies for students in primary and secondary school and that embodied cognition theories are helpful in explaining why and how nature experiences work.

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The author is responsible for the work in its entirety.

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SUPPLEMENTARY MATERIAL

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REFERENCES

Alberghi, S., Foschi, A., Pezzi, G., and Ortolani, F. (2007). Is it More Thrilling to Ride at the Front or the Back of a Roller Coaster. *Phys. Teach.* 45 (9), 536–541. doi:10.1119/1.2809145

Allison, E., Tunks, K., and Hardman, K. (2017). Down by the Bay. *Sci. Child.* 54 (7), 29–33. doi:10.2505/4/sc17_054_07_29

Almeida, S., Bombaugh, R., and Mal, T. K. (2006). Involving School Children in the Establishment of a Long-Term Plant Biodiversity Study of an Urban Green Space. *Am. Biol. Teach.* 68 (4), 213–220. doi:10.2307/4451969

Almers, E., Askerlund, P., and Kjellström, S. (2018). Why Forest Gardening for Children? Swedish Forest Garden Educators' Ideas, Purposes, and Experiences. *J. Environ. Edu.* 49 (3), 242–259. doi:10.1080/00958964.2017.1373619

Aspinall, C. (2016). Using Outdoor Adventure Settings to Teach Physics. *Sch. Sci. Rev.* 98 (362), 110–114.

Aydede-Yalçın, M. N. (2016). The Effect of Active Learning Based Science Camp Activities on Primary School Students' Opinions Towards Scientific Knowledge and Scientific Process Skills. *Int. Electron. J. Environ. Edu.* 6 (2), 108–125. doi:10.18497/iejee-green.78816

Ayotte-Beaudet, J. P., Potvin, P., Lapierre, H. G., and Glackin, M. (2017). Teaching and Learning Science Outdoors in Schools' Immediate Surroundings at K-12 Levels: A Meta-Synthesis. *EURASIA J. Math. Sci. Tech. Edu.* 13 (8), 5343–5363. doi:10.12973/eurasia.2017.00833a

Ballantyne, R., and Packer, J. (2009). Introducing a Fifth Pedagogy: Experience-based Strategies for Facilitating Learning in Natural Environments. *Environ. Educ. Res.* 15 (2), 243–262. doi:10.1080/13504620802711282

Barker, B. S., Larson, K., and Krehbiel, M. (2014). Bridging Formal and Informal Learning Environments. *J. Extension* 52 (5), 1–4.

Barrett, L. F. (2009). The Future of Psychology: Connecting Mind to Brain. *Perspect. Psychol. Sci.* 4 (4), 326–339. doi:10.1111/j.1745-6924.2009.01134.x

Barsalou, L. W. (2010). Grounded Cognition: Past, Present, and Future. *Top. Cogn. Sci.* 2 (4), 716–724. doi:10.1111/j.1756-8765.2010.01115.x

Barsalou, L. W. (2009). Simulation, Situated Conceptualization, and Prediction. *Philos. Trans. R. Soc. Lond. B Biol. Sci.* 364 (1521), 1281–1289. doi:10.1098/rstb.2008.0319

Bentsen, P., and Jensen, F. S. (2012). The Nature Ofudeskole: Outdoor Learning Theory and Practice in Danish Schools. *J. Adventure Edu. Outdoor Learn.* 12 (3), 199–219. doi:10.1080/14729679.2012.699806

Bingaman, D., and Eitel, K. B. (2010). Boulder Creek Study. *Sci. Child.* 47 (6), 52–56.

Boeve-de Pauw, J., Van Hoof, J., and Van Petegem, P. (2019). Effective Field Trips in Nature: The Interplay Between Novelty and Learning. *J. Biol. Edu.* 53 (1), 21–33. doi:10.1080/00219266.2017.1418760

Bølling, M., Niclasen, J., Bentsen, P., and Nielsen, G. (2019). Association of Education Outside the Classroom and Pupils' Psychosocial Well-Being: Results from a School Year Implementation. *J. Sch. Health* 89 (3), 210–218. doi:10.1111/josh.12730

Bølling, M., Otte, C. R., Elsborg, P., Nielsen, G., and Bentsen, P. (2018). The Association Between Education Outside the Classroom and Students' School Motivation: Results from a One-School-Year Quasi-experiment. *Int. J. Educ. Res.* 89, 22–35. doi:10.1016/j.ijer.2018.03.004

Bosse, S., Jacobs, G., and Anderson, T. L. (2009). Science in the Air. *YC Young Child.* 64 (6), 10–15.

Braun, M., Buyer, R., and Randler, C. (2010). Cognitive and Emotional Evaluation of Two Educational Outdoor Programs Dealing with Non-native Bird Species. *Int. J. Environ. Sci. Edu.* 5 (2), 151–168.

Braun, T., and Dierkes, P. (2017). Connecting Students to Nature - How Intensity of Nature Experience and Student Age Influence the Success of Outdoor Education Programs. *Environ. Edu. Res.* 23 (7), 937–949. doi:10.1080/13504622.2016.1214866

Braund, M., and Reiss, M. (2006). Towards a More Authentic Science Curriculum: The Contribution of Out-of-school Learning. *Int. J. Sci. Edu.* 28 (12), 1373–1388. doi:10.1080/09500690500498419

Çapkınoğlu, E., and Yilmaz, S. (2018). Examining the Data Component Used by Seventh Grade Students in Arguments Related to Local Socioscientific Issues. *Edu. Sci.* 43 (196), 125–149. doi:10.15390/EB.2018.7205

Carr, K. (2010). Leading Students to a World of Interdependence. *Sci. Activities* 37 (4), 3–5. doi:10.1080/00368120109603580

Carrier, S. J., Thomson, M. M., Tugurian, L. P., and Stevenson, K. T. (2014). Elementary Science Education in Classrooms and Outdoors: Stakeholder Views, Gender, Ethnicity, and Testing. *Int. J. Sci. Edu.* 36 (13), 2195–2220. doi:10.1080/09500693.2014.917342

Carrier, S. J., Tugurian, L. P., and Thomson, M. M. (2013). Elementary Science Indoors and Out: Teachers, Time, and Testing. *Res. Sci. Educ.* 43 (5), 2059–2083. doi:10.1007/s11165-012-9347-5

Chalmers, A. F. (2013). *What Is This Thing Called Science*. Indianapolis, IN: Hackett Publishing.

Christie, B., Beames, S., and Higgins, P. (2016). Context, Culture and Critical Thinking: Scottish Secondary School Teachers' and Pupils' Experiences of Outdoor Learning. *Br. Educ. Res. J.* 42 (3), 417–437. doi:10.1002/berj.3213

Clements, D. H. (2000). 'Concrete' Manipulatives, Concrete Ideas. *Contemp. Issues early Child.* 1 (1), 45–60. doi:10.2304/ciec.2000.1.1.7

Çobanoğlu, R., and Kumlu, G. D. Y. (2020). Children's Science Learning Outside School: Parental Support. *Turkish J. Edu.* 9 (1), 46–63. doi:10.19128/turje.613091

Cole, A. G. (2004). Outdoor Ecology School. *Sci. Teach.* 71 (5), 52–54.

Cwikla, J., Lasalle, M., and Wilner, S. (2009). My Two boots... A Walk through the Wetlands. An Annual Outing for 700 Middle School Students. *Am. Biol. Teach.* 71 (5), 274–279. doi:10.2307/27669430

De Dominicis, S., Bonaiuto, M., Carrus, G., Passafaro, P., Perucchini, P., and Bonnes, M. (2017). Evaluating the Role of Protected Natural Areas for Environmental Education in Italy. *Appl. Environ. Edu. Commun.* 16 (3), 171–185. doi:10.1080/1533015x.2017.1322014

Demirbas, C. O. (2017). The Effect of Out-Of School Activities on Conceptual Change in Environmental Education. *Jets* 5 (2), 232–242. doi:10.11114/jets.v5i2.2077

Dettweiler, U., Ünlü, A., Lauterbach, G., Becker, C., and Gschrey, B. (2015). Investigating the Motivational Behavior of Pupils During Outdoor Science Teaching Within Self-Determination Theory. *Front. Psychol.* 6, 125. doi:10.3389/fpsyg.2015.00125

Dhanapal, S., and Lim, C. C. Y. (2013). A Comparative Study of the Impacts and Students' Perceptions of Indoor and Outdoor Learning in the Science Classroom. *Asia-Pacific Forum Sci. Learn. Teach.* 14 (2), 1–23.

Dieser, O., and Bogner, F. X. (2016). Young People's Cognitive Achievement as Fostered by Hands-On-Centred Environmental Education. *Environ. Edu. Res.* 22 (7), 943–957. doi:10.1080/13504622.2015.1054265

Djonko-Moore, C. M., Leonard, J., Holifield, Q., Bailey, E. B., and Almughyirah, S. M. (2018). Using Culturally Relevant Experiential Education to Enhance Urban Children's Knowledge and Engagement in Science. *J. Experiential Edu.* 41 (2), 137–153. doi:10.1177/1053825917742164

Dominguez, L., McDonald, J., Kalajian, K., and Stafford, K. (2013). Exploring the Wild World of Wiggly Worms. *Sci. Child.* 51 (4), 44–49.

Drissner, J., Haase, H.-M., and Hille, K. (2010). Short-term Environmental Education - Does it Work? - An Evaluation of the 'Green Classroom'. *J. Biol. Edu.* 44 (4), 149–155. doi:10.1080/00219266.2010.9656215

Drissner, J. R., Haase, H.-M., Wittig, S., and Hille, K. (2014). Short-term Environmental Education: Long-Term Effectiveness. *J. Biol. Edu.* 48 (1), 9–15. doi:10.1080/00219266.2013.799079

Endreny, A. (2007). Watershed Seasons. *Sci. Child.* 44 (9), 20–25.

Eshach, H. (2007). Bridging In-School and Out-Of-School Learning: Formal, Non-formal, and Informal Education. *J. Sci. Educ. Technol.* 16 (2), 171–190. doi:10.1007/s10956-006-9027-1

Fägerstam, E., and Blom, J. (2013). Learning Biology and Mathematics Outdoors: Effects and Attitudes in a Swedish High School Context. *J. Adventure Edu. Outdoor Learn.* 13 (1), 56–75. doi:10.1080/14729679.2011.647432

Fančovičová, J., and Prokop, P. (2011). Plants Have a Chance: Outdoor Educational Programmes Alter Students' Knowledge and Attitudes towards Plants. *Environ. Edu. Res.* 17 (4), 537–551. doi:10.1080/13504622.2010.545874

Føllesdal, D., Walløe, L., and Elster, J. (2005). Politikens Bog Om Moderne Filosofi Og Videnskabsteori. *København: Politikens Forlag* 28 (2), 237. doi:10.7146/politica.v28i2.68026

Fuchs, T. (2017). *Ecology of the Brain: The Phenomenology and Biology of the Embodied Mind*. Oxford, UK: Oxford University Press.

Genc, M., Genc, T., and Rasgele, P. G. (2018). Effects of Nature-Based Environmental Education on the Attitudes of 7th Grade Students Towards the Environment and Living Organisms and Affective Tendency. *Int. Res. Geographical Environ. Edu.* 27 (4), 326–340. doi:10.1080/10382046.2017.1382211

Ghadiri Khanaposhtani, M., Liu, C. J., Gottesman, B. L., Shepardson, D., and Pijanowski, B. (2018). Evidence that an Informal Environmental Summer Camp Can Contribute to the Construction of the Conceptual Understanding and Situational Interest of STEM in Middle-School Youth. *Int. J. Sci. Educ. B* 8 (3), 227–249. doi:10.1080/21548455.2018.1451665

Glaab, S., and Heyne, T. (2020). Focus Wildlife Park: Outdoor Learning at Workstations for Primary School Children. *Appl. Environ. Edu. Commun.* 19 (2), 141–154. doi:10.1080/1533015x.2018.1554461

Glenberg, A. M. (2015). Few Believe the World Is Flat: How Embodiment Is Changing the Scientific Understanding of Cognition. *Can. J. Exp. Psychol.* 69 (2), 165–171. doi:10.1037/cep0000056

Glenberg, A. M. (2011). How Reading Comprehension Is Embodied and Why that Matters. *Int. Electron. J. Elem. Edu.* 4 (1), 5–18.

Golob, N. (2011). Learning Science through Outdoor Learning. *New Educ. Rev.* 25 (3), 221–234.

Hagevik, R. A. (2003). Using Ants to Investigate the Environment. *Sci. Activities: Classroom Projects Curriculum Ideas* 40 (2), 6–13. doi:10.1080/00368120309601117

Hammarsten, M., Askerlund, P., Almers, E., Avery, H., and Samuelsson, T. (2019). Developing Ecological Literacy in a Forest Garden: Children's Perspectives. *J. Adventure Edu. Outdoor Learn.* 19 (3), 227–241. doi:10.1080/14729679.2018.1517371

Hasse, C. (2016). *Anthropology of Learning*. Cham: Springer.

Heras, R., Medir, R. M., and Salazar, O. (2020). Children's Perceptions on the Benefits of School Nature Field Trips. *Education 3-13* 48 (4), 379–391. doi:10.1080/03004279.2019.1610024

Hiller, S. E., and Kitsantas, A. (2014). The Effect of a Horseshoe Crab Citizen Science Program on Middle School Student Science Performance and STEM Career Motivation. *Sch. Sci. Math.* 114 (6), 302–311. doi:10.1111/ssm.12081

Hutchins, E. (2005). Material Anchors for Conceptual Blends. *J. Pragmatics* 37, 1555–1577. doi:10.1016/j.pragma.2004.06.008

Ionescu, T., and Vasc, D. (2014). Embodied Cognition: Challenges for Psychology and Education. *Proced. - Soc. Behav. Sci.* 128, 275–280. doi:10.1016/j.sbspro.2014.03.156

Jesus-Leibovitz, L., Faria, C., Baioa, A. M., and Borges, R. (2017). Exploring Marine Biodiversity Through Inquiry with Primary School Students: A Successful Journey. *Edu. 3-13* 45 (4), 437–449. doi:10.1080/03004279.2015.1107612

Jordan, C., and Chawla, L. (2019). A Coordinated Research Agenda for Nature-Based Learning. *Front. Psychol.* 10, 766. doi:10.3389/fpsyg.2019.00766

Jordet, A. N. (2003). Uteskole - en Didaktikk for Helhetlig Utvikling. *Kroppsøvning* 53 (3), 26–32.

Kärkkäinen, S., Keinonen, T., Kukkonen, J., Juntunen, S., and Ratinen, I. (2017). The Effects of Socio-Scientific Issue Based Inquiry Learning on Pupils' Representations of Landscape. *Environ. Edu. Res.* 23 (8), 1072–1087. doi:10.1080/13504622.2016.1177711

Kelemen-Finan, J., Scheuch, M., and Winter, S. (2018). Contributions from Citizen Science to Science Education: an Examination of a Biodiversity Citizen Science Project with Schools in Central Europe. *Int. J. Sci. Edu.* 40 (17), 2078–2098. doi:10.1080/09500693.2018.1520405

Kiefer, M., and Trumpp, N. M. (2012). Embodiment Theory and Education: The Foundations of Cognition in Perception and Action. *Trends Neurosci. Edu.* 1 (1), 15–20. doi:10.1016/j.tine.2012.07.002

Kilty, T. J., and Burrows, A. C. (2020). Systematic Review of Outdoor Science Learning Activities with the Integration of Mobile Devices. *Int. J. Mobile Blended Learn. (Ijmbl)* 12 (2), 33–56. doi:10.4018/ijmbl.2020040103

King, D., and Ginns, I. (2015). Implementing a Context-Based Environmental Science Unit in the Middle Years: Teaching and Learning at the Creek. *Teach. Sci.* 61 (3), 26. doi:10.3316/informit.493423842304125

Kirsh, D. (2010). Thinking with External Representations. *AI Soc.* 25 (4), 441–454. doi:10.1007/s00146-010-0272-8

Klomberg, B., Schilhab, T., and Burke, M. (2022) *Picturing Fiction through Embodied Cognition: Drawn Representations and Viewpoint in Literary Texts*. Routledge.

Kossack, A., and Bogner, F. X. (2012). How Does a One-Day Environmental Education Programme Support Individual Connectedness with Nature. *J. Biol. Edu.* 46 (3), 180–187. doi:10.1080/00219266.2011.634016

LaDue, N. D., and Pacheco, H. A. (2013). Critical Experiences for Field Geologists: Emergent Themes in Interest Development. *J. Geosci. Edu.* 61 (4), 428–436. doi:10.5408/12-375.1

Lee, V. R. (20142014). Students' Digital Photography Behaviors During a Multiday Environmental Science Field Trip and Their Recollections of Photographed Science Content. *Edu. Res. Int.* 2014, 1–11. doi:10.1155/2014/736791

Lehrer, R., and Schauble, L. (2017). Children's Conceptions of Sampling in Local Ecosystems Investigations. *Sci. Ed.* 101 (6), 968–984. doi:10.1002/sce.21297

Lewis, S., and O'Brien, G. E. (2012). The Mediating Role of Scientific Tools for Elementary School Students Learning about the Everglades in the Field and Classroom. *Int. J. Environ. Sci. Edu.* 7 (3), 433–458.

Magiante, E. S. (2009). Forest or Field. *Sci. Child.* 47 (1), 35–39.

Magntorn, O., and Helldén, G. (2007). Reading Nature from a 'bottom-Up' Perspective. *J. Biol. Edu.* 41 (2), 68–75. doi:10.1080/00219266.2007.9656065

McBride, B. B., and Brewer, C. A. (2010). Nature's Palette. *Sci. Child.* 48 (2), 40–43.

Menary, R. (2010). Introduction to the Special Issue on 4E Cognition. *Phenom Cogn. Sci.* 9 (4), 459–463. doi:10.1007/s11097-010-9187-6

Mygind, E. (2009). A Comparison of Childrens' Statements About Social Relations and Teaching in the Classroom and in the Outdoor Environment. *J. Adventure Edu. Outdoor Learn.* 9 (2), 151–169. doi:10.1080/14729670902860809

Mygind, E. (2007). Udeundervisning: en anden vej til læring, dannelse og faglig indsigt. *Kaskelot* 161, 12–15. doi:10.1080/14729670701717580

Nadelson, L. S., and Jordan, J. R. (2012). Student Attitudes Toward and Recall of Outside Day: An Environmental Science Field Trip. *J. Educ. Res.* 105 (3), 220–231. doi:10.1080/00220671.2011.576715

Ottander, C., Wilhelmsson, B., and Lidestav, G. (2015). Teachers' Intentions for Outdoor Learning: A Characterisation of Teachers' Objectives and Actions. *Int. J. Learn. Teach. Educ. Res.* 13 (2), 208–230.

Parrott, J. (2004). Birds Make Learning Easy. *Sci. Scope* 28 (3), 34–35.

Randler, C., Ilg, A., and Kern, J. (2005). Cognitive and Emotional Evaluation of an Amphibian Conservation Program for Elementary School Students. *J. Environ. Edu.* 37 (1), 43–52. doi:10.3200/joee.37.1.43-52

Rennie, L. o. J., Feher, E., Dierking, L. D., and Falk, J. H. (2003). Toward an Agenda for Advancing Research on Science Learning in Out-Of-School Settings. *J. Res. Sci. Teach.* 40 (2), 112–120. doi:10.1002/tea.10067

Rietveld, E., Denys, D., and Van Westen, M. (2018). "Ecological-Enactive Cognition as Engaging with a Field of Relevant Affordances," in *The Oxford Handbook of 4E Cognition* (Oxford, UK: Oxford University Press), 41. doi:10.1093/oxfordhb/9780198735410.013.3

Rogers, M. P., and Steele, M. (2014). Observing Life in a Square. *Sci. Child.* 52 (4), 26–31. doi:10.2505/4/sc14_052_04_26

Rowlands, M. J. (2010). *The New Science of the Mind: From Extended Mind to Embodied Phenomenology*. Cambridge, MA: Mit Press.

Rye, J. A., Selmer, S. J., Pennington, S., Vanhorn, L., Fox, S., and Kane, S. (2012). Elementary School Garden Programs Enhance Science Education for All Learners. *Teach. Exceptional Child.* 44 (6), 58–65. doi:10.1177/004005991204400606

Schilhab, T., Balling, G., and Kuzmicova, A. (2018a). Decreasing Materiality from Print to Screen reading. *First Monday* 10, 43. doi:10.5210/fm.v23i10.9435

Schilhab, T. (2017a). *Derived Embodiment in Abstract Language*. Cham: Springer-Verlag.

Schilhab, T., Esbensen, G. L., and Nielsen, J. V. (2020). *Børn og unges brug af teknologi til naturoplevelser: Statusrapport for del 1 af forskningsprojektet Naturlig Teknik*. Copenhagen: Center for Børn og Natur.

Schilhab, T., and Esbensen, G. L. (2021). "Outdoor Learning with Apps in Danish Open Education," in *Handbook for Online Learning Contexts: Digital, Mobile and Open* (Cham: Springer), 99–113. doi:10.1007/978-3-030-67349-9_8

Schilhab, T., and Esbensen, G. L. (2019). Socio-cultural Influences on Situated Cognition in Nature. *Front. Psychol.* 10, 980. doi:10.3389/fpsyg.2019.00980

Schilhab, T. (2017c). Impact of iPads on Break-Time in Primary Schools-A Danish Context. *Oxford Rev. Edu.* 43 (3), 261–275. doi:10.1080/03054985.2017.1304920

Schilhab, T. (2017b). *Læringens DNA*. Aarhus: Aarhus Universitetsforlag.

Schilhab, T., and Lindvall, B. (2017). *Naturlig Læring*. Aarhus: Aarhus Universitetsforlag.

Schilhab, T. (2018). Neural Bottom-Up and Top-Down Processes in Learning and Teaching. *Postmodern Probl.* 8 (2), 228–245.

Schilhab, T. (2011). Neural Perspectives on 'Interactional Expertise. *J. Conscious. Stud.* 18 (7-8), 99–116.

Schilhab, T. S. S., Stevenson, M. P., and Bentsen, P. (2018b). Contrasting Screen-Time and Green-time: A Case for Using Smart Technology and Nature to Optimize Learning Processes. *Front. Psychol.* 9, 773. doi:10.3389/fpsyg.2018.00773

Schilhab, T. S. S. (2007). Knowledge for Real: On Implicit and Explicit Representations and Education. *Scand. J. Educ. Res.* 51 (3), 223–238. doi:10.1080/00313830701356034

Scott, G. W., and Boyd, M. (2016). Getting More from Getting Out: Increasing Achievement in Literacy and Science Through Ecological Fieldwork. *Edu. 3-13* 3-1344 (6), 661–670. doi:10.1080/03004279.2014.996242

Scott, R., Grassam, M., and Scott, L. (2011). Blade Runner. *Prim. Sci.* 117, 29–30. doi:10.1007/978-1-84457-571-8_12

Shapiro, L., and Stolz, S. A. (2019). Embodied Cognition and its Significance for Education. *Theor. Res. Edu.* 17 (1), 19–39. doi:10.1177/1477878518822149

Sheckley, B. G., and Bell, S. (2006). Experience, Consciousness, and Learning: Implications for Instruction. *New Dir. adult Contin. Educ.* 2006, 43–52. doi:10.1002/ace.218

Short, D. (2013). Relevance of Science Through Ownership: Why Study the Bumblebee. *Sch. Sci. Rev.* 94 (349), 23–28.

Smeds, P., Jeronen, E., and Kurppa, S. (2015). Farm Education and the Value of Learning in an Authentic Learning Environment. *Int. J. Environ. Sci. Edu.* 10 (3), 381–404. doi:10.12973/ijese.2015.251a

Soga, M., and Gaston, K. J. (2016). Extinction of Experience: The Loss of Human-Nature Interactions. *Front. Ecol. Environ.* 14 (2), 94–101. doi:10.1002/fee.1225

Spring, P., and Harr, N. (2014). Our World Without Decomposers: How Scary. *Sci. Child.* 51 (7), 28–37.

Stevenson, M. P., Dewhurst, R., Schilhab, T., and Bentsen, P. (2019). Cognitive Restoration in Children Following Exposure to Nature: Evidence from the Attention Network Task and mobile Eye Tracking. *Front. Psychol.* 10, 42. doi:10.3389/fpsyg.2019.00042

Stevenson, M. P., Schilhab, T., and Bentsen, P. (2018). Attention Restoration Theory II: A Systematic Review to Clarify Attention Processes Affected by Exposure to Natural Environments. *J. Toxicol. Environ. Health B Crit. Rev.* 21 (4), 227–268. doi:10.1080/10937404.2018.1505571

Strgar, J. (2007). Increasing the Interest of Students in Plants. *J. Biol. Edu.* 42 (1), 19–23. doi:10.1080/00219266.2007.9656102

Taş, E., and Gülen, S. (2019). Analysis of the Influence of Outdoor Education Activities on Seventh Grade Students. *Participatory Educ. Res.* 6 (2), 122–143. doi:10.17275/per.19.17.6.2

Ting, K. L., and Siew, N. M. (2014). Effects of Outdoor School Ground Lessons on Students' Science Process Skills and Scientific Curiosity. *J. Edu. Learn.* 3 (4), 96–107. doi:10.5539/jel.v3n4p96

Townsend, C. (2010). Earth-Heart Astronomy: Astronomy-Related Activities to Enhance Education for Sustainable Development. *Sch. Sci. Rev.* 92 (338), 97–102.

Walter, S. (2009). Locked-in Syndrome, BCI, and a Confusion about Embodied, Embedded, Extended, and Enacted Cognition. *Neuroethics* 3 (1), 61e72. doi:10.1007/s12152-009-9050-z

Wilson, M. (2002). Six Views of Embodied Cognition. *Psychon. Bull. Rev.* 9 (4), 625–636. doi:10.3758/bf03196322

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ORIGINAL RESEARCH
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A Low-Cost Method for Understanding How Nature-Based Early Learning and Childcare Impacts Children's Health and Wellbeing

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Nature-based play and learning provision is becoming increasingly popular across the early learning and childcare (ELC) sector in Scotland. However, there remains a lack of understanding of how the program is expected to function. This has implications for program learning and may affect wider rollout of the program. Secondary data analysis of parent interviews ($n = 22$) and observations ($n = 7$) in Scottish ELC settings, and review of internationally published studies ($n = 33$) were triangulated to develop a program theory using the Theory of Change approach. This approach makes a program's underlying assumptions explicit by systematically demonstrating the relationship between each component: *inputs, activities, outcomes, impact*, and the *contexts* of the program. Findings suggested that location of outdoor nature space, affordances, availability of trained practitioners, and transport to location lead to activities such as free play, educator-led activities, and interactions with nature, resulting in longer durations of physical activity, interactions with peers and educators, and increased engagement with the natural environment. These activities are vital for supporting children's physical, cognitive, social, and emotional development. Our results demonstrate the value of using secondary data analysis to improve our understanding of the underlying theory of nature-based ELC which can support future evaluation designs. These findings will be of interest to program evaluators, researchers, practitioners, and funders, who find themselves with limited resources and want to better understand their program before investing in an evaluation. We encourage researchers and evaluators in the field of early years and outdoor play in other countries to refine this logic model in their own context-specific setting.

Keywords: program theory, play, preschool, nature, outdoors, evaluation, health and wellbeing, children

INTRODUCTION

Early Childhood Nature Experiences

Research suggests that exposure to nature, through outdoor play and learning, can benefit children's physical and mental development (Tillmann et al., 2018; Truelove et al., 2018; Mygind et al., 2019; Dankiw et al., 2020). Elements of nature such as grassy areas, trees, vegetation, and hilly terrain afford children a variety of play options that can positively impact their physical activity levels, play interaction with their peers and others, emotional resilience, self-esteem, curiosity in nature, and even educational attainment (Becker et al., 2014; Chawla, 2015, 2020; Tremblay et al., 2015; Tillmann et al., 2018; Mygind et al., 2019; Khan et al., 2020). However, most of the evidence speaks to older children and adolescents (i.e., >7-years old); there is less evidence available for younger children (0–7 years), specifically in the preschool/kindergarten setting. Additionally, there is less information regarding the mechanistic pathways outlining how early childhood education programs function and are expected to lead to changes in outcomes (Schindler et al., 2019).

For this paper, and specific to the United Kingdom context, Early learning and childcare (ELC) encompasses all forms of early childhood care for children prior to starting primary school at age 5-years. In the international literature other terms are used such as Early Childhood Education (ECE) or Early Childhood Education and Care (ECEC). Existing evaluations of nature-based ELC settings have a geographical bias with most conducted in the United States, Australia, and Norway (Johnstone et al., 2021). Moreover, they tend to be of poor methodological quality and have a high risk of bias most notably due to small sample sizes, many being uncontrolled interventions and cross-sectional studies, poor recognition of confounding variables and poor reporting of participant dropouts (Dankiw et al., 2020; Johnstone et al., 2021). This affects evaluation results due to not being sufficiently powered to detect a difference, risk of false-positive results, and inability to infer causality.

Moreover, although collaborative steps have been made between researchers and practitioners to better understand the human-nature relationship (Salazar et al., 2021), research in this field still suffers from a lack of understanding of how nature-based play and learning programs in the early years are expected to function and achieve their goals. With no clear conceptualization of the underlying theory of nature-based play and learning programs, it is difficult to assess effectiveness and implementation. A lack of understanding of *how* the program is implemented has implications for the provision of the program across ELC settings and future evaluation designs. Many of these issues could be addressed with a well-developed program theory.

Program Theory

A program theory is an explicit model of how an intervention or program functions and achieves its goals; firstly through short/intermediate outcomes and then the intended long-term outcomes (Funnell and Rogers, 2011). An explicit program theory details the processes, mechanisms, and circumstances required to achieve change in target outcomes. An evaluation based on program theory will help identify what elements of a program worked and what did not and if other, unaccounted for, aspects (e.g., context-specific factors) influenced how the program contributed to its outcomes (Gervais et al., 2015). Moreover, if a program theory is not present, interpreting the evaluation result may be more difficult since important contextual factors may have been missed and unintended consequences not considered, rendering the results inadequate for future program implementation. By extension, this could limit a program's ability to inform decision makers (e.g., policy makers and/or urban planners) who need to understand what the active ingredients are.

There are many approaches for developing a program theory such as document reviews, surveys, interviews, workshops, literature reviews and observations (Lam and Skinner, 2021). Although not optimal, re-using data that has been collected for a different primary purpose, in the form of secondary data analysis, is valuable when resources (e.g., time and money) are limited or restrictions on primary data collection are imposed. Additionally, Secondary data analysis demonstrates that program theory development does not require complicated primary data collection methods if a systematic process is followed.

Many funders of evaluation projects, including government and non-government organizations, require a program theory to be submitted for the planning and evaluation of programs (Funnell and Rogers, 2011). However, to our knowledge, program theories are seldom developed using a systematic process with multiple data sources-leading to less rigorous evaluations based on poorly developed program theory. One way of articulating program theory is using a Theory of Change (ToC). The ToC approach makes a program's *underlying assumptions* explicit by systematically demonstrating the relationship between each component: *inputs, activities, outcomes, impact*, and the *contexts* of the program (Connell and Kubisch, 1998). However, there remains a lack of detailed reporting on the ToC process within the public health literature (Breuer et al., 2016b).

The COVID-19 pandemic has put pressure on educational settings, including the early years sector, to find effective methods to support children's play and learning while reducing virus transmission and supporting physical distancing. One approach, in the early years, was to increase provision through outdoor settings (Scottish Government, 2021). As well as reducing virus transmission, this approach has promoted more equal access to nature among preschool-aged children and has unveiled the value of outdoor nature-based play and learning. The Scottish Government outlines the different ELC settings that provide nature-based play and learning in its *Out to Play* document (Scottish Government, 2020b). Nature-based play and learning within the Scottish ELC sector is a complex program with multiple pathways likely contributing to child health and wellbeing outcomes. To support the provision of nature-based ELC and ensure future evaluations are viable, it is important to develop a detailed

understanding of the program itself. To our knowledge, the literature is missing a well-developed program theory of nature-based ELC in the early years setting.

The aim of this study was to demonstrate the value of developing a program theory of nature-based ELC using secondary data. This paper describes the application of the ToC approach and presents the findings as they relate to: (i) the **resources** required to deliver nature-based play and learning and facilitate time spent outdoors in nature (ii) the **activities** that children take part in while engaging with the program and their associated outputs (iii) the child health and wellbeing **outcomes** associated with attending a nature-based ELC and (iv) the underlying **contextual factors** that influence the provision of time spent outdoors in nature while attending ELC settings in Scotland.

MATERIALS AND METHODS

This study used triangulation methodology of three, previously collected, data sources from two independent studies. These two studies were carried out with different aims prior to the initiation of the present study. Secondary analysis is the re-use of data that was collected for a different primary purpose (Heaton, 2008). The decision to conduct secondary data analysis was a pragmatic choice made because of the introduction of national COVID-19 lockdown restrictions in March 2020 at the beginning of this project. This meant that primary data collection with human participants was not possible within the study time frame, therefore secondary data analysis was chosen. Triangulation is the use of more than one data source to address a research question and is often used in mixed-methods studies (O'Cathain et al., 2010). This method encourages researchers to develop a triangulation protocol to display findings and illustrate where findings from each data source agree, partially agree, disagree (dissonance), or where there is silence (findings present in one source but not the other; Farmer et al., 2006; O'Cathain et al., 2010). Silence may occur because of the suitability of a data source to investigate different aspects of a phenomenon (O'Cathain et al., 2010). Using this methodology, we demonstrate how the data addressed each component of the logic model. Three data sources were obtained from two different research projects:

- Interview and focus group transcripts of parents ($n = 22$) whose children attended five different nature-based ELC settings located in the West of Scotland (Project 1—a primary data collection project conducted in 2019).
- Observation schedules of nine outdoor days at $n = 7$ nature-based ELC settings located in the West of Scotland (also from Project 1).
- Published studies extracted from a systematic review ($n = 33$) investigating the relationship between nature-based ELC settings and several child health and wellbeing outcomes across a range of high-income countries (Project 2—a Systematic review project conducted in 2020).

Both Project 1 and Project 2 were conducted independently of the current study. **Supplementary Table S1** provides a description of how the secondary data were analyzed for use in the present study.

Interview and Focus Group Transcripts

Purposeful sampling was used to recruit participants during June/July 2019 to participate in Project 1. Researchers contacted local authority ($n = 9$), partnership ($n = 4$), and private ($n = 3$) ELC settings with outdoor provision in Glasgow (total $n = 16$) and invited them to participate in the study. Of these, 5 agreed to participate ($n = 2$ local authority and $n = 3$ partnership settings) in the interviews and focus groups. Parents ($n = 17$ mothers and $n = 5$ fathers) of children aged 2-4 years attending these five different nature-based ELC settings agreed to take part. During Project 1, parents were told that the purpose of the study was to help researchers understand how parents perceive the role of outdoor ELC for their children's health and wellbeing and how children spend their time while outside at these settings. Seven individual interviews, three paired interviews, and two focus groups with four parents in each took place. Parents aged from 26 to 48 years and represented a diverse range of socio-economic backgrounds. The interviews and focus groups were conducted by AM and JK, based on an interview guide (see **Supplementary Material S6**) developed by AM, PM, and JK. The intention of the interviews and focus groups were to explore how nature-based ELC contributes to child and family wellbeing. These were recorded and then transcribed by a professional transcription service who convert focus group and interview recordings into text. For the present study, this data source supported the identification and justification of logic model components including inputs, activities, outcomes, contextual factors, and assumptions.

Observation Schedules

Of the 16 urban ELC settings referred to above, seven agreed to participate in direct observations. This included the five settings that participated in the interview and focus groups with the addition of two more local authority-managed ELC settings. During June/July 2019, direct observations of 11 nature-based ELC days were carried by one researcher across the seven ELC settings (four settings were observed twice and three were observed once adding up to 11 observations in total) using an observation schedule. The observation schedule was designed by AM, PM, and JK using the Environment Policy and Evaluation Observation (EPAO; Ward et al., 2008) tool as a guide alongside their expert knowledge with the aim to explore how children spend their time at nature-based ELC settings. An example of the observation schedule can be found in **Supplementary Material S7**. None of the recruited ELC settings had any affiliation with the university. A researcher visited the ELC settings, where possible, on two routine childcare days when they were going to their outdoor location (forest, park, or playground). This was to account for potential variations in observed activities, child-staff interactions, and environmental conditions (e.g., weather). On three occasions however, it was not possible to observe a setting for 2 days due to time constraints. Across all observation days, the minimum length of an

observation session was 1 h and 45 min, the maximum was 5 h, and the median was 3 h 50 min. For the present study, analysis of the observation schedules supported the identification and justification of logic model components such as inputs, activities, contextual factors and assumptions. Each round of observations was treated separately within the analysis. Therefore, if the same activity was observed on different days at the same ELC setting, this was considered contextually relevant as a possible component of the logic model. This can be confirmed or refuted during future collaborations with stakeholders.

In total, the observations included 68 children (41 boys and 21 girls) aged 2–5 years. Six of the ELC settings used urban outdoor locations in areas of high deprivation and one ELC setting used an outdoor location with lower level of deprivation.

Published Studies Extracted From a Systematic Review

The studies were identified from a systematic review on nature-based ELC for child health, wellbeing, and development by co-authors AJ, AM, PM (Johnstone et al., 2021). The review included quantitative and qualitative study designs (e.g., cross-sectional, case–control, randomized, and non-randomized studies) with children (2–7 years) or groups of children as the unit of analysis, nature as the exposure/intervention, traditional ELC settings as the comparison/control and a variety of child health attributes as the outcomes (Johnstone et al., 2021). Full details of the methodology can be found elsewhere (Johnstone et al., 2022a,b).

The studies identified for use in the present paper were selected because they used quantitative or mixed-methods methodology to investigate the impact of nature-based ELC on child outcomes. Therefore, studies that only used qualitative methods were excluded from use in this study. This data source supported the identification and justification of the child outcomes applied to the logic model.

Analysis

An adapted Framework Method was used to analyze the data (Gale et al., 2013). A coding framework was developed using the logic model categories: inputs; activities; outcomes; and contextual factors. Transcripts were first coded inductively by OT to identify themes which were then grouped into the framework categories demonstrative of the logic model. Transcripts were analyzed using NVivo version 12 qualitative data analysis computer software (QSR International Pty Ltd., 2020).

The observation schedules of each ELC setting were manually analyzed using the coding framework and multiple-colored highlighters by OT. The identified activities, contextual factors, and resources were then added to a framework matrix on Microsoft Excel. This presented the ELC settings as cases (rows) and the observed activities as themes (columns) within the matrix. The framework facilitated analysis of data across and within cases (ELC settings). Activities that were identified three times or more within the observation schedules were taken forward to the triangulation stage. *Outputs* are suggestions by the authors (informed from analysis of the transcripts and observation schedules) as the immediately quantifiable products resulting from taking part in the activities.

The full-text articles of each published study extracted from the systematic literature review were read, and information extracted, including study's first author, sample size, age group, intervention/exposure, comparator/control, and the outcome(s) of interest. The data from the published studies focused on child health and wellbeing outcomes, such as physical, social, and emotional development, associated with exposure to nature-based ELC. See **Supplementary Table S5** for the study characteristics table of the studies analyzed.

Triangulation Inclusion and Exclusion Criteria

The triangulation protocol is outlined in **Table 1**. The goal of this program theory development was to design a visual logic model that is broadly representative of the study context while being under constant development. Therefore, the default for triangulating data sources was to include all those that *agreed*

TABLE 1 | Triangulation protocol adapted from Farmer et al., 2006.

Category	Definition*
Agreement	There is almost full agreement between the data sources (e.g., high incidences of logic model component identification and at least 80% of findings from each data source in the positive direction*).
Partial agreement	There is a high incidence of logic model component reporting in one data source but less in the other (e.g., eight incidences in the observation schedules to 1 in the transcript), but both are in the positive direction. Or there is an imbalance of null or negative direction results and positive direction results in the published studies data (e.g., two positive effect studies, one negative effect, and one null effect) alongside positive reporting in the transcripts.
Silence	Only one data source reports on the logic model component (positive direction) and it is not identified in the other data source.
Dissonance	There is disagreement between the data sources. Incidences may be high in both data sources, however, there is a clear difference in effect direction (only negative or null effects in the published studies data compared to positive direction in the transcript data).

**Positive and negative direction: for published studies, a positive direction means findings are in favor of nature-based ELC while negative means not in favor of nature-based ELC and null means no association with nature-based ELC. All of the findings in the observation schedules and interview and focus group transcripts were deemed to be in the positive direction (e.g., children navigating obstacles demonstrates possible positive impact on gross motor development).*

or *partially agreed*, unless there were more negative effect directions (i.e., results are not in favor of nature-based ELC within a specific data source) than positive effect directions (i.e., results are in favor of nature-based ELC within a specific data source) associated with a logic model component. For *silence*, if an outcome was discussed in more than half of the interview and focus group transcripts (6 or more), but there was silence from the published studies data, then the outcome was considered contextually specific to the study context and included in the logic model. Any *dissonance* identified was not applied to the logic model.

Following this protocol, the observation framework matrix was triangulated with the transcript framework matrix in Microsoft Excel. Both matrices were triangulated to identify activities, contextual factors, and resources from each data source that agreed, partially agreed, and disagreed (dissonance) with each other, or if there was information present in one data source but silent in the other. Additionally, the outcomes investigated in the published studies data were listed in an outcomes table and triangulated with the outcomes identified in the transcript analysis. This allowed for the identification of outcomes, from each data source, which agreed with each other, partially agreed, disagreed (dissonance), or where there was silence. The underlying assumptions were extracted from the analysis of the interview and focus group transcripts.

RESULTS

The Theory of Change of a nature-based ELC program is illustrated as a logic model in **Figure 1**.

Inputs/Resources

Themes related to inputs that were identified in the analysis of parent interview and focus group transcripts were associated with parents' organizational skills such as, preparing their child for the day outdoors (e.g., enough warm clothes, lunch, water) and cost of enrolment. A parent also mentioned that children have access to outdoor amenities such as a toilet. Beyond what was reported by parents, the observation data revealed that other resources required to provide outdoor play and learning and support children's' activities were natural loose parts (sticks, stones, leaves), manufactured materials (rope swing, cardboard boxes), tarpaulin as cover, and ropes and scarves for setting boundaries.

Analysis of the observation schedules revealed more detail related to the resources and inputs associated with providing outdoor play and learning within Scottish urban ELC settings. These are outlined below:

- The maximum number of children in attendance was 15 with 5 staff members. Across the observations, the average staff to child ratio was 1:3.
- The location of the outdoor setting is an important input (park, woodland, or adventure playground). The observation schedules identified that ELC settings mostly made use of what natural materials were available to them (e.g., fallen trees, natural loose parts, grassy areas, and natural water features) alongside some manufactured materials described above to facilitate children's play and learning. The observation schedules and transcripts reported on the different risk levels associated with the location. For example, some of the wooded areas used by the satellite settings were popular with dog walkers (signs of dog foul) and some had broken glass.
- Transport to the outdoor location was a crucial resource. ELC settings used a public bus (required walking to bus stop), a minibus, or walked. This is discussed further in the following section.

Activities

Supplementary Table S2 presents the findings from the triangulation of transcript and observation schedule analysis for the activities section in the logic model development. These data are too extensive to present in this paper, however, to support their understanding and interpretation, an extract from the supplementary table can be found in **Table 2**. Triangulation of the interview and focus group transcript analysis and observation schedule analysis found agreement across six activities: risk assessment, free play, environmental & nature experiences, educator-led creative activities, learning (literacy and numeracy), and lunch. There was partial agreement with children looking-on/observing. Observation schedules reported this most frequently as young children watching older children play and eventually joining in or copying them. This was considered to be an underlying mechanism of most activities, therefore, was not taken forward as an independent activity in the logic model. The use of fire pits while at nature-based ELC was mentioned once in the transcripts and three times in the observation schedules, therefore, found to only partially agree. Nonetheless, it was only briefly mentioned in one focus group and identified in only three observations where it was used at lunchtime, therefore, the activities "lunch" and "firepit" were merged under "lunch."

Travel from the ELC setting to the outdoor location by staff and children was identified in all of the observation schedules but there was silence in the transcripts (this was to be expected because this aspect of nature-based ELC is not often considered by parents). It was decided to classify 'travel to outdoor location' as an input that is required for nature-based ELC to be delivered optimally. Additionally, this highlights a contextual factor of the nature-based ELC program: sufficiently maintained network of roads and footpaths that facilitate the children and staff to travel from their ELC setting to their outdoor location.

The outputs, as illustrated in **Figure 1**, were defined by the researchers after data triangulation of the parent interviews and observation schedules confirmed the activities of nature-based ELC. The outputs are the immediately quantifiable products as a result of taking part in the activities. The authors propose recording these outputs to determine progress toward changes in the outcomes illustrated in **Figure 1**. Any partial agreement or silence between the data sources was not used to define the outputs.

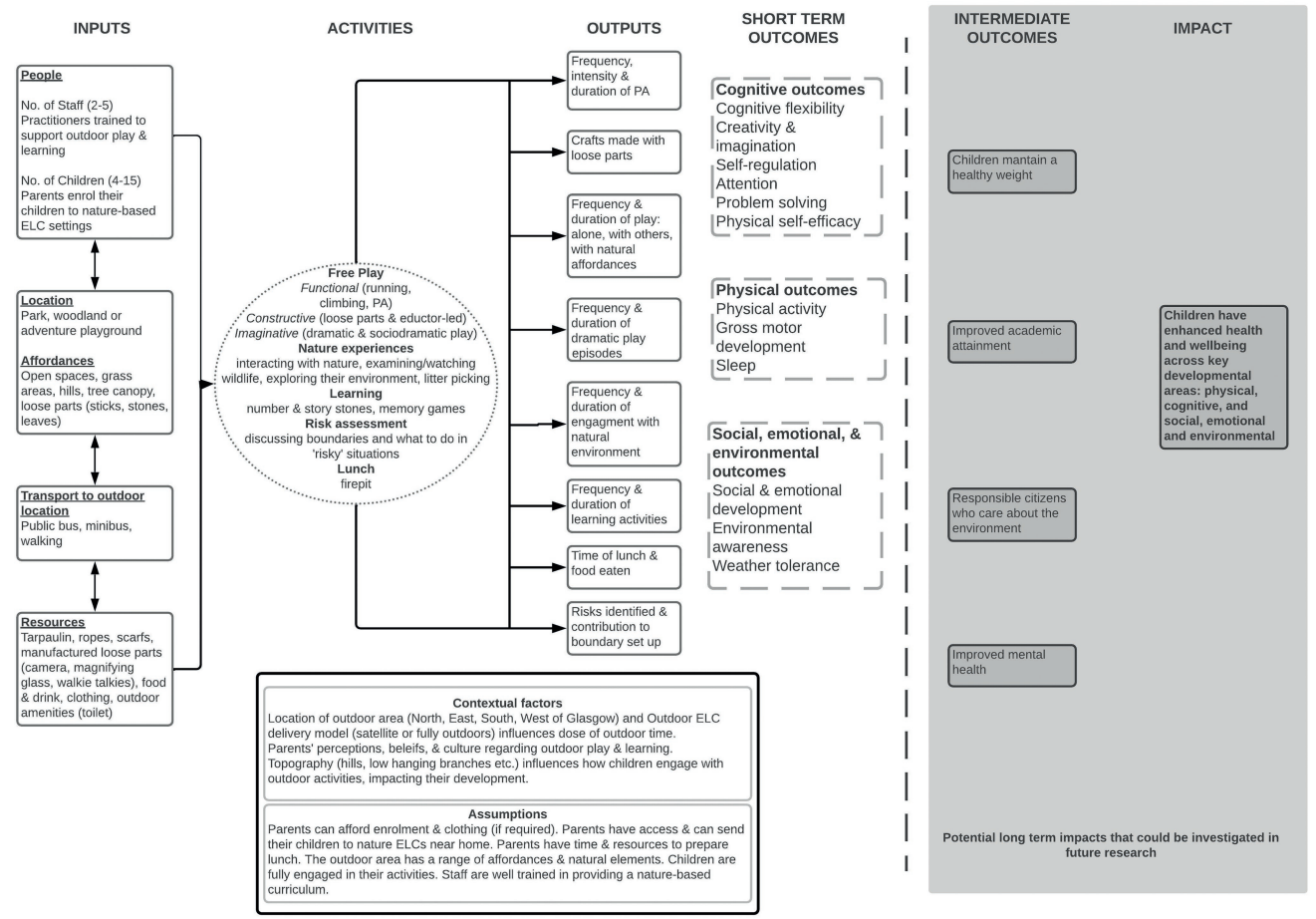

FIGURE 1 | Logic model of a nature-based ELC program in a Scottish urban setting. The figure outlines the inputs required for the activities to take place. The activities produce quantifiable outputs which lead to the measurable short-term outcomes based on the data analyzed in the present study. The outputs are suggestions by the authors based on the evidence demonstrated in this paper. The greyed area show possible intermediate outcomes and long-term impact of the program, however, longitudinal research is required to support these suggestions.

Outcomes

Table 3 is an extract from the triangulation of focus group and interview transcript analysis triangulated with the published studies data to identify outcomes to be included in the logic model. **Supplementary Table S3** has the findings. Across both data sources, three broad themes were identified: (i) cognitive and learning development, (ii) physical development, and (iii) social, emotional, and environmental development.

Cognitive and Learning Development

Eight cognitive and learning development outcomes were identified. Of these, there was *agreement* between parent reports in the interview/focus group transcripts and published studies that nature-based ELC benefited cognitive flexibility, creativity and imagination, and self-regulation (Luchs and Fikus, 2013; Müller et al., 2017; Cordiano et al., 2019; Ernst and Burcak, 2019). There was partial agreement between the data sources regarding nature-based ELC being associated with improved children's attention. The transcript analysis suggested improved attention among children which is in agreement with two published studies (Mårtensson et al., 2009; Ernst and Burcak, 2019) while one study had a negative association and one had null results between nature-based ELC and children's attention ability (Carrus et al., 2012; Müller et al., 2017). Domains of executive function were investigated in two studies from the published study data (Müller et al., 2017; Ernst and Burcak, 2019). Müller et al. (2017) included attention and working memory under their definition, whilst Ernst and Burcak investigated overall executive function. The analysis of the transcripts revealed no references to executive function' as an overarching construct (silence). Therefore, this outcome was not applied to the logic model.

Over half of the transcripts discussed improvements in children's problem solving and physical self-efficacy, however, there was silence in the published studies data. Given the high reporting of these outcomes in the transcripts, they were considered context-specific to the study and applied to the logic model. Finally, applied learning was discussed in three transcripts but not investigated in the published studies data (silence), therefore, this outcome was not applied to the logic model.

TABLE 2 | Extract from triangulation of transcript and observation schedule analysis to determine activities to be included in the logic model.

Activity	Number of transcripts or observation schedules mentioning each activity		Example transcript quote	Example observation	Agree/partial agree/ dissonance/silence*	Output
	Transcripts	Observation schedules				
Risk assessment	6	8	*"No mummy. That's risky business." You know he really got that very early on and loved teaching me about what was risky and what was safe,"*	*"Discussion of boundaries"*	*Agree*	*Risks identified and contribution to boundary set up*
Free play	9	9	*"they encourage so much free play and then give them chance to kind of explore specific things and the knowledge, as you say, they sort of pick that up"*	*"one child sat in a tree… pretended it was an ice cream van."* *"Played on a rope bridge over the stream."*	*Agree*	*Frequency, intensity, and duration of physical activity.* *And play alone and with others.*
Environmental/nature experiences	9	5	*"they were all clustered around examining the frog… he's got an awareness of them and thinks they are important to be understood and enjoyed like that."*	*"All were really interested in watching the butterfly"*	*Agree*	*Frequency and duration of engagement with the natural environment*
Travel to outdoor location	0	9	N/A.	"Walk to woods"	*Silence* (only identified in observations)	*N/A (Classified as INPUT)*

**Dissonance suggests disagreement and silence within a data source signifies neither agreement nor disagreement.*
N/A, not applicable.

Physical Development

Four physical development outcomes were identified. An extract of these are shown in **Table 3**. Of these, there was *agreement* between parent reports in the interview/focus group transcripts and the published studies that nature-based ELC benefited children's physical activity, and sleep (Boldemann et al., 2006; Storli and Hagen, 2010; Nicaise et al., 2011; Söderström et al., 2013; Cosco et al., 2014; Müller et al., 2017; Torkar and Rejc, 2017; Gubbels et al., 2018; Christian et al., 2019; Määttä et al., 2019; Sando, 2019). Only three studies reported less physical activity (Sugiyama et al., 2012; Olesen et al., 2013; Luchs and Fikus, 2018). *Partial agreement* was identified between the transcripts and published studies that nature-based ELC benefited children's gross motor development (Fjørtoft, 2004; Müller et al., 2017; Lysklett et al., 2019). This is likely due to the poor quality of current evidence. There is possibly a relationship between physically activity and gross motor competence, however, this requires further investigation.

Dissonance was identified between the data sources regarding the impact of nature-based ELC on rates of illness and injury among children. The parent interview and focus group data suggested reduced rates of illness and injury among their children. However, the published studies data found no difference and two studies found a higher incidence of injury within a certain population when comparing nature-based ELC to a traditional ELC setting (Weisshaar et al., 2006; Moen et al., 2007; Söderström et al., 2013; Frenkel et al., 2018). Therefore, this outcome was not applied to the logic model, however, future research should investigate this relationship further.

Social, Emotional, and Environmental Development

Three social, emotional, and environmental development outcomes were identified as demonstrated in **Table 3**. Of these, there was agreement between the interview transcripts and the published studies data that nature-based ELC benefited children's social and emotional development, and environmental awareness (Carrus et al., 2012; Söderström et al., 2013; Giusti et al., 2014; Park et al., 2016; Müller et al., 2017; Nazaruk and Klim-Klimaszewska, 2017; Sando, 2019). Only two studies found less positive social behavior among children attending nature-based ELC (Cosco et al., 2014; Cordiano et al., 2019).

Weather tolerance among children attending nature-based ELC was not investigated in the published study data identified

TABLE 3 | Extract from the triangulation of transcript analysis with analysis of the published studies extracted from a systematic literature search to determine outcomes to be included in the logic model.

	Number of transcripts and published studies highlighting outcome		Example transcript quote	Agree/partial agree/ dissonance/silence*
Outcome	**Transcripts**	**Published studies**		
Cognitive and learning development				
Cognitive flexibility	6	1	"I think it makes them more open minded and more creative in their thoughts, because they are able to see things in a different way."	*Agree*
Attention	5	4	"I mean in great detail, and he has the concentration to do that for that whole two hours aged kind of three and a half…. And with great detail be able to talk about and think and record in his mind what insects are called."	*Partially agree*
problem solving	7	0	"I do feel that, she is getting more sort of, more abstract learning… You know, it's more like being resourceful with having nothing."	*Silence*
Physical development				
Physically active	12	14	"He wants to go and like climb up things and just do whatever he's doing. Run about mental with his brother."	*Agree*
Gross motor development	5	3	"overall, in the first six months or a year, I saw that her like balance, her like gross motor skills really improved quite a lot."	*Partially agree*
Illness/ injury	5	4	"(name of child) has got I think quite a good stomach and is not prone to vomiting and diarrhea, she has still got those bugs more in indoor nurseries… but there have been none here [outdoor nursery]."	*Dissonance*
Social, emotional, and environmental development				
Social and emotional development	8	7	"(name of child)'s more able to articulate what she's feeling and what she sees and what she's thinking, you know, explain how she's feeling.	*Agree*
Weather tolerance	10	0	"he does not really bother with the weather, you stick his wellies on and he's quite happy and I think that's probably…because he was so outdoorsy at nursery"	*Silence*
Environmental awareness	10	4	"constantly telling me things about insects …He talks to me about pollution…so he's bringing a lot of stuff back from this [outdoor] nursery which he's not bringing back from his normal [traditional] nursery"	*Agree*

**Dissonance suggests disagreement and silence within a data source signifies that the outcome was not investigated, therefore, neither agreement nor disagreement.*

for use in this study, however, it was mentioned across 10 interview and focus group transcripts with parents. Therefore, although triangulation identified *silence* between the two data sources, the outcome *weather tolerance* was still considered important for the context of this study.

Contextual Factors and Assumptions

Contextual Factors

Table 4 demonstrates the triangulation of contextual factors & underlying assumptions from the interview and focus group transcripts and observation schedule analysis. **Supplementary**

TABLE 4 | Triangulation of contextual factors and underlying assumptions from analysis transcript and observation schedules.

	Number of transcripts or observation schedules mentioning contextual factor or assumption		Example transcript quote	Information from observational data	Agree/partial agree/ dissonance/disagree/ silence
Contextual factor	**Transcripts**	**Observation schedules**			
Location of the outdoor area and ELC delivery model	8	9	"Especially if they go to where they are going and [name] Park is almost at the edge of the city." "I just live round the corner. So, that was a big factor."	All ELC settings were based in an urban location. 6 ELC settings were satellite models. 1 was a fully outdoor model.	*Agree*
Parents' perceptions beliefs, and culture regarding outdoor play and learning	9	0	"something we have encouraged at home as well, is to be, you know, very aware of nature and the need to, you know, kind of protect things and take care of this and, you know, be kind really. That's the main kind of value we try and instill in our child"	N/A.	*N/A.*
Topography and affordances of outdoor space	4	9	"they used to all get in these, this kind of pallet truck and be dragged along. And it was funny and it was cute at first, but you know, you are really thinking after a while, it's just quite good for them to kind of like define their own space and investigate it and explore it themselves."	"all in an open area of the woods with lots of loose parts, leaves, sticks, rocks" "huge tree which had fallen down – children used as a climbing frame"	*Agree*
Assumptions					
Parents can afford clothing (if required)	5	0	"The cost of purchasing outdoor wear… wellie boots and the thermal hat, and the thermal socks… that could have been one preventative that could have…stopped me enrolling for an outdoor nursery."	N/A.	*N/A*
Parents have access to and can send their child to nature ELC settings near home.	6	0	"Like I chose this particular nursery because where I stay.…One) location. Two) it did look like a fun nursery. So, yes, that's why I chose mine."	N/A.	*N/A*
Parents have the time and resources to prepare their child's lunch everyday they are outdoors	4	0	"that [unhealthy food] was a really source of stress for me. It was really important. So, now, although it takes more of my time I provide food for [child] which I think is healthy for her."	N/A.	*N/A*
Staff are well trained in supporting nature-based play and learning	5	0	"They're really clear that they want to kind of encourage that strong independent assertive kind of traits in the wee ones…but they look at the positives of kind of non-conformist behaviour"	N/A.	*N/A*

N/A, not applicable.

Table S4 has additional examples. Three contextual factors were identified. Of these, there was agreement between the interview/focus group data and observation schedule data that the location of the outdoor are and ELC delivery and topography and affordances of the outdoor space are factors that would influence the delivery of nature-based ELC.

Finally, *parents' perceptions, beliefs, and culture regarding outdoor play* and learning was identified in nine transcripts. Due to the nature of the observation schedules, it is not possible to observe parent's perceptions, nonetheless, this is still considered an important contextual factor to be included in the logic model. These parental factors can have a significant influence over whether their child is enrolled into a nature-based ELC setting. For example, parents in the interviews and focus groups had a variety of social and cultural backgrounds and had their childhoods in different countries (e.g., Russia, Romania, Guatemala, India, and Scotland) which influenced how they thought about the benefits or dangers of playing outdoors.

Assumptions

As demonstrated in **Table 4**, underlying assumptions were only identified in the interview and focus group transcripts, nonetheless, these are considered essential for the nature-based ELC program to function as expected. The underlying assumptions include: parents can afford their child's outdoor clothing (if required), parents have access to and can send their child to a nature ELC setting near their home, parents have the time and resources to prepare their child's lunch everyday they are outdoors, and staff are well trained in supporting nature-based play and learning. The final assumption was included because parents often compared practitioner methods across settings (e.g., traditional/indoor vs. nature-based) and mentioned how impressed they were with the resourcefulness of practitioners at nature-based ELC settings and the behaviors they encourage among the children.

DISCUSSION

To our knowledge, this is the first attempt to define and visually represent the program theory of nature-based ELC. Using triangulation methodology, we have demonstrated how nature-based ELC programs function within a Scottish urban setting, the inputs and resources required to support the activities within this setting, and how the program might exert an effect on children's health outcomes. Additionally, by outlining how exposure to outdoor play and learning within ELC settings is operationalized, we can acquire a better understanding of the mechanisms that lead to changes in outcomes. This has highlighted the value of a secondary data analysis approach for any researcher wishing to develop a Theory of Change (ToC) of their program. Using these findings, it is possible for ELC practitioners to explore how they might be able to take advantage of their local green space to support children's play and learning.

The current evidence-base is unable to support ongoing policy decisions in this field, especially related to explicit recommendations such as: dose of nature exposure at ELC settings; minimum and/or optimal environmental affordances required for benefit on child health outcomes; which child health and wellbeing outcomes benefit the most from nature-based play and learning; the activities that support child-led play; and contextual factors that might affect nature-based play and learning implementation (e.g., level of deprivation within the local area). We have attempted to address these issues through our data triangulation process. By using this method, we have demonstrated how to make the ToC explicit. This can now be used as a foundation for researchers and evaluators to identify and test the active ingredients/pathways in the program. Thus, if effectiveness studies support the theorized pathways, the model offers stakeholders the opportunity to make informed funding, policy, and planning decisions. Importantly, these pathways need to be tested formally in an evaluation. Triangulation of the data indicated that nature-based ELC programs could provide children with free play and learning opportunities in nature while supporting development of their cognitive, physical, social, emotional, and environmental outcomes. By engaging in different types of play, interacting with nature, learning activities, and risk assessment through play, children attending urban nature-based ELC may experience improvements in their physical activity levels, gross motor development, and sleep duration. Additionally, children can develop their self-regulation skills, physical self-efficacy, cognitive flexibility, problem solving, attention, creativity and imagination. Finally, children may also experience improved social and emotional development, environmental awareness, and weather tolerance. However, for these experiences to occur there are several underlying assumptions and contextual factors that must be present as demonstrated in the results section and **Figure 1**.

Findings in Relation to Other Studies

Although the use of multiple data sources to develop program logic models and Theory of Change (ToC) have been used before, mostly in Evaluability Assessments (Leviton et al., 2010), there is less evidence in the literature regarding the triangulation of data to develop a program theory (Trevisan, 2007; Lam and Skinner, 2021). Where triangulation has been mentioned, such as in the study protocol of a realist evaluation of the Universal Health Visiting Pathway in Scotland, it is not clear whether triangulation of the data sources would be visually represented and how it would inform refinement of the program theory (Doi et al., 2020). Additionally, researchers in Canada applied triangulation methodology in their Evaluability Assessment with a water-based non-governmental organization (Lu et al., 2017). Researchers followed a triangulation protocol defined by Farmer et al. (2006), however it was not clear how many data sources agreed, partially agreed, or disagreed with each other, nor was there any attempt to visually represent the triangulation process (Lu et al., 2017). In this paper, we outlined a formal and transparent process of triangulation

that can be used in future studies—improving the replicability of the method.

We identified one study that applied the ToC methodology in a nature-based educational setting (Tiplady and Menter, 2021). Researchers used mixed methods to develop a ToC of how a Forest School program impacted young children's (primary school aged children) emotional wellbeing. They applied a data triangulation approach to improve the robustness of their results. However, there was little supporting information on the practical implementation of the process. The authors reinforced the benefits of using the ToC approach for identifying important contextual factors that influence change in target outcomes, but there were important differences from the present analysis, specifically the difference in educational setting and age of the study population. The present analysis sheds light on the impact of nature-based ELC on children's health and wellbeing outcomes, and the contextual factors, inputs, and resources of this institutional setting that influence child development. Furthermore, many of the outcomes we identified are shared by the views of early years professionals interviewed in North America (Beery et al., 2020). For example, interviewed participants from both studies suggested that access to nature in the early years setting can support children's development of cognitive interest (Beery et al., 2020). Nonetheless, these potential mechanistic pathways need to be tested in an effectiveness evaluation.

Significance of Our Theory of Change

A theory of change (ToC) is important for further design, implementation, and development of program evaluations. Connell and Kubisch, (1998) propose that a "good" ToC is one that is *plausible, doable*, and *testable. Plausible* refers to the level to which the activities are linked, through existing evidence or inherent logic, to their target outcomes. Mayne (2017) expands upon this, suggesting a ToC must also be robust. To be robust, a ToC must be agreed upon with stakeholders and have assumptions that when recognized can support the program's implementation. *Do-able* refers to the extent to which the activities are deliverable within the timescale, context, and resources available to the program. Mayne (2017) adds that the effort involved in the activities and outputs should be comparable with the expected results. Finally, *testable* relates to whether the theory is defined enough to support measuring of its progress toward the identified outcomes with acknowledgement of the strength of evidence supporting the results, and assumptions that are unambiguous (Mackenzie and Blamey, 2005; Mayne, 2017). If these criteria can be sufficiently addressed, the ToC can be considered good and robust. These criteria may be considered as guidelines for examining the strength of a ToC and the program it represents while being improved overtime progressing toward a more robust version (Mayne, 2017).

Through the illustrative logic model in **Figure 1**, we have demonstrated the *plausibility* of our ToC of nature-based ELC. If program implementers apply the inputs and resources illustrated in our logic model, they will be able to provide a variety of nature-based play and learning activities for children to engage with and develop their cognitive, physical, social, emotional, and environmental outcomes. With regards to outcomes, researchers have shown that preschool children who play outdoors in nature spend less time being sedentary and more time being physically active compared with children attending a traditional ELC setting, therefore supporting their physical development (Johnstone et al., 2021). Additionally, active play has been found to be positively and significantly associated with self-regulation in preschool-aged children (Becker et al., 2014). There was also a significant indirect effect between active play and academic achievement through children's self-regulation (Becker et al., 2014). Therefore, reinforcing the plausibility of our ToC by demonstrating the impact of the program activities on certain outcomes are illustrated in our logic model.

Mayne (2017) stresses the importance of underlying assumptions for the plausibility of a ToC. Our ToC assumes that ELC practitioners are well trained in supporting nature-based play and learning for child development. Researchers have identified how this underlying assumption might be at risk if practitioners have a lack of knowledge regarding how to support preschool children's play outdoors (McClintic and Petty, 2015). To support the realization of the underlying assumption and the overall plausibility of the ToC, practitioner training around supporting outdoor play and learning in nature is required.

Moreover, our ToC is considered *doable* in the sense that the inputs and contextual information are sufficiently detailed to support the implementation of the program's activities.

Our findings identified how contextual factors, like topography and location of the outdoor space influence the *do-ability* of program activities. Field observations with twenty-one 3- to 6-year-olds attending a Danish Forest preschool found that forest sites varied with regards to the outdoor features affording children different activities (Lerstrup and Refshauge, 2016). For example, locations with open ground afforded children the opportunity to run around and felled trees afforded climbing. Additionally, distance to the forest site was an important contextual factor and influenced how much time children and practitioners spent at their outdoor location (2–5 h) while availability of practitioners and their professional skills influenced the choice of forest site used on a particular day (Lerstrup and Refshauge, 2016). Similarly, our findings identified potential differences in the characteristics of the outdoor locations. Some of the ELC settings in our study were located in areas of high deprivation. Although not having a direct effect on nature-based ELC provision, area deprivation can have a cumulative effect on the *do-ability* of how an ELC setting functions and supports nature-based play and learning. Research investigating the provision of outdoor play areas across area level deprivation in Glasgow found that more deprived areas had significantly greater number of outdoor play spaces, however, there may be important differences in quality of the outdoor spaces (Ellaway et al., 2007). Therefore, area level deprivation of where an outdoor play area is located could play an important role with regards to children's exposure to good quality nature and the play affordances available to them. However, this requires further investigation.

Furthermore, research investigating the socio-spatial distribution of walkable environments in Glasgow and Edinburgh found that more deprived areas had greater walkability compared with more affluent areas suggesting that access to nature spaces for children and practitioners may not be any more of a challenge in deprived neighborhoods compared with ELC settings based in less deprived areas (Kenyon and Pearce, 2019). However, the study did not investigate the quality of access (e.g., safety of paths). Further research is required to determine whether the quality of footpath networks connecting ELC settings to their outdoor spaces influences the *do-ability* of implementing the program (e.g., arriving at outdoor space safely). Research in Minnesota found that although most preschools were within 400 m of a greenspace, survey and focus groups identified several contextual barriers associated with access such as ice on the pavements in the winter and misinterpretation of nature play policies (Beery, 2020). This highlights the context-specific nature of do-ability.

The ToC approach has been used for the planning and development of mental health care programs across low- and middle-income countries (Breuer et al., 2016a). The researchers made explicit the influence of context on the do-ability of the program. For example, political buy-in was required to ensure adequate funding and committed leadership for the mental health program to be implemented/doable. The authors accounted for this by having explicit indicators on the pathway to the anticipated outcomes, thus, ensuring that the ToC was testable (Breuer et al., 2016a). In our ToC illustrated in **Figure 1**, there are explicit outputs, that we have suggested, that can be measured to identify progress toward the outcomes demonstrating the *testability* of the ToC, however, these still require rigorous testing.

Nonetheless, formal stakeholder engagement is required to better assess the do-ability and testability of the ToC. This was not possible in the present study due to the newly implemented COVID-19 national lockdown measures in March 2020. Nonetheless, a ToC should be under constant development and our secondary data analysis approach has been valuable in identifying important contextual information regarding how nature-based ELC is implemented in an urban context.

Strengths and Limitations

Our methods can help researchers, evaluators, and practitioners in the field of program development and implementation better use finite resources before investing in evaluations. However, generalizability of our findings is not applicable outside of Scotland since two of the data sources (interviews and observation schedules) were specific to the urban Scottish city the study was conducted and the studies extracted from the systematic review were from an international context of high-income countries. Additionally, the original observations were conducted by one researcher, therefore, it was not possible to conduct test reliability rounds to confirm accuracy and consistency of the data recording procedure and the time spent outside varied between ELC settings. This means that there is a risk of bias within the observational data. Moreover, purposeful sampling was used to recruit the ELC settings and the parents who participated during Project 1. It is possible that the ELC settings and parents who chose to participate in the study were not representative of the wider population within the ELC sector. For example, families who value nature less or ELC settings that spend most of their outdoor time in a concrete playground may have chosen not to participate. The interview and focus group sample was also relatively small (17 parents from five ELC settings), approximating 3 parents per ELC setting. Care should therefore be taken if extrapolating these findings more widely.

Moreover, this study did not include the quality score of the published studies used as identified by Johnstone et al. (2021). Future research should investigate the quality of the published studies used as well as the effect direction when determining which outcomes to use in the logic model.

Furthermore, all settings in the observational data required a mode of transport to access the nature space. This may limit the generalizability of the findings to other setting where nature space is available at the premises. Finally, the outputs are only suggestions based on the data we have analyzed and there is not yet enough evidence to confirm the intermediate outcomes and long-term impact illustrated in the logic model. Collaborative work with key stakeholders involved in delivering nature-based ELC is required to further refine the Theory of Change and ensure no key contextual factors or underlying assumptions have been overlooked.

Implications for Future Research

Importantly, these pathways need to be tested formally in an evaluation.

We have shown how researchers can save costs by using secondary data to develop a program theory rather than spending more money on primary data collection. By having open access to qualitative data within the early years research field, context specific program theories can be developed around the world. We encourage researchers and evaluators in the field of early years and outdoor play to refine this logic model in their own context-specific setting.

Finally, we developed our program theory using secondary data collected pre-COVID-19. Therefore, the Theory of Change will need to be sense-checked with stakeholders from the Scottish ELC context to ensure that it still applies to the present context. This program theory will be continually developed through EA workshops with ELC staff involved in the delivery of the program, identifying key aspects that may have been missed using secondary data analysis alone. These findings will help design a feasibility and pilot study aiming to evaluate nature-based ELC for child health and wellbeing in Glasgow, Scotland. This feasibility and pilot study will address likely key uncertainties such as recruitment methods, randomization methods, and outcome measures, before performing an impact evaluation of the program. This in turn will have implications for policy and practice by informing implementation and rollout of the program across Scotland and improve the available evidence in the academic literature.

CONCLUSION

In response to the COVID-19 pandemic, nature-based ELC has been crucial and many ELC settings in Scotland have been looking to further maximize their natural green space (Scottish Government, 2020a). To support implementation of nature-based play and learning, it is important to understand the theory behind the program. This paper has demonstrated the value of developing a program theory using secondary data to improve our understanding regarding the provision of nature-based ELC and its impact on child health and wellbeing. We have demonstrated how urban ELC settings can optimize their local green space to support the development of children's health and wellbeing with minimal financial investment as long as practitioner numbers are sufficient. We have shown that even when resources and context are limited, a plausible, doable, and testable Theory of Change can and should still be developed. This paper has addressed the issue of poor quality of theory underlying the provision of nature-based ELC. However, stakeholder collaboration is required to refine the program theory, inform future program evaluations, and support the implementation and rollout of nature-based ELC.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by The College of Medical, Veterinary and Life Sciences Ethics Committee (reference number 200180152), University of Glasgow. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

PM and AM conceptualized and led the qualitative study of interviews and observation schedules. JK contributed to the collection of the qualitative data. AJ, AM, and PM conceptualized and led the systematic review that provided the published studies used in this paper. OT performed analysis of all secondary data sources and wrote each draft of the manuscript. PM, AM, NC, and OT contributed to the conception and theoretical underpinning of the manuscript. All authors contributed to manuscript revision, read, and approved the submitted version.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2022.889828/full#supplementary-material

REFERENCES

Becker, D. R., McClelland, M. M., Loprinzi, P., and Trost, S. G. (2014). Physical activity, self-regulation, and early academic achievement in preschool children. *Early Educ. Dev.* 25, 56–70. doi: 10.1080/10409289.2013.780505

Beery, T. (2020). Exploring access to nature play in urban parks: resilience, sustainability, and early childhood. *Sustain* 12:4894. doi: 10.3390/SU12124894

Beery, T., Chawla, L., and Levin, P. (2020). Being and becoming in nature: defining and measuring connection to nature in young children. *Int. J. Early Child. Environ. Educ.* 7:3.

Boldemann, C., Blennow, M., Dal, H., Mårtensson, F., Raustorp, A., Yuen, K., et al. (2006). Impact of preschool environment upon children's physical activity and sun exposure. *Prev. Med.* 42, 301–308. doi: 10.1016/J.YPMED.2005.12.006

Breuer, E., De Silva, M. J., Shidaye, R., Petersen, I., Nakku, J., Jordans, M. J. D., et al. (2016a). Planning and evaluating mental health services in low- and middle-income countries using theory of change. *Br. J. Psychiatry* 208, s55–s62. doi: 10.1192/BJP.BP.114.153841

Breuer, E., Lee, L., De Silva, M., and Lund, C. (2016b). Using theory of change to design and evaluate public health interventions: A systematic review. *Implement. Sci.* 11:63. doi: 10.1186/s13012-016-0422-6

Carrus, G., Pirchio, S., Passiatore, Y., Mastandrea, S., Scopelliti, M., and Bartoli, G. (2012). Contact with nature and Children's wellbeing in educational settings. *J. Soc. Sci.* 8, 304–309. doi: 10.3844/JSSP.2012.304.309

Chawla, L. (2015). Benefits of nature contact for children. *J. Plan. Lit.* 30, 433–452. doi: 10.1177/0885412215595441

Chawla, L. (2020). Childhood nature connection and constructive hope: A review of research on connecting with nature and coping with environmental loss. *People Nat.* 2, 619–642. doi: 10.1002/PAN3.10128/SUPPINFO

Christian, H., Lester, L., Trost, S. G., Trapp, G., Schipperijn, J., Boruff, B., et al. (2019). Shade coverage, ultraviolet radiation and children's physical activity in early childhood education and care. *Int. J. Public Health* 64, 1325–1333. doi: 10.1007/s00038-019-01289-y

Connell, J. P., and Kubisch, A. C. (1998). "Applying a theory of change approach to the evaluation of comprehensive community initiatives: progress, prospects, and problems," in *New Approaches to Evaluating Community Initiatives: Theory, Measurement and Analysis*. eds. A. Fullbright-Anderson, A. C. Kubisch and J. P. Connell (Washington DC: Aspen Institute), 15–44.

Cordiano, T. S., Lee, A., Wilt, J., Elszasz, A., Damour, L. K., and Russ, S. W. (2019). Nature-based education and kindergarten readiness: nature-based and traditional preschoolers are equally prepared for kindergarten. *Int. J. Early Child. Environ. Educ.* 6:18

Cosco, N. G., Moore, R. C., and Smith, W. R. (2014). Childcare outdoor renovation as a built environment health promotion strategy: evaluating the preventing obesity by design intervention. *Am. J. Health Promot.* 28, S27–S32. doi: 10.4278/ajhp.130430-QUAN-208

Dankiw, K. A., Tsiros, M. D., Baldock, K. L., and Kumar, S. (2020). The impacts of unstructured nature play on health in early childhood development: a systematic review. *PLoS One* 15:e0229006. doi: 10.1371/journal.pone.0229006

Doi, L., Morrison, K., Astbury, R., Eunson, J., Horne, M. A., Jepson, R., et al. (2020). Study protocol: a mixed-methods realist evaluation of the universal health visiting pathway in Scotland. *BMJ Open* 10:e042305. doi: 10.1136/bmjopen-2020-042305

Ellaway, A., Kirk, A., Macintyre, S., and Mutrie, N. (2007). Nowhere to play? The relationship between the location of outdoor play areas and deprivation in Glasgow. *Health Place* 13, 557–561. doi: 10.1016/J.HEALTHPLACE.2006.03.005

Ernst, J., and Burcak, F. (2019). Young children's contributions to sustainability: the influence of nature play on curiosity, executive function skills, creative thinking, and resilience. *Sustain.* 11. doi: 10.3390/su11154212

Farmer, T., Robinson, K., Elliott, S. J., and Eyles, J. (2006). Developing and implementing a triangulation protocol for qualitative health research. *Qual. Health Res.* 16, 377–394. doi: 10.1177/1049732305285708

Fjørtoft, I. (2004). Landscape as Playscape: the effects of natural environments on Children's play and motor development. *Child. Youth Environ.* 14, 21–44. doi: 10.7721/chilyoutenvi.14.2.0021

Frenkel, H., Tandon, P., Frumkin, H., and Vander Stoep, A. (2018). Illnesses and injuries at nature preschools. *Environ. Behav.* 51, 936–965. doi: 10.1177/0013916518773469

Funnell, S., and Rogers, P. (2011). *Purposeful Program Theory*. San Francisco: Jossy-Bass.

Gale, N. K., Heath, G., Cameron, E., Rashid, S., and Redwood, S. (2013). Using the framework method for the analysis of qualitative data in multi-disciplinary health research. *BMC Med. Res. Methodol.* 13:117. doi: 10.1186/1471-2288-13-117

Gervais, C., de Montigny, F., Lacharité, C., and Dubeau, D. (2015). The father friendly initiative within families: using a logic model to develop program theory for a father support program. *Eval. Program Plann.* 52, 133–141. doi: 10.1016/j.evalprogplan.2015.04.006

Giusti, M., Barthel, S., and Marcus, L. (2014). Nature routines and affinity with the biosphere: a case study of preschool children in Stockholm. *Child. Youth Environ.* 24:42. doi: 10.7721/chilyoutenvi.24.3.0016

Gubbels, J. S., van Kann, D. H. H., Cardon, G., and Kremers, S. P. J. (2018). Activating childcare environments for All children: the importance of Children's individual needs. *Int. J. Environ. Res. Public Health* 15. doi: 10.3390/IJERPH15071400

Heaton, J. (2008). Secondary analysis of qualitative data: an overview. *Hist. Soc. Res.* 33, 33–45. doi: 10.12759/hsr.33.2008.3.33-45

Johnstone, A., Martin, A., Cordovil, R., Fjørtoft, I., Iivonen, S., Jidovtseff, B., et al. (2022a). Nature-based early childhood education and Children's social, emotional and cognitive development: a mixed-methods systematic review. *Int. J. Environ. Res. Public Health* 19:5967. doi: 10.3390/IJERPH19105967

Johnstone, A., McCrorie, P., Cordovil, R., Fjørtoft, I., Iivonen, S., Jidovtseff, B., et al. (2022b). Nature-based early childhood education and Children's physical activity, sedentary behavior, motor competence, and other physical health outcomes: a mixed-methods systematic review. *J. Phys. Act. Health* 19, 456–472. doi: 10.1123/JPAH.2021-0760

Johnstone, A., McCrorie, P., Thomson, H., Wells, V., and Martin, A. (2021). Nature-based early learning and childcare - influence on children's health, wellbeing and development: literature review. Edinburgh Available at: https://www.gov.scot/publications/systematic-literature-review-nature-based-early-learning-childcare-childrens-health-wellbeing-development/ [Accessed 24 March 2021].

Kenyon, A., and Pearce, J. (2019). The socio-spatial distribution of walkable environments in urban Scotland: a case study from Glasgow and Edinburgh. *SSM Popul. Health* 9:100461. doi: 10.1016/j.ssmph.2019.100461

Khan, M., McGeown, S., and Bell, S. (2020). Can an outdoor learning environment improve Children's academic attainment? A quasi-experimental mixed methods study in Bangladesh. *Environ. Behav.* 52, 1079–1104. doi: 10.1177/0013916519860868

Lam, S., and Skinner, K. (2021). The use of Evaluability assessments in improving future evaluations: a scoping review of 10 years of literature (2008–2018). *Am. J. Eval.* 42, 523–540. doi: 10.1177/1098214020936769

Lerstrup, I., and Refshauge, A. D. (2016). Characteristics of forest sites used by a Danish forest preschool. *Urban For. Urban Green.* 20, 387–396. doi: 10.1016/j.ufug.2016.09.010

Leviton, L. C., Khan, L. K., Rog, D., Dawkins, N., and Cotton, D. (2010). Evaluability assessment to improve public health policies, programs, and practices. *Annu. Rev. Public Health* 31, 213–233. doi: 10.1146/annurev.publhealth.012809.103625

Lu, S. K., Elliott, S. J., and Perlman, C. M. (2017). Evaluability assessment of a small NGO in water-based development. *Evaluation* 23, 226–241. doi: 10.1177/1356389017697620

Luchs, A., and Fikus, M. (2013). A comparative study of active play on differently designed playgrounds. *J. Adventure Educ. Outdoor Learn.* 13, 206–222. doi: 10.1080/14729679.2013.778784

Luchs, A., and Fikus, M. (2018). Differently designed playgrounds and preschooler's physical activity play. *Early Child Dev. Care* 188, 281–295. doi: 10.1080/03004430.2016.1213726

Lysklett, O. B., Berg, A., and Moe, B. (2019). Motor competence and physical fitness among children attending nature preschools and traditional preschools. *Int. J. Play* 8, 53–64. doi: 10.1080/21594937.2019.1580337

Määttä, S., Lehto, R., Konttinen, H., Ray, C., Sajaniemi, N., Erkkola, M., et al. (2019). Preschool group practices and preschool children's sedentary time: a cross-sectional study in Finland. *BMJ Open* 9:32210. doi: 10.1136/bmjopen-2019-032210

Mackenzie, M., and Blamey, A. (2005). The practice and the theory: lessons from the application of a theories of change approach. *Evaluation* 11, 151–168. doi: 10.1177/1356389005055538

Mårtensson, F., Boldemann, C., Söderström, M., Blennow, M., Englund, J. E., and Grahn, P. (2009). Outdoor environmental assessment of attention promoting settings for preschool children. *Health Place* 15, 1149–1157. doi: 10.1016/j.healthplace.2009.07.002

Mayne, J. (2017). Theory of change analysis: building robust theories of change. *Can. J. Program Eval.* 32, 155–173. doi: 10.3138/cjpe.31122

McClintic, S., and Petty, K. (2015). Exploring early childhood teachers' beliefs and practices about preschool outdoor play: A qualitative study. *J. Early Child. Teach. Educ.* 36, 24–43. doi: 10.1080/10901027.2014.997844

Moen, K. H., Bakke, H. K., Bakke, Ø., and Fors, E. A. (2007). Preschool children's sickness absenteeism from Norwegian regular and outdoor day care centres: a comparative study. *Scand. J. Public Health* 35, 490–496. doi: 10.1080/14034940701271916

Müller, U., Temple, V. A., Smith, B., Kerns, K., Eycke, K.Ten, Crane, J., et al. (2017). Effects of nature kindergarten attendance on Children's functioning. *Child. Youth Environ.* 27, 47. doi:10.7721/chilyoutenvi.27.2.0047

Mygind, L., Kjeldsted, E., Hartmeyer, R., Mygind, E., Bølling, M., and Bentsen, P. (2019). Mental, physical and social health benefits of immersive nature-experience for children and adolescents: a systematic review and quality assessment of the evidence. *Health Place* 58:102136. doi: 10.1016/j.healthplace.2019.05.014

Nazaruk, S. K., and Klim-Klimaszewska, A. (2017). Direct learning about nature in 6-year-old children living in urban and rural environments and the level of their knowledge and skills. *J. Balt. Sci. Educ.* 16, 524–532. doi: 10.33225/jbse/17.16.524

Nicaise, V., Kahan, D., and Sallis, J. F. (2011). Correlates of moderate-to-vigorous physical activity among preschoolers during unstructured outdoor play periods. *Prev. Med.* 53, 309–315. doi: 10.1016/j.ypmed.2011.08.018

O'Cathain, A., Murphy, E., and Nicholl, J. (2010). Three techniques for integrating data in mixed methods studies. *BMJ* 341, c4587–c1150. doi: 10.1136/bmj.c4587

Olesen, L. G., Kristensen, P. L., Korsholm, L., and Froberg, K. (2013). Physical activity in children attending preschools. *Pediatrics* 132, e1310–e1318. doi: 10.1542/peds.2012-3961

Park, S. A., Cho, M. K., Yoo, M. H., Kim, S. Y., Im, E. A., Song, J. E., et al. (2016). Horticultural activity program for improving emotional intelligence, Prosocial behavior, and scientific investigation abilities and attitudes in kindergarteners. *HortTechnology* 26, 754–761. doi: 10.21273/HORTTECH03489-16

QSR International Pty Ltd. (2020). NVivo (released in March 2020). Available at: https://www.qsrinternational.com/nvivo-qualitative-data-analysis-software/home

Salazar, G., Monroe, M. C., Jordan, C., Ardoin, N. M., and Beery, T. H. (2021). Improving assessments of connection to nature: a participatory approach. *Front. Ecol. Evol.* 8:498. doi: 10.3389/FEVO.2020.609104/BIBTEX

Sando, O. J. (2019). The outdoor environment and children's health: a multilevel approach. *Int. J. Play* 8, 39–52. doi: 10.1080/21594937.2019.1580336

Schindler, H. S., McCoy, D. C., Fisher, P. A., and Shonkoff, J. P. (2019). A historical look at theories of change in early childhood education research. *Early Child Res. Q.* 48, 146–154. doi: 10.1016/j.ecresq.2019.03.004

Scottish Government (2020a). Coronavirus (COVID-19): Strategic Framework for Reopening Schools and Early Learning and Childcare Settings: initial impact Assessment. Edinburgh Available at: https://www.gov.scot/publications/coronavirus-covid-19-strategic-framework-reopening-schools-early-learning-childcare-settings-initial-impact-assessment/pages/1/ [Accessed 24 February, 2021].

Scottish Government (2020b). Out to Play - Creating Outdoor play Experiences for children: Practical Guidance. Edinburgh Available at: https://www.gov.scot/publications/out-play-practical-guidance-creating-outdoor-play-experiences-children/ [Accessed 18 September, 2020].

Scottish Government (2021). Coronavirus (COVID-19): Early Learning and Childcare (ELC) Services. Edinburgh Available at: https://www.gov.scot/publications/coronavirus-covid-19-early-learning-and-childcare-services/pages/outdoor-spaces/ [Accessed 24 February, 2021].

Söderström, M., Boldemann, C., Sahlin, U., Mårtensson, F., Raustorp, A., and Blennow, M. (2013). The quality of the outdoor environment influences childrens health - A cross-sectional study of preschools. *Acta Paediatr. Int. J. Paediatr.* 102, 83–91. doi: 10.1111/apa.12047

Storli, R., and Hagen, T. L. (2010). Affordances in outdoor environments and children's physically active play in pre-school. *Eur. Early Child. Educ. Res. J.* 18, 445–456. doi: 10.1080/1350293X.2010.525923

Sugiyama, T., Okely, A. D., Masters, J. M., and Moore, G. T. (2012). Attributes of child care centers and outdoor play areas associated With preschoolers' physical activity and sedentary behavior. *Environ. Behav.* 44, 334–349. doi: 10.1177/0013916510393276

Tillmann, S., Tobin, D., Avison, W., and Gilliland, J. (2018). Mental health benefits of interactions with nature in children and teenagers: a systematic review. *J. Epidemiol. Community Health* 72, 958–966. doi: 10.1136/jech-2018-210436

Tiplady, L. S. E., and Menter, H. (2021). Forest School for wellbeing: an environment in which young people can "take what they need." *J. Adventure Educ. Outdoor Learn.* 21, 99–114. doi:10.1080/14729679.2020.1730206

Torkar, G., and Rejc, A. (2017). Children's play and physical activity in traditional and Forest (natural) playgrounds. *Int. J. Educ. Methodol.* 3, 25–30. doi: 10.12973/ijem.3.1.25

Tremblay, M., Gray, C., Babcock, S., Barnes, J., Bradstreet, C., Carr, D., et al. (2015). Position statement on active outdoor play. *Int. J. Environ. Res. Public Health* 12, 6475–6505. doi: 10.3390/ijerph120606475

Trevisan, M. S. (2007). Evaluability assessment from 1986 to 2006. *Am. J. Eval.* 28, 290–303. doi: 10.1177/1098214007304589

Truelove, S., Bruijns, B. A., Vanderloo, L. M., O'Brien, K. T., Johnson, A. M., and Tucker, P. (2018). Physical activity and sedentary time during childcare outdoor play sessions: a systematic review and meta-analysis. *Prev. Med.* 108, 74–85. doi: 10.1016/j.ypmed.2017.12.022

Ward, D., Hales, D., Haverly, K., Marks, J., Benjamin, S., Ball, S., et al. (2008). An instrument to assess the obesogenic environment of child care centers. *Am. J. Health Behav.* 32, 380–386. doi: 10.5993/AJHB.32.4.5

Weisshaar, E., Schaefer, A., Scheidt, R. R. W., Bruckner, T., Apfelbacher, C. J., and Diepgen, T. L. (2006). Epidemiology of tick bites and borreliosis in children attending kindergarten or so-called "forest kindergarten," in Southwest Germany. *J. Invest. Dermatol.* 126, 584–590. doi: 10.1038/SJ.JID.5700160

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CONCEPTUAL ANALYSIS
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Developing Connectedness to Nature in Urban Outdoor Settings: A Potential Pathway Through Awe, Solitude, and Leisure

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Outdoor leisure experiences may represent an understudied yet effective pathway to promote connectedness to nature for urban park visitors. In contrast to outdoor recreation, this critical essay argues outdoor leisure more heavily emphasizes eudaimonic sentiments and intrinsic motivation in comparison with the goal-oriented and hedonic nature of outdoor recreation. It is further argued that two specific social psychological constructs, awe and solitude, may be especially useful in promoting leisure experiences in urban outdoor spaces. Relevant philosophical and social psychological literature is reviewed and synthesized to outline how land managers and environmental educators may facilitate experiences of awe and solitude to better promote contexts for experiencing outdoor leisure in urban parks. Specifically, reviewed literature suggests that utilizing the recreation opportunity spectrum framework and co-creative processes may be an effective path forward in better supporting urban park environments that are conducive to awe, solitude, and leisure. The review and synthesis of this research may ultimately guide environmental educators, land managers, and researchers in ways to more effectively support connectedness to nature *via* outdoor leisure experiences as an outcome for visitors to outdoor urban spaces.

Keywords: solitude, urban parks, awe, connectedness to nature, leisure

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INTRODUCTION

Currently, over 55% of the world's population resides in urban areas (World Health Organization, 2021). While urban centers are often cited as providing an array of social and cultural benefits for residents (e.g., Clark and Kahn, 1988; Machado et al., 2013; Borgoni et al., 2018), a range of psychological (Nisbet and Zelenski, 2011), infrastructural (Biernacka and Kronenberg, 2018), and sociocultural (Rigolon, 2017; Mowatt, 2018) barriers may result in urban residents feeling disconnected from the natural world. This disconnect may be concerning regarding the well-being of social-ecological systems (i.e., both humans and more-than-human nature), as connection and access to nature links to numerous individual and collective health benefits for humans (e.g., lower levels of anxiety, higher levels of prosocial emotions; Kuo, 2015; Jennings et al., 2017; Lopes et al., 2020; McConnell and Jacobs, 2020) and urban ecological systems

(e.g., Anderson and Minor, 2017). To bridge this physical and psychological gap between urban residents and outdoor spaces, practitioners often use outdoor recreation as a pathway to connect individuals with the outdoors (e.g., Thompson et al., 2005; Wolch et al., 2011). Outdoor recreation broadly refers to an activity occurring during one's free time that involves participants interacting with the natural world in some manner (Jenkins and Pigram, 2003; Lackey et al., 2021). Although practitioners often uncritically accept outdoor recreation as an effective tool in developing a relationship between humans and outdoor spaces in urban areas (e.g., Outdoor Foundation, 2020), some limitations may exist in relying too heavily on outdoor recreation, given such pursuits often emphasize hedonic well-being and extrinsically motivated, goal-oriented behaviors (Holba, 2013; Dattilo and Lopez Frias, 2020). Even though these pursuits can have beneficial outcomes for outdoor recreation participants, finding ways to also promote eudaimonic well-being (Ryff and Singer, 2008; Huta and Waterman, 2014) and intrinsic motivation (Ryan and Deci, 2000) may provide alternative beneficial outcomes for individuals in ways that complement those encouraged by outdoor recreation.

In contrast to outdoor recreation, outdoor *leisure* may provide this alternative pathway to connect urban residents with outdoor spaces. While recreation and leisure are often used interchangeably, some scholars assert that the terms have different historical origins as well as practical connotations (e.g., Holba, 2013; Dattilo and Lopez Frias, 2020). For instance, Holba (2013) argues that leisure represents an action that holistically consumes an individual's mental state, arising from intrinsic motivation and thoughtfulness when participating in the chosen activity, and contrasts leisure and recreation by stating, "The most obvious difference between transformative leisure and recreation is the action of contemplation—transformative leisure has it and recreation does not" (p: 22). Such contemplation (i.e., leisure) without a specific purpose is believed to be essential to the human condition (Pieper, 1963). Dattilo and Lopez Frias (2020) align with Holba's (2013) assertion, stating that moments of leisure may occur during recreation, but engagement in recreation activities does not constitute a leisure experience in and of itself.

In further contrasting outdoor recreation and outdoor leisure, as alluded to previously, the former primarily promotes hedonic well-being while the latter emphasizes eudaimonic well-being. Promoting eudaimonic experiences *via* outdoor leisure may help develop an authentic and personal relationship between urban residents and the natural world in a manner that is not emphasized in the hedonic nature of outdoor recreation. In keeping with the broader approach taken throughout this critical essay, eudaimonia and hedonia are utilized in a manner that integrates both philosophical and social psychological perspectives on the terms (e.g., Deci and Ryan, 2008; Ryff and Singer, 2008; Huta and Waterman, 2014). The conceptual distinction between hedonia and eudaimonia can be traced to Aristotle's (2004/ca. 350 B.C.E.) discussion on the nature of happiness and well-being, and interest regarding the terms in a social psychological sense can be traced to Ryan and Deci's (2001) prominent literature review. Aristotle (2004/ca. 350 B.C.E.) asserts that happiness exists as the primary objective of life, but individuals differ on what constitutes the nature of this happiness (i.e., eudaimonic versus hedonic conceptualizations). Hedonic well-being largely aligns with what Aristotle (2004/ca. 350 B.C.E.) describes as the pursuit of pleasant and material-based well-being, a path toward what he acknowledges would be an enjoyable life, though potentially not as deep-seeded with meaning as eudaimonia. Social psychologists have built upon this philosophical conceptualization to describe hedonic well-being as the presence of pleasure and the avoidance of negative affect (e.g., Lengieza et al., 2019). Recreation's goal-oriented nature often prioritizes the pursuit of such hedonic objectives. In contrast, as summarized by Aristotle (2004/ca. 350 B.C.E.) and Ryff and Singer (2008) asserts that eudaimonia is supported by pursuing a virtuous life, one that strives for balance between excess and deficiency. Through contemplation and striving for this balance, an individual may find a way forward in life that allows them to actualize their true nature [i.e., pursuing an intrinsically inspired path; Aristotle (2004/ca. 350 B.C.E.)]. As it is relevant to leisure experiences, many social psychologists have expanded Aristotle's (2004/ca. 350 B.C.E.) original conceptualization of eudaimonia to describe human well-being in a manner that balances several complementary dimensions including: self-reflection, personal meaning, authenticity, and intrinsic motivation (Ryan and Deci, 2001; Ryff and Singer, 2008; Huta and Waterman, 2014; Lengieza et al., 2019). Scholars have asserted that leisure, in contrast to recreation, may provide space to pursue these ideals (e.g., Holba, 2013; Dattilo and Lopez Frias, 2020). Regarding outdoor leisure in urban outdoor spaces, eudaimonic experiences in the outdoors may support connectedness to nature in a manner that is personal, authentic, and intrinsically motivated.

Two key components may be especially useful in facilitating outdoor leisure experiences: awe and solitude. Awe broadly refers to a transcendental feeling facilitated by being in the presence of something vast (Bai et al., 2017). Alternatively, solitude is generally characterized by self-reflective thoughts and feelings facilitated by being alone (Long et al., 2003). Each of these components, discussed in greater length further in this critical essay, may allow for the outdoor environment to facilitate intrinsic and contemplative moments inherent in the eudaimonic nature of leisure experiences (Holba, 2013; Dattilo and Lopez Frias, 2020). Given the potential benefits associated with connecting urban residents to outdoor spaces, environmental educators and land managers may look to experiences of awe and solitude as mechanisms to promote outdoor leisure opportunities that complement outdoor recreation. In turn, these contextual factors may enhance both social and environmental health outcomes by developing a meaningful connection between urban residents and the natural world (Kuo, 2015; Jennings et al., 2017).

This critical essay intends to provide a framework for land managers, educators, and academics to facilitate contexts supportive of outdoor leisure for urban residents. Specifically, this writing has three primary purposes: (a) to explore the philosophical and psychological basis of awe and solitude facilitating outdoor leisure experiences, (b) to review current

academic literature on what is known about awe, solitude, and leisure in urban outdoor spaces specifically, (c) and to provide guidance for land managers and environmental educators on how to facilitate these experiences. As done thus far, the terms "natural world," "nature," and "outdoor spaces" are used interchangeably throughout this writing. These terms align with the thinking of scholars across cultures (e.g., Asian, Indigenous American, Euro-American) that such terms encapsulate ecological systems that are dynamic over space and time and include living beings embedded within these systems (Leopold, 1949; Talukder, 2014; Kimmerer, 2015). Connection to nature, the outcome of outdoor leisure experiences explored in this paper, is defined by Lengieza and Swim (2021), referring to the "psychological joining of nature and the self which manifests as a sense of oneness with nature" (p: 2). In addition, it should be noted that the statements presented here primarily center within a Euro-American academic context within which the author is based.

LEISURE IN THE OUTDOOR CONTEXT

The following section outlines ways awe and solitude may support outdoor leisure experiences. How outdoor leisure may promote connectedness to nature is also explored. This, in turn, provides the basis for the second section of this critical essay that explores how such constructs have been understood in urban outdoor spaces specifically.

Awe and the Outdoor Leisure Experience

If leisure in the outdoor context is contemplative, intrinsically motivated, and mindful (aligning with a eudaimonic perspective on well-being), awe may play a role in how outdoor leisure diverges from outdoor recreation. Awe can be conceptualized through the atmospheric lens as described by German philosopher Hermann Schmitz (Kazig, 2016). From this perspective, emotion is not bounded by the bodily self. Rather, emotion flows outward and can be influenced by contextual factors within which it is embedded (Kazig, 2016). Regarding awe specifically, Bai et al. (2017) assert that awe is "defined by two central appraisals: that one is in the presence of something vast, and that the elicitor transcends one's current frame of reference for understanding the world" (p: 186). Furthermore, McShane (2018) expands this conceptualization by stating that awe has an outward-facing element to it. In other words, someone is normally "in awe" of an external object or phenomenon such as mountains, a hurricane, or innumerable other focal points (McShane, 2018). Although the outward-facing nature of awe may seem contradictory to the intrinsic nature of leisure (e.g., Holba, 2013), awe is a reflexive feeling. Although awe partially directs attention externally, the root of the appraisal ultimately returns to how individuals perceive a diminished sense of self in relation to their broader surroundings (Bai et al., 2017). Research in the field of social psychology further builds upon this conception of awe in the outdoors; for example, Bethelmy and Corraliza (2019) assert that awe consists of five elements: fear, threat, vulnerability, fragility, and respect for nature. Losing oneself in the grandeur of the natural environment closely parallels what Pieper (1963) defines as a philosophical act. Such philosophizing, a central element to experiencing leisure, allows humans "to go beyond the trusted enclosures of the normal, customary day-to-day reality of the whole of existing things, to go beyond the 'environment' to the 'world' in which that environment is enclosed" (Pieper, 1963, p: 111). Further, eudaimonia, and concurrent moments of leisure, may be supported by the contemplation that is spurred by experiences of awe (e.g., Graves et al., 2020).

Experiencing awe and leisure in relation to urban outdoor spaces may specifically help individuals contemplate and gain perspective on their role in the broader social-ecological systems within which they exist (Bai et al., 2017; Bethelmy and Corraliza, 2019). If the eudaimonic nature of outdoor leisure supports authenticity and personal reflection, these direct, emotional experiences in the outdoors may play an important role in helping individuals develop a meaningful connection with the outdoors (Chawla, 1998; Heberlein, 2012; Williams and Chawla, 2016). Specifically, the intense and overwhelming emotions associated with awe may encourage individuals to conclude the natural world holds value beyond its economic and utilitarian value. For example, Leopold (1949) advocates for the intrinsic worth of ecosystems broadly through his "Land Ethic" philosophy. In making his points, he regularly refers to moments of awe he feels toward the natural environment. It is directly from these moments of intangible emotion that he derives many of his arguments. He writes:

> Sometimes in June, when I see unearned dividends of dew hung on every lupine, I have doubts about the real poverty of the sands. On solvent farmlands lupines do not even grow, much less collect a daily rainbow of jewels. If they did, the weed-control officer, who seldom sees a dewy dawn, would doubtless insist that they be cut. Do economists know about lupines? (Leopold, 1949, p: 102).

Leopold (1949) contrasts the early morning beauty of wildflowers with the constant push for greater economic return in the United States, questioning what is lost when taking the latter approach. Scholars outside of the Euro-American context (e.g., Talukder, 2014; Kimmerer, 2015) have also shared similar conceptualizations of awe toward the natural world. Given awe and contemplation through outdoor leisure may lead to a diminished sense of self (Bai et al., 2017), such experiences invite individuals to contemplate where they fit into broader world systems.

Solitude and the Outdoor Leisure Experience

In addition to feelings of awe, solitude may play a valuable role in maximizing individuals' potential to experience leisure in urban outdoor areas. Contemplation plays a critical role in the eudaimonic nature of leisure (Holba, 2013), and solitude in outdoor settings may provide space for this contemplation.

According to Long et al. (2003), solitude is a multi-faceted experience that, while alone, allows individuals to feel various positive emotions ranging from inner peace to creativity; solitude contrasts with loneliness which is commonly considered a negative emotion with individuals longing for contact with others. Moments of solitude in the outdoors may offer individuals the opportunity to escape from the "work-a-day world," a key tenet of leisure experiences as defined by Pieper (1963). Managerial practices (Pilcher et al., 2009) and legislation (The Wilderness Act, 1964) in the United States institutionally support the independence and escape associated with solitude in the outdoors. For example, the Wilderness Act of 1964 stipulates that a wilderness in the United States is "recognized as an area where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain" (p: 2). This intentional language codifies natural areas as a place to escape from the rush of daily life that is synonymous with existing in a capitalist society, a place to experience the outdoors in a personal manner that is integral to eudaimonia and leisure. The definition provided by the Wilderness Act of 1964 generally refers to large tracts of land separate from urban areas, indicating a level of tension on how to operationalize solitude in urban outdoor areas. The later sections of this critical essay further explore this tension.

Potentially due to this contrast with how many individuals live their daily lives, many people idealize solitude as an aspirational way of life. For example, individuals, such as Henry David Thoreau and his 2 years living alone along Walden Pond (Thoreau, 1948), have become canonized in Western culture for embracing solitude and the contemplative processes that can come with it. This builds upon Aristotle's (2004/ca. 350 B.C.E.) previously established arguments that space for solitude, and subsequently contemplation, is necessary for living a virtuous life. According to some scholars (Leopold, 1949; Kimmerer, 2015), this virtuous way of life, which can be encouraged through leisure experiences, further requires individuals to behave in an ethical manner toward the natural world. Solitude in the outdoors provides the context for an escape from daily life, both physically and mentally, for individuals to contemplate and pursue this ideal (Pieper, 1963). Such contemplation further supports the eudaimonic nature of leisure in a manner that is not similarly encouraged by recreation and hedonia. The extensive research suggesting that exposure to natural sounds (as well as the absence of anthropogenic noise) enhances mood and attention (e.g., Benfield et al., 2014; Abbott et al., 2016), further bolsters the case that solitude may promote outdoor leisure. Research conducted in rural (e.g., Pilcher et al., 2009) and urban contexts (e.g., Gidlöf-Gunnarsson and Öhrström, 2007) support the value of natural sounds in this regard.

Outdoor Leisure as a Context for Promoting Connectedness to Nature

Land managers and environmental educators in urban areas may be especially interested in awe and solitude as factors promoting outdoor leisure, given such experiences may help individuals develop a closer relationship with the natural environment. Previous scholars have articulated connectedness to nature in a variety of ways, with various philosophical threads asserting human consciousness, existence, and morality are inextricably linked to their embeddedness within the natural world (e.g., Leopold, 1949; Naess, 1973; Wilson, 1984; Kimmerer, 2015). For example, the "deep ecology" movement described by Naess (1973) argues that the natural environment holds intrinsic worth in parallel to the value frequently placed upon anthropocentric entities. Thus, humans and the natural world are linked by their intrinsic value (Naess, 1973). Alternatively, Wilson's (1984) "biophilia" hypothesis asserts humans are innately attracted to other living things due to their shared evolutionary history. In parallel to these philosophical origins, social psychological research has explored how connectedness to nature ultimately influences human behavior. Psychological connectedness to nature has been linked to both human (e.g., Kuo, 2015; Lopes et al., 2020) and ecological (Nisbet et al., 2009) health. Regarding human well-being, a variety of individual and collective health benefits have been documented. Feeling psychologically close to nature is related to individuals holding stronger prosocial emotions (McConnell and Jacobs, 2020), enhanced ability to focus (Barbiero and Berto, 2018), and lower levels of anxiety (Martyn and Brymer, 2016). Regarding ecological well-being, connectedness to nature has been consistently linked to pro-environmental behavior in the environmental psychology literature (e.g., Mayer and Frantz, 2004; Nisbet et al., 2009). Thus, previous research indicates feeling a sense of psychological oneness with the natural world can support both human and ecological health.

As outdoor recreation generally focuses on participating in an activity to promote an intended outcome such as providing health benefits or filling free time (Jenkins and Pigram, 2003; Lackey et al., 2021), these activities can easily be co-opted for economic purposes or emphasize hedonic pleasure at the expense of eudaimonic sentiments (Simon and Alagona, 2013). The potentially utilitarian relationship with the natural environment promoted by outdoor recreation may not be enough to facilitate a meaningful relationship between humans and the remainder of the natural world. Leopold (1949) warns against this, stating, "We can be ethical only in relation to something we can see, feel, understand, love, or otherwise have faith in" (p: 214). If outdoor recreation is used to primarily serve instrumental outcomes, this emotional relationship with the land may be sacrificed at the expense of achieving these other goals. Notably, Høyem (2020) found reflection on human—nature relationships as a critical antecedent of outdoor recreationists adopting pro-environmental behaviors, suggesting the contemplative aspects of outdoor leisure may be effective in promoting a pro-environmental mindset for individuals.

Eudaimonic experiences facilitated by outdoor leisure may provide a pathway to this personal connection with the natural world. Awe and solitude, specifically as components of outdoor leisure, may provide the context for individuals to develop an ethical relationship with the natural environment. By challenging individuals' frames of reference (Bai et al., 2017), awe inspired by the natural environment may encourage individuals to contemplate the broader workings of the world and ways they

fit into these systems (Pieper, 1963). Additionally, solitude in the outdoors may allow individuals to escape from the frenetic nature of their daily lives and provide them space for contemplation, an important aspect of leisure (Pieper, 1963; Holba, 2013). Cumulatively, it is the integration of these elements that can provide a context for personal, eudaimonic experiences in relation to the natural environment, aligning with the assertion that leisure experiences are an end in and of themselves rather than a means to an end (Pieper, 1963). Similar spiritual and intrinsically motivated experiences with the outdoors have been articulated through the Norwegian concept of *friluftsliv* (e.g., Beery, 2013; Løvoll, 2019; Graves et al., 2020) These intimate experiences in the outdoors may allow individuals to develop the personal connection and care for the outdoors that Leopold (1949) argues must preclude development of healthy social-ecological systems. These intrinsically motivated and personal experiences in the outdoors may also potentially influence ways individuals view themselves in relation to the natural environment (Clayton, 2003). Viewing oneself as part of the natural environment, rather than separate from it (i.e., an environmental identity), generally links to a range of pro-environmental behaviors (Udall et al., 2020). If urban land managers and environmental educators can look to awe and solitude as contextual factors to promote outdoor leisure experiences, individuals may also be more likely to develop this personal identification with the natural environment. The framework outlined in this, and previous, sections is summarized in **Figure 1**.

PROMOTING AWE AND SOLITUDE IN URBAN OUTDOOR SPACES

If awe and solitude provide contexts that promote outdoor leisure and eudaimonia, land managers and environmental educators may play a useful role in facilitating these experiences. As Cheesbrough et al. (2019) state, "Any particular landscape is not intrinsically health promoting, but rather the experience of the place produces effects that may be healing" (p: 43). Thus, land managers and environmental educators may act as catalysts for these healthy experiences. Following the arguments provided in the previous sections that outline ways awe and solitude may promote outdoor leisure experiences, literature associated with experiences of awe and solitude in urban outdoor spaces specifically is reviewed.

Awe in Urban Outdoor Spaces

Cronon (1996) calls for seeing "wildness" embedded within our surroundings at all times, rather than seeing "wilderness" as a distant, otherized construct. This perspective asserts that awe, and the inner contemplation it may invoke, can be found in a wide variety of natural spaces with different levels of human presence (Cronon, 1996; Heintzman, 2009). The deconstruction of this binary between social and ecological systems has received widespread support in the academic literature (e.g., Haila, 2000; Oetelaar, 2014; Linnell et al., 2015). Despite this, the reviewed literature suggests that feelings of awe associated with large, rural natural areas (e.g., Loeffler, 2004; D'Amato and Krasny, 2011; Anderson et al., 2018) have been researched more frequently in comparison to urban outdoor areas. This may potentially limit how awe is understood in relation to the natural spaces within cities, also constraining our understanding of how leisure and eudaimonia can be promoted as well.

Despite this imbalance, several notable studies have examined awe in urban parks. Cheesbrough et al. (2019) utilized a photovoice methodology to explore how residents in Edmonton, Canada attached meaning to outdoor spaces throughout the city. Park visitors described feelings of awe in conjunction

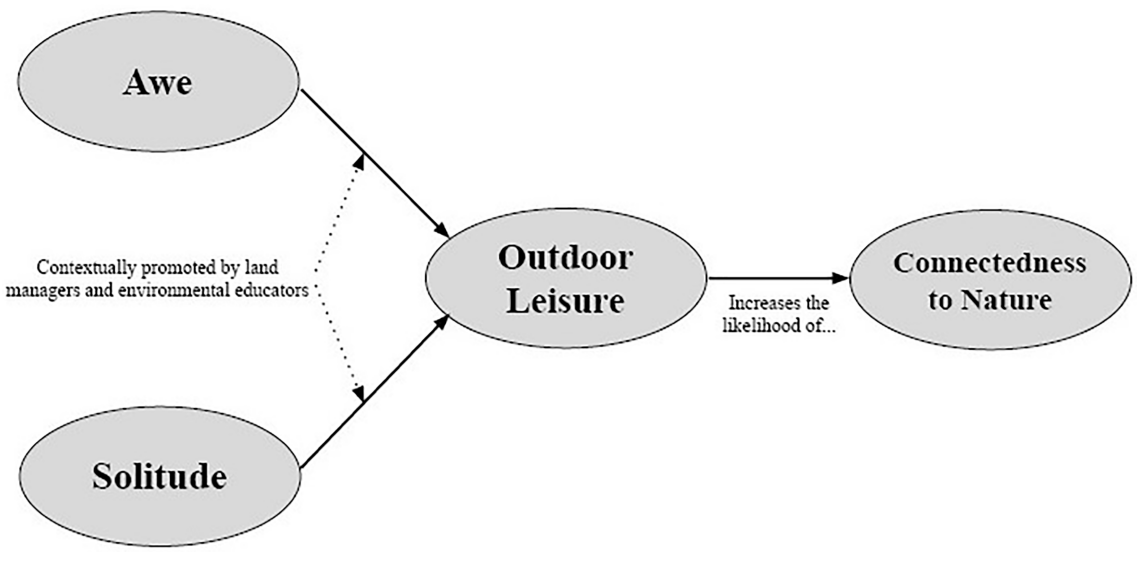

FIGURE 1 | The proposed framework outlining the relationship between awe, solitude, outdoor leisure, and connectedness to nature in urban natural spaces.

with feelings of spirituality and perspective on life when immersed in the natural environment (Cheesbrough et al., 2019). Moffat et al. (2009) provide a unique complement to this study through an ethnographic exploration of youth marijuana use in local natural areas and how this practice influences their connectedness to the natural world. While marijuana use has been considered a precursor to other unhealthy habits (e.g., Fergusson and Horwood, 2000), teenagers who smoked marijuana in local outdoor spaces cited the experience as being uniquely influential toward their sense of awe in relation to the natural world. These experiences were further described as a "gateway" to connectedness with the natural world (Moffat et al., 2009).

These qualitative findings are further corroborated by a small body of social psychological studies supporting the benefits of awe in urban natural settings. Broadly, general research in social psychology has linked awe to prosocial and pro-environmental sentiments (e.g., Piff et al., 2015; Zhao et al., 2018; Li et al., 2019). Specifically, regarding urban outdoor spaces, findings reported by Lopes et al. (2020) suggest that a walk as short as 30 min in an urban park can reduce feelings of rumination with awe acting as a mediator between experimental condition (walking in an urban park or along the street) and levels of rumination for one of the developed models (Lopes et al., 2020). Further, Collado and Manrique (2020) found that exposure to awe-evoking images, of both natural and built scenes, have positive cognitive effects for individuals. The positive influence across both image types (built and natural) may hold insight into how urban parks, given their embeddedness within cities, may invoke awe and its positive psychological outcomes for visitors.

While not explicitly examining feelings of awe, other research on urban outdoor spaces indicates park visitors may experience other outcomes related to awe such as spirituality (e.g., Krenichyn, 2006; Svendsen et al., 2016) and introspection (Shin et al., 2005). Furthermore, a recent literature review on positive mental outcomes associated with urban outdoor spaces builds upon this evidence. Pulling mostly on research outside of the urban context, the authors cite awe as a potential mechanism for nature to develop intrinsic motivation and self-discovery within urban park visitors (Leavell et al., 2019). Collectively, previous research suggests that experiences of awe in urban outdoor spaces closely aligns with the intrinsic, contemplative, and eudaimonic characteristics of leisure experiences (Holba, 2013; Dattilo and Lopez Frias, 2020). This information on awe in urban outdoor spaces provides direction for future research to expand upon this relatively small body of work while also providing useful guidance for practitioners in urban communities.

Solitude in Urban Outdoor Spaces

Much research examining solitude in urban outdoor spaces discusses the construct in conjunction with other experiences such as "reprieve" or "escape" (e.g., Chiesura, 2004; Thompson et al., 2005). Being around non-human flora and fauna (Cheesbrough et al., 2019) and greater exposure to "natural" sounds in comparison to anthropogenic noise (Gidlöf-Gunnarsson and Öhrström, 2007; Tse et al., 2012) were often cited as two contextual factors promoting solitude in urban outdoor spaces. An open-ended survey of park visitors in Amsterdam, The Netherlands indicates that many individuals go to urban parks to remove themselves, both physically and mentally, from the stress associated with living near many people (Chiesura, 2004). Similar desires to seek solitude in urban outdoor spaces were expressed by residents in other cities such as Hong Kong, China (Wong and Domroes, 2004), New York City, United States (Svendsen et al., 2016), and Kuala Lumpur, Malaysia (Sreetheran, 2017). Solitude promoted by urban parks further relates to various health benefits such as providing space for contemplation (Kim et al., 2020), self-expression (Svendsen et al., 2016), and developing a closer relationship with the natural world (Cheesbrough et al., 2019).

It should also be noted that literature suggests that the desire or ability to experience solitude in urban outdoor spaces may not be culturally universal (e.g., Wesely and Gaarder, 2004; Jim and Chen, 2006; Wessels et al., 2021). For example, in a survey administered to visitors across urban parks in six cities throughout South Korea, solitude/privacy was reported as the least important outcome of 16 options provided (though solitude/privacy was still rated as "moderately important" or higher for residents across five of the six cities; Shin et al., 2005). Alternatively, in the Nelson Mandela Bay Municipality, South Africa, many individuals were hesitant to enter local parks alone due to safety concerns (Wessels et al., 2021). Depending on the broader cultural and social context within which urban outdoor spaces are embedded, solitude may not be a desired or feasible experience for some. Similar limiting factors may also exist for specific social groups in urban areas as well. Park characteristics, such as overgrown brush, may help some individuals feel a sense of solitude and escape from the built city environment (Cheesbrough et al., 2019). Alternatively, for others, the same overgrown brush may contribute to some individuals feeling unsafe due to factors such as decreased visibility (Kuo et al., 1998). Similar tensions may exist over law enforcement presence in urban parks (e.g., Slater et al., 2013; Mowatt, 2018). Reviewed literature suggests that the tension between facilitators and barriers toward solitude should be considered by land managers and environmental educators in urban outdoor spaces when aiming to facilitate leisure experiences.

RECOMMENDATIONS FOR FACILITATING LEISURE IN URBAN OUTDOOR SPACES

Land managers and environmental educators may look to awe and solitude as contextual factors to support leisure in urban outdoor spaces, potentially resulting in greater connectedness to nature for visitors. Previous research has suggested that spatial availability of parks is not enough to encourage use; the characteristics of outdoor spaces also matter (Hughey et al., 2016; Rigolon, 2017). This must be acknowledged if investments in urban outdoor spaces are to be maximized. Somewhat unsurprisingly, the reviewed literature suggests that exposure to natural sights and sounds facilitates both awe and solitude

for urban park visitors. While providing beneficial aspects to the visitor experience, the nature of these natural sights and sounds may influence the likelihood of individuals experiencing awe, solitude, and subsequently, leisure. While some individuals may experience awe and solitude readily in a woodland stewarded for its "natural" characteristics (Cheesbrough et al., 2019), others may feel unsafe in areas that are overgrown, unlit, or less intensively managed in general (Kuo et al., 1998). These divergent needs to experience awe and solitude may necessitate intentional managerial approaches in facilitating contexts to promote leisure. Utilizing strategies to satisfy various needs for leisure experience, such as the recreation opportunity spectrum (e.g., Xiao et al., 2018), may provide useful guidance for land managers and environmental educators. The recreation opportunity spectrum creates "zones" within an outdoor space where certain areas are managed to promote specific outdoor activities or experiences (Joyce and Sutton, 2009; Xiao et al., 2018). While traditionally utilized to meet the needs of various recreation activities with conflicting requirements in parks or protected areas, a similar approach may be helpful in providing contexts to facilitate awe, solitude, and leisure for visitors as well. Reviewed literature suggests that exposure to different types of flora and fauna (Kuo et al., 1998), soundscapes (Tse et al., 2012), as well as built and natural environments (Cheesbrough et al., 2019) may influence whether some individuals experience leisure in some settings and not others. Given the intrinsic nature of leisure (Pieper, 1963; Holba, 2013; Dattilo and Lopez Frias, 2020), individuals may gravitate toward the areas in park settings that satisfy these personal inclinations. Thus, adapting the recreation opportunity spectrum to facilitate contexts for awe and solitude may present a possible pathway to maximize investments in urban park management.

Additionally, the aggregated literature suggests that visitors to urban outdoor spaces experience awe and solitude in contexts that extend beyond what may be considered "traditional" outdoor experiences (e.g., hiking and biking; Outdoor Foundation, 2020). The reviewed literature outlines a variety of ways that park visitors found pathways to experiencing awe and solitude. The presented studies emphasize that unique individuals in unique contexts use urban parks in very different ways. While certain activities, such as walking and hiking, were referenced frequently (e.g., Krenichyn, 2006; Lopes et al., 2020), park visitors also found awe and solitude through less recognized activities like smoking marijuana (Moffat et al., 2009), artistic expression (Svendsen et al., 2016), and simply laying underneath trees (Burgess et al., 1988). While providing contexts to support some activities, like smoking marijuana, may be questionable (e.g., Fergusson and Horwood, 2000), land managers and environmental educators may be able to work more effectively with communities to meet diverse activity-based needs in order to facilitate leisure and eudaimonia. A process of co-creation regarding urban outdoor spaces may allow for community members to have a tangible voice in how investments in their local outdoor spaces are utilized, allowing them to advocate for their own ways of finding awe, solitude, and leisure. Practitioners and scholars may look to previous projects utilizing a transdisciplinary research lens for guidance on how to go about this (e.g., Mauser et al., 2013; Bergendahl et al., 2018). The transdisciplinary approach generally calls for a research process that is community-based and collaborative (Lang et al., 2012). While generally outlining how to go about research in a more practical and applied manner, a similar approach can be applied when designing urban park spaces, developing environmental education curriculum, and creating policies relevant to urban outdoor spaces. The transdisciplinary framework outlined by Lang et al. (2012) calls for regular discourse between stakeholders in what is called a "co-creative" process. This collaborative approach to promoting leisure in urban outdoor spaces may allow for communities to find leisure experiences and develop parks spaces that are uniquely meaningful to them.

CONCLUSION

Distinguishing itself from outdoor recreation due to the intrinsic and contemplative aspects of the experience, outdoor leisure may serve as a pathway to connect individuals with the natural world in urban settings. Awe and solitude may serve as two contextual factors that promote this experience. To enhance the likelihood of this outcome, land managers and environmental educators may aim to find ways of stewarding outdoor areas and facilitating experiences that promote these elements of the park visitor experience. Reviewed literature suggests that embracing the embeddedness of urban parks within the city setting, managing for a range of environments to facilitate awe and solitude within urban parks, and understanding community-driven ideas of what it means to utilize urban parks in a meaningful way may all help to maximize the likelihood of outdoor leisure experiences for park visitors. To build resilient and thriving social-ecological systems within cities, outdoor leisure may represent and useful yet underutilized concept in building connectedness to nature.

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TM is responsible for the conceptualization, literature review, and writing for this manuscript.

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REFERENCES

Abbott, L. C., Taff, D., Newman, P., Benfield, J. A., and Mowen, A. J. (2016). The influence of natural sounds on attention restoration. *J. Park. Recreat. Adm.* 34, 5–15. doi: 10.18666/JPRA-2016-V34-I3-6893

Anderson, E. C., and Minor, E. S. (2017). Vacant lots: An underexplored resource for ecological and social benefits in cities. *Urban For. Urban Green.* 21, 146–152. doi: 10.1016/j.ufug.2016.11.015

Anderson, C. L., Monroy, M., and Keltner, D. (2018). Awe in nature heals: evidence from military veterans, at-risk youth, and college students. *Emotion* 18, 1195–1202. doi: 10.1037/emo0000442

Aristotle (2004). The Nicomachean Ethics. Penguin. (Translation: J. A. K. Thomson, Intro: J. Barnes; Original work published 350 B.C.E.).

Bai, Y., Maruskin, L. A., Chen, S., Gordon, A. M., Stellar, J. E., McNeil, G. D., et al. (2017). Awe, the diminished self, and collective engagement: universals and cultural variations in the small self. *J. Pers. Soc. Psychol.* 113, 185–209. doi: 10.1037/pspa0000087

Barbiero, G., and Berto, R. (2018). From biophilia to naturalist intelligence passing through perceived restorativeness and connection to nature. *Annals of Rev. Res.* 3:555604. doi: 10.19080/ARR.2018.03.555604

Beery, T. H. (2013). Nordic in nature: Friluftsliv and environmental connectedness. *Environ. Educ. Res.* 19, 94–117. doi: 10.1080/13504622.2012.688799

Benfield, J. A., Taff, B. D., Newman, P., and Smyth, J. (2014). Natural sound facilitates mood recovery. *Ecopsychology* 6, 183–188. doi: 10.1089/eco.2014.0028

Bergendahl, J. A., Sarkis, J., and Timko, M. T. (2018). Transdisciplinarity and the food energy and water nexus: ecological modernization and supply chain sustainability perspectives. *Resour. Conserv. Recycl.* 133, 309–319. doi: 10.1016/j.resconrec.2018.01.001

Bethelmy, L. C., and Corraliza, J. A. (2019). Transcendence and sublime experience in nature: awe and inspiring energy. *Front. Psychol.* 10:509. doi: 10.3389/fpsyg.2019.00509

Biernacka, M., and Kronenberg, J. (2018). Classification of institutional barriers affecting the availability, accessibility and attractiveness of urban green spaces. *Urban For. Urban Green.* 36, 22–33. doi: 10.1016/j.ufug.2018.09.007

Borgoni, R., Michelangeli, A., and Pontarollo, N. (2018). The value of culture to urban housing markets. *Reg. Stud.* 52, 1672–1683. doi: 10.1080/00343404.2018.1444271

Burgess, J., Harrison, C. M., and Limb, M. (1988). People, parks and the urban green: a study of popular meanings and values for open spaces in the city. *Urban Stud.* 25, 455–473. doi: 10.1080/00420988820080631

Chawla, L. (1998). Significant life experiences revisited: A review of research on sources of environmental sensitivity. *J. Environ. Educ.* 29, 11–21. doi: 10.1080/1350462980040402

Cheesbrough, A. E., Garvin, T., and Nykiforuk, C. I. (2019). Everyday wild: urban natural areas, health, and well-being. *Health Place* 56, 43–52. doi: 10.1016/j.healthplace.2019.01.005

Chiesura, A. (2004). The role of urban parks for the sustainable city. *Landsc. Urban Plan.* 68, 129–138. doi: 10.1016/j.landurbplan.2003.08.003

Clark, D. E., and Kahn, J. R. (1988). The social benefits of urban cultural amenities. *J. Reg. Sci.* 28, 363–377. doi: 10.1111/j.1467-9787.1988.tb01088.x

Clayton, S. (2003). "Environmental identity: a conceptual and an operational definition," in *Identity and the Natural Environment: The Psychological Significance of Nature*. eds. S. Clayton and S. Opotow (The MIT Press), 317–341.

Collado, S., and Manrique, H. M. (2020). Exposure to awe-evoking natural and built scenes has positive effects on cognitive performance and affect. *Environ. Behav.* 52, 1105–1132. doi: 10.1177/0013916519868733

Cronon, W. (1996). The trouble with wilderness: Or, getting back to the wrong nature. *Environ. Hist.* 1, 7–28. doi: 10.2307/3985063

D'Amato, L. G., and Krasny, M. E. (2011). Outdoor adventure education: applying transformative learning theory to understanding instrumental learning and personal growth in environmental education. *J. Environ. Educ.* 42, 237–254. doi: 10.1080/00958964.2011.581313

Dattilo, J., and Lopez Frias, F. J. (2020). A critical examination of leisure in modernity: rejecting instrumentalism and embracing flourishing. *J. Leis. Res.* 52, 581–598. doi: 10.1080/00222216.2020.1789013

Deci, E. L., and Ryan, R. M. (2008). Hedonia, eudaimonia, and well-being: An introduction. *J. Happiness Stud.* 9, 1–11. doi: 10.1007/s10902-006-9018-1

Fergusson, D. M., and Horwood, L. J. (2000). Does cannabis use encourage other forms of illicit drug use? *Addiction* 95, 505–520. doi: 10.1046/j.1360-0443.2000.9545053.x

Gidlöf-Gunnarsson, A., and Öhrström, E. (2007). Noise and well-being in urban residential environments: The potential role of perceived availability to nearby green areas. *Landsc. Urban Plan.* 83, 115–126. doi: 10.1016/j.landurbplan.2007.03.003

Graves, M., Løvoll, H. S., and Sæther, K. W. (2020). "Friluftsliv: Aesthetic and Psychological Experience of Wilderness Adventure," in *Issues in Science and Theology: Nature and Beyond*. eds. M. Fuller, D. Evers, A. Runehov, K.-W. Sæther and B. Michollet (Cham: Springer), 207–220.

Haila, Y. (2000). Beyond the nature-culture dualism. *Biol. Philos.* 15, 155–175. doi: 10.1023/A:1006625830102

Heberlein, T. A. (2012). *Navigating Environmental Attitudes*. England: Oxford University Press.

Heintzman, P. (2009). Nature-based recreation and spirituality: A complex relationship. *Leis. Sci.* 32, 72–89. doi: 10.1080/01490400903430897

Holba, A. (2013). *Transformative Leisure: A Philosophy of Communication*. Milwaukee: Marquette.

Høyem, J. (2020). Outdoor recreation and environmentally responsible behavior. *J. Outdoor Recreat. Tour.* 31:100317. doi: 10.1016/j.jort.2020.100317

Hughey, S. M., Walsemann, K. M., Child, S., Powers, A., Reed, J. A., and Kaczynski, A. T. (2016). Using an environmental justice approach to examine the relationships between park availability and quality indicators, neighborhood disadvantage, and racial/ethnic composition. *Landsc. Urban Plan.* 148, 159–169. doi: 10.1016/j.landurbplan.2015.12.016

Huta, V., and Waterman, A. S. (2014). Eudaimonia and its distinction from hedonia: developing a classification and terminology for understanding conceptual and operational definitions. *J. Happiness Stud.* 15, 1425–1456. doi: 10.1007/s10902-013-9485-0

Jenkins, J., and Pigram, J. (2003). *Encyclopedia of Leisure and Outdoor Recreation*. Oxfordshire: Routledge.

Jennings, V., Baptiste, A. K., Jelks, O., and Skeete, R. (2017). Urban green space and the pursuit of health equity in parts of the United States. *Int. J. Environ. Res. Public Health* 14:1432. doi: 10.3390/ijerph14111432

Jim, C. Y., and Chen, W. Y. (2006). Recreation–amenity use and contingent valuation of urban greenspaces in Guangzhou, China. *Landscape and Urban Planning* 75, 81–96. doi: 10.1016/j.landurbplan.2004.08.008

Joyce, K., and Sutton, S. (2009). A method for automatic generation of the recreation opportunity Spectrum in New Zealand. *Appl. Geogr.* 29, 409–418. doi: 10.1016/j.apgeog.2008.11.006

Kazig, R. (2016). *Presentation of Hermann Schmitz'paper, "Atmospheric Spaces"*. Ambiances. Environnement sensible, architecture et espace urbain.

Kim, J., Lopez Frias, F. J., and Dattilo, J. (2020). Urban parks as spaces to pursue virtuous character, friendship, and contemplation: an Aristotelian perspective. *J. Leis. Res.* 51, 107–123. doi: 10.1080/00222216.2019.1637703

Kimmerer, R. W. (2015). Braiding sweetgrass. Milkweed Editions.

Krenichyn, K. (2006). 'The only place to go and be in the city': women talk about exercise, being outdoors, and the meanings of a large urban park. *Health Place* 12, 631–643. doi: 10.1016/j.healthplace.2005.08.015

Kuo, M. (2015). How might contact with nature promote human health? Promising mechanisms and a possible central pathway. *Front. Psychol.* 6:1093. doi: 10.3389/fpsyg.2015.01093

Kuo, F. E., Bacaicoa, M., and Sullivan, W. C. (1998). Transforming inner-city landscapes: trees, sense of safety, and preference. *Environ. Behav.* 30, 28–59. doi: 10.1177/0013916598301002

Lackey, N. Q., Tysor, D. A., McNay, G. D., Joyner, L., Baker, K. H., and Hodge, C. (2021). Mental health benefits of nature-based recreation: a systematic review. *Annals of Leisure Res.* 24, 379–393. doi: 10.1080/11745398.2019.1655459

Lang, D. J., Wiek, A., Bergmann, M., Stauffacher, M., Martens, P., Moll, P., et al. (2012). Transdisciplinary research in sustainability science: practice, principles, and challenges. *Sustain. Sci.* 7, 25–43. doi: 10.1007/s11625-011-0149-x

Leavell, M. A., Leiferman, J. A., Gascon, M., Braddick, F., Gonzalez, J. C., and Litt, J. S. (2019). Nature-based social prescribing in urban settings to improve social connectedness and mental well-being: a review. *Current Environ. Health Reports* 6, 297–308. doi: 10.1007/s40572-019-00251-7

Lengieza, M. L., Hunt, C. A., and Swim, J. K. (2019). Measuring eudaimonic travel experiences. *Ann. Tour. Res.* 74, 195–197. doi: 10.1016/j.annals.2018.05.002

Lengieza, M. L., and Swim, J. K. (2021). The paths to connectedness: A review of the antecedents of connectedness to nature. *Front. Psychol.* 12:763231. doi: 10.3389/fpsyg.2021.763231

Leopold, A. (1949). *The Land Ethic, A Sand County Almanac: And Sketches Here and There*. England: Oxford University Press.

Li, J. J., Dou, K., Wang, Y. J., and Nie, Y. G. (2019). Why awe promotes prosocial behaviors? The mediating effects of future time perspective and self-transcendence meaning of life. *Front. Psychol.* 10:1140. doi: 10.3389/fpsyg.2019.01140

Linnell, J. D., Kaczensky, P., Wotschikowsky, U., Lescureux, N., and Boitani, L. (2015). Framing the relationship between people and nature in the context of European conservation. *Conserv. Biol.* 29, 978–985. doi: 10.1111/cobi.12534

Loeffler, T. A. (2004). A photo elicitation study of the meanings of outdoor adventure experiences. *J. Leis. Res.* 36, 536–556. doi: 10.1080/00222216.2004.11950035

Long, C. R., Seburn, M., Averill, J. R., and More, T. A. (2003). Solitude experiences: varieties, settings, and individual differences. *Personal. Soc. Psychol. Bull.* 29, 578–583. doi: 10.1177/0146167203029005003

Lopes, S., Lima, M., and Silva, K. (2020). Nature can get it out of your mind: the rumination reducing effects of contact with nature and the mediating role of awe and mood. *J. Environ. Psychol.* 71, 101489–101487. doi: 10.1016/j.jenvp.2020.101489

Løvoll, H. S. (2019). The inner feeling of glacier hiking: an exploratory study of "immersion" as it relates to flow, hedonia and eudaimonia. *Scand. J. Hosp. Tour.* 19, 300–316. doi: 10.1080/15022250.2019.1581084

Machado, A. F., Simões, R. F., and Diniz, S. C. (2013). Urban amenities and the development of creative clusters: The case of Brazil. *Curr. Urban Stud.* 1, 92–101. doi: 10.4236/cus.2013.14010

Martyn, P., and Brymer, E. (2016). The relationship between nature relatedness and anxiety. *J. Health Psychol.* 21, 1436–1445. doi: 10.1177/1359105314555169

Mauser, W., Klepper, G., Rice, M., Schmalzbauer, B. S., Hackmann, H., Leemans, R., et al. (2013). Transdisciplinary global change research: the co-creation of knowledge for sustainability. *Curr. Opin. Environ. Sustain.* 5, 420–431. doi: 10.1016/j.cosust.2013.07.001

Mayer, F. S., and Frantz, C. M. (2004). The connectedness to nature scale: A measure of individuals' feeling in community with nature. *J. Environ. Psychol.* 24, 503–515. doi: 10.1016/j.jenvp.2004.10.001

McConnell, A. R., and Jacobs, T. P. (2020). Self-nature representations: On the unique consequences of nature-self size on pro-environmental action. *J. Environ. Psychol.* 71:101471. doi: 10.1016/j.jenvp.2020.101471

McShane, K. (2018). The role of awe in environmental ethics. *J. Aesthet. Art Critic.* 76, 473–484. doi: 10.1111/jaac.12595

Moffat, B. M., Johnson, J. L., and Shoveller, J. A. (2009). A gateway to nature: Teenagers' narratives on smoking marijuana outdoors. *J. Environ. Psychol.* 29, 86–94. doi: 10.1016/j.jenvp.2008.05.007

Mowatt, R. A. (2018). The case of the 12-year-old boy: Or, the silence of and relevance to leisure research. *Leis. Sci.* 40, 54–70. doi: 10.1080/01490400.2017.1296389

Naess, A. (1973). The shallow and the deep, long-range ecology movement. A summary. *Inquiry* 16, 95–100. doi: 10.1080/00201747308601682

Nisbet, E. K., and Zelenski, J. M. (2011). Underestimating nearby nature: affective forecasting errors obscure the happy path to sustainability. *Psychol. Sci.* 22, 1101–1106. doi: 10.1177/0956797611418527

Nisbet, E. K., Zelenski, J. M., and Murphy, S. A. (2009). The nature relatedness scale: linking individuals' connection with nature to environmental concern and behavior. *Environ. Behav.* 41, 715–740. doi: 10.1177/0013916508318748

Oetelaar, G. A. (2014). Worldviews and human–animal relations: critical perspectives on bison–human relations among the euro-Canadians and Blackfoot. *Crit. Anthropol.* 34, 94–112. doi: 10.1177/0308275X13510187

Outdoor Foundation (2020). 2019 Outdoor Participation Report. Available at: https://outdoorindustry.org/resource/2019-outdoor-participation-report/ (Accessed January 11, 2021).

Pieper, J. (1963). *Leisure: The basis of Culture*. New York, NY: Random House.

Piff, P. K., Dietze, P., Feinberg, M., Stancato, D. M., and Keltner, D. (2015). Awe, the small self, and prosocial behavior. *J. Pers. Soc. Psychol.* 108, 883–899. doi: 10.1037/pspi0000018

Pilcher, E. J., Newman, P., and Manning, R. E. (2009). Understanding and managing experiential aspects of soundscapes at Muir woods National Monument. *Environ. Manag.* 43, 425–435. doi: 10.1007/s00267-008-9224-1

Rigolon, A. (2017). Parks and young people: An environmental justice study of park proximity, acreage, and quality in Denver, Colorado. *Landsc. Urban Plan.* 165, 73–83. doi: 10.1016/j.landurbplan.2017.05.007

Ryan, R. M., and Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *Am. Psychol.* 55, 68–78. doi: 10.1037//0003-066X.55.1.68

Ryan, R. M., and Deci, E. L. (2001). On happiness and human potentials: A review of research on hedonic and eudaimonic well-being. *Annu. Rev. Psychol.* 52, 141–166. doi: 10.1146/annurev.psych.52.1.141

Ryff, C. D., and Singer, B. H. (2008). Know thyself and become what you are: a eudaimonic approach to psychological well-being. *J. Happiness Stud.* 9, 13–39. doi: 10.1007/s10902-006-9019-0

Shin, W. S., Gyo Kwon, H., Hammitt, W. E., and Soo Kim, B. (2005). Urban forest park use and psychosocial outcomes: A case study in six cities across South Korea. *Scand. J. For. Res.* 20, 441–447. doi: 10.1080/02827580500339930

Simon, G. L., and Alagona, P. S. (2013). Contradictions at the confluence of commerce, consumption and conservation; Or, an REI shopper camps in the forest, does anyone notice? *Geoforum* 45, 325–336. doi: 10.1016/j.geoforum.2012.11.022

Slater, S., Fitzgibbon, M., and Floyd, M. F. (2013). Urban adolescents' perceptions of their neighborhood physical activity environments. *Leis. Sci.* 35, 167–183. doi: 10.1080/01490400.2013.761912

Sreetheran, M. (2017). Exploring the urban park use, preference and behaviours among the residents of Kuala Lumpur, Malaysia. *Urban For. Urban Green.* 25, 85–93. doi: 10.1016/j.ufug.2017.05.003

Svendsen, E. S., Campbell, L. K., and McMillen, H. L. (2016). Stories, shrines, and symbols: recognizing psycho-social-spiritual benefits of urban parks and natural areas. *J. Ethnobiol.* 36, 881–907. doi: 10.2993/0278-0771-36.4.881

Talukder, M. M. H. (2014). Companionship with nature in Asian traditions: A resource for environmental education. *Agathos* 5, 124–139.

The Wilderness Act (1964). 16 U.S.C.

Thompson, C. W., Aspinall, P., Bell, S., and Findlay, C. (2005). "It gets you away from everyday life": local woodlands and community use—what makes a difference? *Landsc. Res.* 30, 109–146. doi: 10.1080/0142639042000324794

Thoreau, H. D. (1948). Walden: or, life in the woods. On the Duty of Civil Disobedience. Rinehart.

Tse, M. S., Chau, C. K., Choy, Y. S., Tsui, W. K., Chan, C. N., and Tang, S. K. (2012). Perception of urban park soundscape. *J. Acoust. Soc. Am.* 131, 2762–2771. doi: 10.1121/1.3693644

Udall, A. M., de Groot, J. I., de Jong, S. B., and Shankar, A. (2020). How do I see myself? A systematic review of identities in pro-environmental behaviour research. *J. Consum. Behav.* 19, 108–141. doi: 10.1002/cb.1798

Wesely, J. K., and Gaarder, E. (2004). The gendered "nature" of the urban outdoors: women negotiating fear of violence. *Gend. Soc.* 18, 645–663. doi: 10.1177/0891243204268127

Wessels, N., Sitas, N., Esler, K. J., and O'Farrell, P. (2021). Understanding community perceptions of a natural open space system for urban conservation and stewardship in a metropolitan city in Africa. *Environ. Conserv.* 48, 244–254. doi: 10.1017/S0376892921000345

Williams, C. C., and Chawla, L. (2016). Environmental identity formation in nonformal environmental education programs. *Environ. Educ. Res.* 22, 978–1001. doi: 10.1080/13504622.2015.1055553

Wilson, E. O. (1984). *Biophilia*. Cambridge, MA: Harvard University Press.

Wolch, J., Jerrett, M., Reynolds, K., McConnell, R., Chang, R., Dahmann, N., et al. (2011). Childhood obesity and proximity to urban parks and recreational resources: a longitudinal cohort study. *Health Place* 17, 207–214. doi: 10.1016/j.healthplace.2010.10.001

Wong, K. K., and Domroes, M. (2004). Users' perception of Kowloon Park, Hong Kong: visiting patterns and scenic aspects. *Chin. Geogr. Sci.* 14, 269–275. doi: 10.1007/s11769-003-0058-8

World Health Organization (2021). Urban health. Available at: https://www.who.int/health-topics/urban-health (Accessed January 11, 2021).

Xiao, X., Manning, R., Lawson, S., Valliere, W., and Krymkowski, D. (2018). Indicators for a transportation recreation opportunity Spectrum in National Parks. *J. Park. Recreat. Adm.* 36, 90–112. doi: 10.18666/JPRA-2018-V36-I1-8117

Zhao, H., Zhang, H., Xu, Y., Lu, J., and He, W. (2018). Relation between awe and environmentalism: The role of social dominance orientation. *Front. Psychol.* 9:2367. doi: 10.3389/fpsyg.2018.02367

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Passive patient or active agent? An under-explored perspective on the benefits of time in nature for learning and wellbeing

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Introduction

A rapidly expanding body of research documents that access to nature in places of everyday life, including learning environments, promotes healthy functioning and wellbeing (for recent reviews, see Kuo et al., 2019; Jimenez et al., 2021). What mechanisms explain this effect? There is an active search to answer this question, as explanations can help guide investments in greening public places and naturalizing school grounds in order to achieve optimal outcomes.

Two major perspectives characterize the current search for answers. One is a medical model that compares natural settings to a type of medication that needs to be administered in the right dose and formulation. It seeks to deliver scientific evidence about the benefits of exposure to nature to decision-makers in fields like public health, urban planning, parks, recreation, and education. In this case, professionals in these fields serve like "physicians" who provide nature to "patients" by greening settings of daily life to produce automatic physiological benefits and encourage healthy activities like exercise and social connection. This is an important direction for research and practice. Another perspective is a transactional approach that seeks to understand opportunities that natural environments provide for people to exercise capabilities and satisfy basic needs that sustain a flourishing life. In this case, people are viewed as active agents in their own development, and the goal is to provide natural settings that are well stocked with resources that support positive development, in social contexts that encourage engagement.

The following sections identify theories and hypotheses consistent with each perspective. Because a transactional perspective is applied less often in the literature on health and wellbeing, this opinion piece will present it in more detail. The conclusion suggests outcomes from learning in nature that a transactional approach is well suited to explore.

Passive exposure to nature

An underlying assumption of the medical model is that just being exposed to nature benefits people even without their conscious awareness, due to direct physiological, emotional, and cognitive effects. Evidence consistent with this premise includes many studies that show reduced stress in natural settings vs. built spaces, improved immune system activity, and better working memory and attentional control (Kondo et al., 2018; Stevenson et al., 2018; Corazon et al., 2019; Andersen et al., 2021). These are experimentally demonstrated short-term effects, but epidemiological studies indicate that having nature nearby can also have long-term benefits, including lower rates of depression, anxiety and other illnesses, and lower mortality rates, especially from cardiovascular diseases (Maas et al., 2009; Gascon et al., 2016; Jimenez et al., 2021). Commonly, people report that they feel greater wellbeing and better general health when they are in nature or live among green surroundings (Bowler et al., 2010).

Most hypotheses put forward to explain these effects share an evolutionary premise: humans evolved in natural environments, and therefore our bodies and minds function best in natural surroundings, on the condition that settings signal safety and security. The most commonly cited theories of this kind are the "stress reduction theory" of Ulrich (1983) and the "attention restoration theory" of Kaplan and Kaplan (1989). Other lines of explanation follow the "old friends" hypothesis of Rook (2013), who argued that the human immune system needs exposure to biodiverse microorganisms in natural habitats to function efficiently, and the claim of Li (2010) that trees and other vegetation vaporize essential oils that boost immune functioning. Joye and van den Berg (2011) propose that natural surroundings are restorative because the human visual system fluently processes the structure of natural settings, including its fractal patterns (see Table 1). The evolutionary premises behind these theories are points of discussion (e.g., Heft, 2021; van den Berg, 2021).

Some researchers note that nearby nature affords healthy exercise and outdoor social interactions (e.g., Ward Thompson and Aspinall, 2011; Russell et al., 2013; Markevych et al., 2017; Hartig, 2021). In their review of studies of nature-based learning, Kuo et al. (2019) observed that natural settings foster autonomy and more cohesive and cooperative social relations. These suggestions have not been theorized, however, at the same level as physiological effects. The following section presents theoretical frameworks consistent with these and other benefits.

Active engagement with nature

A transactional approach to learning and wellbeing views people as active agents who seek to fulfill basic needs and capabilities as they engage with the world, and who rely on supportive physical and social conditions (see Table 1) Three prominent examples of this perspective are a capabilities approach to development, self-determination theory, and ecological psychology. In the 1980s, the economist Sen (1985) advanced a capabilities approach to human welfare. With colleagues, he drew on Aristotle's idea of *eudaimonic* happiness, or "being well and doing well" in different realms of human functioning (Aristotle, 2014/ca. 350 B.C.E.). Sen emphasized that each society needs open debates to identify these valued capabilities; but to get discussion going, Nussbaum (2011) proposed 10 central capabilities. Her list includes living with concern for and in relation to animals, plants and the natural world as one of the components of a fully realized human life (For suggestions regarding how access to nature can help children realize all 10 capabilities, see Chawla, 2015). Central to this approach, people must be free to choose how they want to express their capabilities, with the recognition that these expressions are likely to be culturally shaped.

Similar ideas have deep roots in psychology among theorists who propose that people strive to fulfill their human potential (e.g. Maslow, 1954; White, 1959). In this tradition, the self-determination theory of Deci and Ryan (1985) focuses on motivations that underlie the development of capabilities. According to Ryan and Deci (2017), people are born with three basic psychological needs: autonomy, competence, and relatedness in the sense of feeling cared for and caring for others in turn. They present a large body of evidence that people find their lives satisfying and meaningful when conditions support fulfillment of these needs; whereas people experience more anxiety, depression and ill health when these needs are thwarted. Recently, Ryan and Deci (2017, p. 263–6) suggested that time in nature may be another basic need because it activates intrinsic motivation; catalyzes a sense of vitality and wellbeing; and encourages positive social relations, prosocial tendencies, and community cohesion (see also Baxter and Pelletier, 2019).

Ryan and Deci (2017, pp. 613–4) align their ideas with a capabilities approach to development, as both bodies of work adopt Aristotle's *eudaimonic* view of happiness and emphasize the importance of autonomy, or free choice in action. Empirical research suggests a good fit between the theories. People who say that they are actualizing Nussbaum's 10 capabilities are more likely to say that they feel happiness, vitality, meaning in life, and life satisfaction; while experiences of autonomy, competence, and relatedness mediate these outcomes (DeHaan et al., 2016).

The ecological psychologist Gibson (1986) introduced the idea of "affordances" in the sense of features of the environment that provide people with possibilities for action and experience. The concept is widely applied in environmental design to create a good fit between people's goals and capabilities and the environment's provisions; but its embeddedness in a view of wellbeing that involves autonomy, agency, relationship, and living wisely within ecological limits is less often acknowledged (Gibson, 1986; Reed, 1996a; Chawla, 2021). Gibson extended the concept to social affordances that people offer each other; and

TABLE 1 Theorizing benefits of time in nature for learning and wellbeing.

	Humans are viewed as passive recipients of benefits from natural surroundings	Humans are viewed as active agents who benefit from interacting with nature
Some associated theories and theorists	• Stress reduction theory (Ulrich, 1983) • Attention restoration theory (Kaplan and Kaplan, 1989) • "Old friends" hypothesis (Rook, 2013) • Forest medicine (Li, 2010) • Perceptual fluency account (Joye and van den Berg, 2011)	• Ecological psychology (Gibson, 1986; Reed, 1996a,b; Chawla, 2021) • Capabilities approach to human development (Sen, 1985; Nussbaum, 2011) • Self-determination theory (Deci and Ryan, 1985) • Theory of loose parts (Nicholson, 1971)
Some associated benefits	• Decreased physiological levels of stress • Increased positive emotions • Reduced anxiety, depression, and negative moods • Better working memory • More focused attention • Improved immune system activity • Lower rates of many diseases	• Autonomy • Sense of competence and efficacy • Physical balance, agility and coordination • Sense of vitality • Creativity • Engaged learning • Cooperative social relationships • Relatedness with other species and living things • Peaceful refuge
Some suggested mechanisms	• Stress hormones decrease in safe natural areas • When extended focused attention leads to mental fatigue, views of nature and being in nature restore depleted cognitive resources through fascination, compatibility, a sense of extent, and being away from sources of stress • Microbiomes associated with biodiverse environments stimulate immune system development • Volatile oils from trees increase Natural Killer cells and other markers of protective lymphocyte activity • The human visual system fluently processes the structure of green settings, in part due to fractal patterns in nature	• Many elements of nature, animate and inanimate, immediately respond to engagement—providing information for feelings of effectance and intrinsic motivation to continue learning about properties of the natural world and capacities of the self • The natural world's sensory diversity, manipulability, and inherent change encourage interest and curiosity • Natural settings afford free movement and free choice in selecting activities as well as setting and mastering challenges • Because nature's elements were not manufactured by humans for prescribed purposes, they invite creative use • The number and variety of "loose parts" in nature invite creative combinations • Natural areas provide refuges to escape over-stimulation, relax, and sort out thoughts and feelings • Natural settings provide materials for imaginative play and construction that require social cooperation • In some cultures, traditional interactions with regional landscapes are an important part of cultural identity
Typically recommended interventions	Planners, designers, developers, park managers, school administrators, teachers, and other professionals provide nearby nature: • Views of trees outside buildings • Trees along streets and pedestrian pathways • Landscaping for nature around homes and neighborhoods • Naturalizing the grounds of schools and child care centers • Bringing nature into buildings and classrooms through green walls and plants	In addition to providing access to nature, family members, teachers, staff in environmental organizations, other community mentors, and designers facilitate: • Free play and exploration in nature • Manageable risk-taking outdoors • Appreciative and caring attention to nature • Skills for outdoor recreation and the sustainable use of nature • Collective work to protect and restore the natural world • Learning across the curriculum in outdoor classrooms, using elements of nature • Place-based education that focuses on learning local natural and cultural history • Participatory processes that engage people who use environments, including children, in planning, designing, and creating green spaces

Reed (1996b) discussed the role of social influences and social learning in accessing, detecting and using affordances.

Conclusion: Creating conditions for wellbeing

What do these theories of capability, self-determination, and affordances offer, beyond medical models of nature's value, to help researchers understand how the natural world contributes to learning and wellbeing and help practitioners create settings for optimal functioning? Epidemiological studies offer a "zoom out" view that establishes that people with more greenery around their homes and nearby green spaces have lower rates of physical and mental illnesses. Experimental and quasi-experimental studies "zoom in" closer. Through observation and real-time measures like biomarkers, cognitive tests, and mood reports, they show how people respond to specific settings. Theories related to capabilities, self-determination and affordances invite research to zoom in from a different perspective. Exactly what do natural areas provide, compared to built spaces, that facilitates the development of different capabilities and experiences of competence, relatedness and autonomy? How do social interactions influence environmental use, and vice versa?

Many theory-driven research designs can fit here. For example, observations and videos that show how people interact with affordances of the environment, individually and in groups, can be combined with assessments of developing capabilities over time, as well as measures of autonomy, competence, and qualities of relatedness to other people and to nature (e.g. Sleev and Allan, 2019; Lee et al., 2021; Pollin and Retzlaff-Furst, 2021). GPS tracking, surveys, and qualitative methods like mapping, drawing and interviews can gather where people go, what they do and feel in places, what they find meaningful, and why (e.g. Chawla et al., 2014; Doherty et al., 2014). A focus on people's agency invites participatory research, planning and design to understand people's own views about how to create places that meet their needs (Derr et al., 2018).

Ideas about capabilities, self-determination and affordances are well suited to understand settings that promote learning. For children, free play and exploration are important means of learning. Decades of research indicate that nature spaces support better balance and coordination than built playgrounds, and nature's "loose parts" (Nicholson, 1971) encourage more dramatic, imaginative, constructive and cooperative play, associated with creativity and social-emotional learning (Wojciehowski and Ernst, 2018; Dankiw et al., 2020). Although adventure playgrounds are also stocked with loose parts that can be manipulated in creative ways (Houser et al., 2016); they cannot rival the range of multisensory experiences that biodiverse green spaces provide. Play in nature introduces children to elements of nature and other animals, forming a basis for affiliation and connection with nature, which is associated with both a sense of wellbeing and care for the natural world (Chawla, 2020; Lerstrup et al., 2021). Nature's diversity affords unlimited graduated challenges that enable young people to reach for ever-new achievements as their capacities grow—for example, the next wider point in a creek for a young child to leap, or the next higher cliff for teenagers to climb. These self-chosen mastery experiences promote autonomy and competence (Chawla and Heft, 2002; Chawla, 2021). These are examples of learning in preschools and informal settings. In the tradition of progressive education, many school programs for place-based education encourage students to make new discoveries and undertake new challenges outdoors in nature as part of formal learning (Smith and Sobel, 2010). Transactional theories encourage active processes of learning, rather than learning as the passive reception and repetition of information, and they form a framework for assessing it.

When people engage with nature through activities that support the development of their capabilities and self-determination, automatic physiological and psychological benefits of exposure to nature can be expected to happen simultaneously. For example, a study of Finnish preschools showed that when forest soil and biodiversity were layered over schoolyards, it stimulated the children's immune systems in positive ways (Roslund et al., 2020), as well as creative play, learning, and care for nature (Puhakka et al., 2019). Physiological and psychological benefits can be interactive, consistent with current knowledge in developmental and evolutionary biology which shows that interactions between an organism and its environment are part of a dynamic nested system with potential impacts at behavioral, psychological, anatomical, and physiological levels (Lickliter and Honeycutt, 2003). First steps in this direction have been taken by Dettweiler et al. (2022), who show that students who participated in an outdoor education program 1 day a week over the course of a year, compared to conventional classrooms, reported a greater sense of autonomy, which had a positive direct effect on brain maturation. A transactional approach can explore how time in nature *and* active engagement with its resources promotes healthy psychological and physiological development, to help guide investments in greening that support multiple dimensions of learning and wellbeing.

Author contributions

The author confirms being the sole contributor of this work and has approved it for publication.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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References

Andersen, L., Corazon, S. S., and Stigsdotter, U. K. (2021). Nature exposure and its effects on immune system functioning: a systematic review. *Int. J. Environ. Res. Public Health* 18, 1416. doi: 10.3390/ijerph18041416

Aristotle. (2014). *Nichomachean Ethics*. Trans. by R. Crisp (Cambridge: Cambridge University Press). Originally written ca. 350 B.C.E.

Baxter, D. E., and Pelletier, L. G. (2019). Is nature relatedness a basic human psychological need? A critical examination of the extant literature. *Can. Psychol.* 60, 21–34. doi: 10.1037/cap0000145

Bowler, D. E., Buyung-Ali, L. M., Knight, T. M., and Pullin, A. S. (2010). A systematic review of evidence for the added benefits to health of exposure to natural environments. *BMC Public Health* 10, 456. doi: 10.1186/1471-2458-10-456

Chawla, L. (2015). Benefits of nature contact for children. *J. Plan. Lit.* 30, 433–452. doi: 10.1177/0885412215595441

Chawla, L. (2020). Childhood nature connection and constructive hope: a review of research on connecting with nature and coping with environmental loss. *People Nat.* 2, 619–642. doi: 10.1002/pan3.10128

Chawla, L. (2021). "Knowing nature in childhood: Learning and wellbeing through engagement with the natural world," in *Nature and Psychology*, eds A. R. Schutte, J. C. Torquatti, and J. R. Stevens (Berlin: Springer), 153–93. doi: 10.1007/978-3-030-69020-5_6

Chawla, L., and Heft, H. (2002). Children's competence and the ecology of communities. *J. Environ. Psychol.* 22, 201–216. doi: 10.1006/jevp.2002.0244

Chawla, L., Keena, K., Pevec, I., and Stanley, E. (2014). Green schoolyards as havens from stress and resources for resilience. *Health Place* 28, 1–13. doi: 10.1016/j.healthplace.2014.03.001

Corazon, S. S., Sidenius, U., Poulsen, D. V., Gramkow, M. C., and Stigsdotter, U. K. (2019). Psycho-physiological stress recovery in outdoor nature-based interventions: a systematic review of the past eight years of research. *Int. J. Environ. Res. Public Health* 16, 1711. doi: 10.3390/ijerph16101711

Dankiw, K. A., Tsiros, M. D., Baldock, K. L., and Kumar, S. (2020). The impacts of unstructured nature play on health in early childhood development: a systematic review. *PLoS ONE* 15, e0229006. doi: 10.1371/journal.pone.0229006

Deci, E. L., and Ryan, R. M. (1985). *Intrinsic Motivation and Self-Determination in Human Behavior* (New York, NY: Plenum) doi: 10.1007/978-1-4899-2271-7

DeHaan, C. R., Hirai, T., and Ryan, R. M. (2016). Nussbaum's capabilities and self-determination theory's basic psychological needs: relating some fundamentals of human wellness. *J. Happiness Stud.* 17, 2037–2049. doi: 10.1007/s10902-015-9684-y

Derr, V., Chawla, L., and Mintzer, M. (2018). *Placemaking With Children and* Youth: Participatory Practices for Planning Sustainable Communities (New York, NY: New Village Press).

Dettweiler, U., Simon, P., Gerchen, M., and Kirsch, P. (2022). Choice matters: Pupil's stress regulation, brain development and brain function in an outdoor education project. *Br. J. Educ. Psychol.* doi: 10.111/bjep.12528

Doherty, S. T., McKeever, P., Aslam, H., Stephens, L., and Yantzi, N. (2014). Use of GPS tracking to interactively explore disabled children's mobility and accessibility patterns. *Child. Youth Environ.* 24, 1–24. doi: 10.7721/chilyoutenvi.24.1.0001

Gascon, M., Triguero-Mas, M., Martinez, D., Rojas-Rueda, D., Plascència, A., and Nieuwenhuijsen, M. J. (2016). Residential green space and mortality: a systematic review. *Environ. Int.* 86, 60–67. doi: 10.1016/j.envint.2015.10.013

Gibson, J. J. (1986). *The Ecological Approach to Visual Perception*. Mahwah, NJ: Lawrence Erlbaum Associates. Originally published in 1979.

Hartig, T. (2021). "Restoration in nature: beyond the conventional narrative," in: *Nature and Psychology*, eds A. R. Schutte, J. C. Torquatti, and J. R. Stevens (Berlin: Springer), 89–151. doi: 10.1007/978-3-030-69020-5_5

Heft, H. (2021). "Perceiving "natural" environments: an ecological perspective with reflections on the chapters," in: *Nature and Psychology*, eds A. R. Schutte, J. C. Torquatti, and J. R. Stevens (Berlin: Springer), 235–73. doi: 10.1007/978-3-030-69020-5_8

Houser, N. E., Roach, L., Stone, M. R., Turner, J., and Kirk, S. F. L. (2016). Let the children play. *AIMS Public Health* 3, 781–799. doi: 10.3934/publichealth.2016.4.781

Jimenez, M. P., DeVille, N. V., Elliott, E. G., Schiff, J. E., Wilt, G. E., Hart, J. E., et al. (2021). Associations between nature exposure and health: a review of the evidence. *Int. J. Environ. Res. Public Health* 18:4790. doi: 10.3390/ijerph18094790

Joye, Y., and van den Berg, A. E. (2011). Is love for green in our genes? A critical analysis of evolutionary assumptions in restorative environments research. *Urban For. Urban Green.* 10, 261–268. doi: 10.1016/j.ufug.2011.07.004

Kaplan, R., and Kaplan, S. (1989). *The Experience of Nature* (Cambridge: Cambridge University Press).

Kondo, M. C., Jacoby, S. F., and South, E. C. (2018). Does spending time outdoors reduce stress? A review of real-time stress response to outdoor environments. *Health Place* 51, 136–150. doi: 10.1016/j.healthplace.2018.03.001

Kuo, M., Barnes, M., and Jordan, C. (2019). Do experiences with nature promote learning? Converging evidence of a cause-and-effect relationship. *Front. Psychol.* 10:305. doi: 10.3389/fpsyg.2019.00305

Lee, E. S., Maillet, M. A., and Grouzet, F. M. E. (2021). Why do individuals engage with the natural world? A self-determination theory perspective on the effect of nature engagement and well-being. *Appl. Res. Qual Life.* 17: 1501–32. doi: 10.1007/s11482-021-09970-2

Lerstrup, I., Chawla, L., and Heft, H. (2021). Affordances of small animals for young children: a path to environmental values of care. *Int. J. Early Child. Environ. Educ.* 9, 58–76.

Li, Q. (2010). Effect of forest bathing trips on human immune function. *Environ. Health Prev. Med.* 15, 9–17. doi: 10.1007/s12199-008-0068-3

Lickliter, R., and Honeycutt, H. (2003). Developmental dynamics: toward a biologically plausible evolutionary psychology. *Psychol. Bull.* 129, 819–835. doi: 10.1037/0033-2909.129.6.819

Maas, J., Verheij, R. A., de Vries, S., Spreeuwenberg, P., Schellevis, F. G., and Groenewegen, P. P. (2009). Morbidity is related to a green living environment. *J. Epidemiol. Community Health* 63, 967–973. doi: 10.1136/jech.2008.079038

Markevych, I., Schoierer, J., Hartig, T., Chudnovsky, A., Hystad, P., Dzhambov, A. M., et al. (2017). Exploring pathways linking greenspace to health: theoretical and methodological guidance. *Environ. Res.* 158, 301–317. doi: 10.1016/j.envres.2017.06.028

Maslow, A. (1954). *Motivation and Personality* (New York, NY: Harper).

Nicholson, S. (1971). How not to cheat children: the theory of loose parts. *Landsc. Archit.* 62, 30–35.

Nussbaum, M. (2011). *Creating Capabilities* (Cambridge, MA: Harvard University Press). doi: 10.4159/harvard.9780674061200

Pollin, S., and Retzlaff-Furst, C. (2021). The school garden: a social and emotional place. *Front. Psychol.* 12:567720. doi: 10.3389/fpsyg.2021.567720

Puhakka, R., Rantala, O., Roslund, M. I., Rajaniemi, J., Laitinen, O. H., Sinkkonen, A., and ADELE Research Group (2019). Greening of daycare yards with biodiverse materials affords well-being, play and environmental relationships. *Int. J. Environ. Res. Public Health* 16, 2948. doi: 10.3390/ijerph16162948

Reed, E. S. (1996a). *The Necessity of Experience* (New Haven, CT: Yale University Press).

Reed, E. S. (1996b). *Encountering the World* (Oxford: Oxford University Press).

Rook, G. A. (2013). Regulation of the immune system by biodiversity from the natural environment. *Proc. Natl. Acad. Sci. U. S. A.* 110, 18360–18367. doi: 10.1073/pnas.1313731110

Roslund, M. I., Puhakka, R., Grönroos, M., Nurminen, N., Oikarinen, S., Gazali, A. M., et al. (2020). Biodiversity intervention enhances immune regulation and health-associated commensal microbiota among daycare children. *Sci. Adv.* 6. 134. doi: 10.1126/sciadv.aba2578

Russell, R., Guerry, A. D., Balvanera, P., Gould, R. K., Basurto, X., Chan, K. M. A., et al. (2013). Humans and nature: how knowing and experiencing nature affect well-being. *Annu. Rev. Environ. Resour.* 38, 473–502. doi: 10.1146/annurev-environ-012312-110838

Ryan, R. M., and Deci, E. L. (2017). *Self-Determination Theory* (New York, NY: Guilford Press).

Sen, A. K. (1985). Well-being, agency and freedom: the Dewey lectures 1984. *J. Philos.* 82, 169–221. doi: 10.2307/2026184

Slee, V., and Allan, J. F. (2019). Purposeful outdoor learning empowers children to deal with school transitions. *Sports* 7. doi: 10.3390/sports7060134

Smith, G. A., and Sobel, D. (2010). *Place- and Community-Based Education in Schools* (Routledge).

Stevenson, M. P., Schilhab, T., and Bentsen, P. (2018). Attention restoration theory II: a systematic review to clarify attention processes affected by exposure to natural environments. *J. Toxicol. Environ. Health B* 21, 227–268. doi: 10.1080/10937404.2018.1505571

Ulrich, R. S. (1983). "Aesthetic and affective response to natural environment," in: *Behavior and the Natural Environment*, eds I. Altman and J. F. Wohlwill (New York, NY: Plenum), 85–125. doi: 10.1007/978-1-4613-3539-9_4

van den Berg, A. E. (2021). "The natural-built distinction in environmental preference and restoration: bottom-up and top-down explanations," in: *Nature and Psychology*, eds A. R. Schutte, J. C. Torquatti, and J. R. Stevens (Berlin: Springer), 31–60. doi: 10.1007/978-3-030-69020-5_3

Ward Thompson, C., and Aspinall, P. A. (2011). Natural environments and their impact on activity, health, and quality of life. *Appl. Psychol. Health Well-Being* 3, 230–260. doi: 10.1111/j.1758-0854.2011.01053.x

White, R. W. (1959). Motivation reconsidered: the concept of competence. *Psychol. Rev.* 66, 297–333. doi: 10.1037/h0040934

Wojciehowski, M., and Ernst, J. (2018). Creative by nature: Investigating the impact of nature preschools on young children's creative thinking. *Int. J. Early Child Environ. Educ.* 6, 3–20.

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Campus Nature Rx: How investing in nature interventions benefits college students

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Introduction

The college experience is a time of discovery, learning, and personal growth. However, many U.S. college students report unprecedentedly high levels of mental health problems during these formative years. According to the 2021 National Collegiate Health Assessment, over 30 percent of students received psychological or mental health services in the previous 12 months. These challenges impact academic performance, with student classroom effectiveness reportedly reduced 22% due to depression, and nearly 38% due to stress (American College Health Assessment, 2022). Further, psychological issues are worsening. The most recent American Freshman National Survey revealed that incoming college students' self-reported physical and emotional health has been steadily declining since 1985 (Stolzenberg et al., 2020). Anxiety, depression, and sleep disorders are especially prevalent among college students (Pedrelli et al., 2015). In a 2020 national survey, two-thirds of student respondents cited loneliness as a distinct problem, an all-time high that reflects the mental health impact of the COVID-19 pandemic, including social distancing and other measures (McAlpine, 2021). Alongside these other stressors, chronic loneliness can, in extreme cases, cause young people to consider suicide. A pediatric emergency department study found a significant increase in suicide-risk among youth aged 11–21, before, vs. after the onset of the pandemic (Hill et al., 2021). In another national study, suicide death rates were highest among American Indian and Alaska Native people, males, and residents of rural areas (Saunders and Nirmita, 2022).

There are numerous underlying causes of this mental health crisis among college-aged youth. Among these are the effects of academic and financial pressures, relationship issues, information overload, anxiety about the future, screentime, and social media (Pedrelli et al., 2015). Rising campus mental health issues have placed unsustainable demands on college health clinics, particularly counseling and psychological service (CAPS) units. One study estimated that colleges with student populations of 15,000 spend on average $750,000 annually on student mental health care (Eisenberg, 2015). Further, higher caseloads per counselor are associated with fewer sessions per student,

less frequent appointments, reduced improvement in symptoms, and burnout among clinicians (American College Health Assessment, 2022).

Nature as a preventative, non-pharmacological intervention

In recent decades, an impressive number of studies have provided scientific evidence for the mental, and other health benefits of nature engagement. Among these benefits are reductions in stress (Antonelli et al., 2019; Hunter et al., 2019), anxiety (Bratman et al., 2015), and depression (Kondo et al., 2018), as well as improved memory recall, concentration, sleep patterns, and overall mood (Berman et al., 2008; Bratman et al., 2012). A 2017 review provided a comprehensive listing of the psychological, physiological, and behavioral benefits that can be derived from time in nature, as well as further research that needs to be conducted on each of these (Frumkin et al., 2017). Given the ample positive effects of nature exposure, a movement has arisen in recent years whereby healthcare providers prescribe time outdoors, to improve their patient's physical and mental health. These programs include Park Rx, Nature Rx, Walk with a Doc, Healthy Parks Healthy People, Nature as Medicine, among others.

The importance of time in nature for mental health and wellbeing also served as the nucleus of what has evolved into the Campus Nature Rx (CNRx) Network. From an initial partnership of four schools in 2019– Cornell University, University of California- Davis, University of Minnesota, and William & Mary– the network is now a coalition of over 50 U.S. colleges and universities (for a full list of current members, visit campusnature.com).

The Campus Nature Rx approach is based on the belief that a university education involves more than academics, addressing the whole person, including their connection to the natural world. Such programs support a sense of place and belonging at these institutions and are consistent with studies that have shown college students' valuing and use of green spaces on their campuses (Speake et al., 2013). Another unifying understanding among CNRx members is that any campus can support nature engagement, outside or indoors, *via* greenspace, gardens, trees, plants, nature imagery, biophilic design, and other approaches. Further, nature exposure can accommodate even the busiest student schedules. Research has shown that 1 and 5-min green microbreaks on campus greenspaces effectively support stress-relief (Ibes et al., 2018). Nature experiences of between 10 and 20 min have been shown to improve mood an average of 86% among student participants (Ibes and Forestell, 2022), and can significantly and positively impact psychological and physiological markers for college-aged individuals (Meredith et al., 2020). Given the theme of this special issue, the time duration of 20–30 min has been found to most efficient, after which physiological benefits continued to accrue but at a reduced rate (Hunter et al., 2019).

Campus Nature Rx approaches

At their respective institutions, members of the CNRx Network apply a diverse set of approaches to provide nature exposure and encourage nature engagement on their campuses. In many cases, members are collecting data to evaluate the reach and impact of such efforts. The primary approaches can be organized into the categories of Nature Rx programs, physical infrastructure, online maps, courses, communications, and nature-oriented activities.

Nature Rx programs

Since, 2017 professionals at the Cornell Health clinic have prescribed time in nature to students through electronic health records. During the '21-'22 academic year, 406 students received nature prescriptions, and 36 percent responded to a follow-up survey. At University of Kentucky, an interdisciplinary team is working with healthcare leadership to design and implement a pilot Nature Rx project adjacent to cancer treatment clinics. At William & Mary, a peer referral approach is employed by the Parks and Ecotherapy Research Lab (PERL) Campus Park Rx program, established in 2014. Trained Peer Park Ambassadors use a database to refer fellow students to one of over 100 local greenspaces based on their interests, needs, transportation options, and schedule. During the academic year, over 100 students receive a referral *via* an online form or tabling event on campus.

Green infrastructure

Some programs have focused on making existing outdoor spaces more comfortable, welcoming, and convenient. At Cornell, student-built sod sofas were placed around campus, Swarthmore provided oversized chairs on campus greens, and at William & Mary chair-bombing provides comfortable seating in underutilized campus greenspace. At University of Kentucky, the student-informed, interdisciplinary Mindful Oasis project partnered with Facilities Management to provide intentional spaces for wellness campus-wide, including pop-up seating areas. California State University Monterey Bay (CSUMB) was the first university to undertake the Living Community Challenge as part of its master planning processes. In a Research Methods class, students review the basic biophilic design elements, then use colored frames to highlight aspects of campus that feel supportive (green frames) or that they would change (red frames) to make the landscape more biophilic. In

terms of mental restoration, the majority of students emphasized the importance of light and views from interiors because that is where they spend the majority of their time, both studying and working. They also expressed wanting to see more blurring between the indoors and out, with interior gardens or plantings, and windowed areas that lead out to natural courtyards.

Online maps

Some CNRx members have developed online maps to support time outdoors. In March of 2020, William & Mary's PERL released their Campus Greenspace Map. Ten interactive maps display photos and details for 12 birding sites, 50 significant trees, and more than 100 greenspaces, hiking trails, sport areas, patios, and other outdoor spaces on campus. The sites are organized by activity (e.g., studying, relaxing, eating), so users can quickly find outdoor spaces that fit their needs and preferences, while helping them get their daily dose of nature. The map series is accessible *via* the official William & Mary app, and online (campusgreenspace.wm.edu). Members of NatureRx at UConn mapped 122 miles of hiking trails on and near campus. Mapped sites feature a description with photographs, alongside a student-produced guide to activities for engaging with nature (see naturerx.initiative.uconn.edu).

Courses

Both Cornell and UC Davis offer Nature Rx courses specific to their respective campuses. Pre- and post-surveys in both courses over a 2 year period demonstrated that students associate participation in the course with a strengthened belief in the value of spending time in nature to reduce stress, the creation and solidification of social bonds, and an expectation that the class would have a lasting impact (Kiers et al., 2021). At William & Mary, The Science and Experience of Ecotherapy has been a course offering since 2017. Validated pre- and post-surveys found that nature connectedness increased significantly following the course, and weekly 80-min ecotherapy practicums increased multiple dimensions of mood among students an average of 56%. Campus Nature Rx courses are also an opportunity to address inequity and barriers to nature access. A course at the University of Maryland, Black Bodies and Green Spaces: From 1619 to Today, critically examines how systemic racism has shaped the experience, connection, and relationship to nature among Black Americans. It also explores how many Black Americans regard nature as a space of freedom, humanity, and spirituality. At some institutions, a Nature Rx component has been a successful addition to existing course offerings. At the University of Minnesota, a virtual forest bathing experience was added to the first 20 min of each class in an evidence-based nursing practice and research course. The students reported a reduction in perceived stress and feelings of calm and increased awareness of the importance of taking time for oneself.

Communications and outreach

Campus Nature Rx programs utilize various modes of communication to support nature appreciation and engagement including social media, websites, newsletters, and media walls. Social media platforms including Facebook, Instagram, Twitter and TikTok are used by programs at UC Davis, U of Maryland, and W&M. William & Mary's PERL 2021 Greenspace March Madness and Where's Walnut Social Media campaigns garnered over 4,000 interactions in less than a month, and the program's website (which shares nature and health resources, research, and events), attracts an average of over 2,000 unique visitors a year. The UC Davis and W&M programs host regular newsletters, while media walls around the Cornell campus display messages of the benefits of time in nature.

Nature-oriented activities

CNRx programs are continuously experimenting with new ways to engage students with campus nature. Leaders at UC Davis have organized a Nature Rx Campus Community Health and Wellbeing Series, Sheep mowers, Chair Share Program, Learning by Leading internship program, and Public Outreach and Engagement activities including stargazing, Yoga in the Arboretum, Arboretum Bingo, and Nature Rx photo Scavenger Hunt. NatureRx at UConn has hosted a mini-symposium and Room to Grow, a house plant workshop, and co-sponsored an event called "Forest Bathing in the HEEP Forest." U of Maryland Master of Public Health students and faculty organized a forest bathing session. PERL at W&M has served over 200 students with programs including a Bird Scavenger Hunt and Map, Campus Tree Tours, and Greenspace Scavenger Hunt. The University of Florida produces illustrated nature guides that include images and descriptions of local organisms to increase students' awareness of and excitement about nearby nature. At U of Kentucky, CNRx members host wellness coaching, Walk with a Doc, tree walks, and tree week.

Discussion

The COVID pandemic had some administrators questioning the need for residential college experiences, particularly given the high cost of campus maintenance. The burgeoning Campus Nature Rx movement provides compelling evidence that on-campus nature experiences provide a high return on investment

by offering scientifically proven, equitable, and cost-effective solutions for improving college student mental health, among other benefits. Quantitative and qualitative data reveal that students value the natural elements and spaces on their campuses, as well as efforts to enhance their engagement with them. This sentiment was expressed by a Cornell Nature Rx student who wrote in a semester-end assessment, "Thank you so much for making my last semester at Cornell so special. Your class has been really impactful and I'm grateful for what we learned and experienced." Likewise, in an anonymous evaluation of the Science & Experience of Ecotherapy course, a Spring 2020 William & Mary graduate wrote, "There has been no more essential class in my career at WM—essential to my personal health, empowerment for the pursuit of my values, confidence in the expression of myself in the natural world and the increasing awareness of the beauty unfolding around me at all times. I feel closer to myself and more equipped to maneuver the adversity of life moving forward as a result of this class." In the midst of a college mental health crisis exacerbated by a global pandemic, CNRx offerings represent cost-effective and meaningful approaches for bolstering psychological resilience, helping students, and colleges, grow and thrive.

Author contributions

This opinion piece was co-authored by DR and DI, with much input from various members of the Campus Nature Rx Network. All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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References

American College Health Assessment (2022). *American College Health Association-National College Health Assessment III: Reference Group Executive Summary Fall 2021*. Silver Spring, MD: American College Health Association.

Antonelli, M., Grazia, B., and Davide, D. (2019). Effects of forest bathing (shinrin-yoku) on levels of cortisol as a stress biomarker: a systematic review and meta-analysis. *Int. J. Biometeorol.* 63, 1117–1134. doi: 10.1007/s00484-019-01717-x

Berman, M. G., Jonides, J., and Kaplan, S. (2008). The cognitive benefits of interacting with nature. *Psychol. Sci.* 19, 1207–2012. doi: 10.1111/j.1467-9280.2008.02225.x

Bratman, G. N., Hamilton, J. P., and Daily, G. C. (2012). The impacts of nature experience on human cognitive function and mental health. *Ann. N. Y. Acad. Sci.* 1249, 118–136. doi: 10.1111/j.1749-6632.2011.06400.x

Bratman, G. N., Hamilton, J. P., Hahn, K. S., Daily, G. C., and Gross, J. J. (2015). Nature experience reduces rumination and subgenual prefrontal cortex activation. *Proc. Natl. Acad. Sci. U.S.A.* 112, 8567–8572. doi: 10.1073/pnas.1510459112

Eisenberg, D. (2015). What should colleges spend on student mental health? *Psychol. Today*.

Frumkin et al. (2017). Nature contact and human health: a research agenda. *Environ. Health Perspect.* 125, 075001. doi: 10.1289/EHP1663

Hill, R. M., Rufino, K., Kurian, S., et al. (2021). Suicide ideation and attempts in a pediatric emergency department before and during COVID-19. *Pediatrics* 147, e2020029280. doi: 10.1542/peds.2020-029280

Hunter, M. C., Gillespie, B. W., and Chen, S. Y.-P. (2019). Urban nature experiences reduce stress in the context of daily life on salivary biomarkers. *Front. Psychol.* 10, 722. doi: 10.3389/fpsyg.2019.00722

Ibes, D. C., and Forestell, C. A. (2022). The role of campus greenspace and meditation on college students' mood disturbance. *J Am Coll Health* 70, 99–106. doi: 10.1080/07448481.2020.1726926

Ibes, D. C., Hirama, I., and Schuyler, C. (2018). Greenspace ecotherapy interventions: the stress reduction potential of green micro breaks integrating nature connection and mind body skills. *J. Ecopsychol.* 10, 137–150. doi: 10.1089/eco.2018.0024

Kiers, A., Donald, H. A., Rakow, Stacey, P., and Dewa, C. S. (2021). A pilot study on the potential for formalized nature-based instruction to mitigate stress and increase social bonds in university students. *J. Am. Coll. Health*. doi: 10.1080/07448481.2021.1943412

Kondo, M. C., Jacoby, S. F., and South, E. C. (2018). Does spending time outdoors reduce stress? A review of real-time stress response to outdoor environments. *Health Place* 51, 136–150. doi: 10.1016/j.healthplace.2018.03.001

McAlpine, K. J. (2021). Depression, Anxiety, Loneliness are Peaking in College Students. *The Brink*. https://www.bu.edu/articles/2021/depression-anxiety-loneliness-are-peaking-in-college-students (accessed May 8, 2022).

Meredith, G., Rakow, D. A., Eldermire, E. R. B., Madsen, G. C., Sachs, N. A., and Shelley, S. P. (2020). What is the minimum time dose in nature to positively impact the mental well-being of college-aged students and how to measure it: a scoping review. *Front. Psychol.* 10. doi: 10.3389/fpsyg.2019.02942

Pedrelli, P., Nyer, M., Yeung, A., Zulauf, C., and Wilens, T. (2015). College students: mental health problems and treatment considerations. *Acad. Psychiatry* 39, 503–511. doi: 10.1007/s40596-014-0205-9

Saunders, H., and Nirmita, P. (2022). *A Look at Suicide Rates Ahead of 988 Launch- A National Three-Digit Suicide Prevention Hotline. Kaiser Family Foundation News*. Available online at: https://www.kff.org/other/issue-brief/a-look-a-suicide-rates-ahead-of-988-launch-a-national-three-digit-suicide-prevention-hotline/ (accessed May 8, 2022).

Speake, J., Edmonson, S., and Nawaz, H. (2013). Everyday encounters with nature: students' perceptions and use of university campus green spaces. *Hum. Geogr.* 7, 21–31. doi: 10.5719/hgeo.2013.71.21

Stolzenberg, E. B., Aragon, M. C., Romo, E., Couch, V., McLennan, D., Eagan, M. K., et al. (2020). *The American Freshman: National Norms Fall 2019*. Los Angeles: Higher Education Research Institute, UCLA.

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Young children contribute to nature stewardship

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Research on young children in environmental education (EE) has focused on unstructured play in, or experiencing, nature. Little attention has been paid to young children's stewardship efforts, or to the relation of such efforts to young children's learning and capacity to contribute to their communities and local nature. This perspectives paper draws on the first author's experience guiding pre-k and kindergarten children (4–6 years old) in outdoor educational projects in Santo Domingo (SD), Dominican Republic, in which the children produced a park guide and a short film. In addition to becoming resources for the local community, these products are an example of children's civic contributions. In "return on investment" language, guiding young children in outdoor experiences and reflecting on the experience represent the investment and the park guide and other products, and importantly, children's recognition of their ability to make contributions to their community, represent the return on investment. Based on our observations that young children can make significant contributions to their communities when given the opportunity, this perspectives paper argues for a research agenda and investment in opportunities for young children to contribute to their socio-ecological communities. To support our perspective, we first review and critique the prevailing and emerging paradigms of early childhood EE, following which we briefly describe the Santo Domingo (SD) project, and close by integrating past work with the first author's experience to argue for the importance of including young children in stewardship efforts.

KEYWORDS

young children's nature stewardship, early childhood environmental education, children as active citizens, children's contribution, early childhood education for sustainability

Introduction

Young children are generally viewed as "actors and creators of the future" (Heggen et al., 2019, p. 387, 2019). But what if, instead of environmental education (EE[1]) programs viewing young children as *future* adult stewards, young children engaged in stewardship, i.e., community participation to enhance circumstances for participants, the greater community of life, and future generations of both humans and nature (Elliott and Davis, 2009). Recognizing that some scholars will object to what may be seen as inappropriate pedagogies for early childhood, we argue that when adults provide age-appropriate affordances, young children are capable of contributing to nature restoration and improving their communities, and themselves benefit from such engagement. To support our perspective, we first review and critique the literature on early childhood EE approaches, and then offer a short description of programs in which young children engaged in stewardship in SD, Dominican Republic.

Literature review

Below we review four trends in early childhood EE: Nature play, post-humanism, early childhood education for sustainability (ECEfS), and positive youth development (PYD).

Nature-play as environmental education

EE has often neglected young children's capacity to contribute to their local socio-ecological communities. Traditionally, EE has emphasized children as future environmental stewards and has assumed that children's outdoor play and joyful time in nature leads to connection to or love for nature (Chawla, 1998, 1999; Hägglund and Samuelsson, 2009; Rice and Torquati, 2013; McClain and Vandermaas-Peeler, 2016) and that these dispositions will encourage children to become adults who are capable of nurturing and taking care of nature (Chawla, 1998, 1999, 2009; Wells and Lekies, 2006; McClain and Vandermaas-Peeler, 2016; Hoover, 2021). However, there is limited evidence that outdoor play and connection to nature as a child leads to adult nature stewardship (Gill, 2014; Rosa and Collado, 2019).

Research has demonstrated the social, cognitive, and health benefits of young children's unstructured play in nature (Louv, 2008; Ardoin and Bowers, 2020). Moreover, Ernst and Burcak (2019) conducted four pilot studies of nature-based preschools where children had weekly time for play and exploration in nature. They found that play in nature promoted curiosity, creative thinking, executive functioning, and resilience, which are key problem-solving skills for humans to contribute to a sustainable future.

Post-humanist environmental education

More recently, EE has made use of post-humanist theories and common-world pedagogies to challenge the dichotomy between human/nature and nature/culture, and contest notions that suggest (a) humans are apart from nature and (b) humans' role is to protect nature. These scholars argue that children are nature and encourage a relational approach or kinship-making with the non-human world (Taylor, 2017; Cutter-Mackenzie-Knowles et al., 2020). Post-humanist and common world pedagogies scholars argue that stewardship pedagogies do not offer the necessary transformation to counteract the effects of the Anthropocene and to transgress the narratives that shape today's world, and thus, they reinforce human-centric perspectives in EE (Taylor, 2017; Cutter-Mackenzie-Knowles et al., 2020). For them, educational approaches must radically change human thinking to understand that agency is a shared trait across humans, non-human species, and objects. For example, Stevenson et al. (2020) explains that non-human nature's materiality interacts with human agency, by delineating what "humans learn about/in/for nature" (p. 1417). Thus, non-human nature is not an inactive entity for children's knowledge and experiences, and humans should not assume the role of nature steward or conserver.

Early childhood education for sustainability

In contrast to Post humanist approaches, Education for Sustainability (ESD) understands humans as "agents of change" (Elliott and Davis, 2009, p. 67) and focuses on the process of learning to act in a "sustainable way" (Christie and Higgins, 2012, p. 7). It is inclusive of groups that have been considered of minor importance, such as children, future generations, and non-human nature. According to Ernst and Burcak (2019), ECEfS seeks to promote children's critical thinking and problem-solving, and children becoming "agents of change for sustainability" (p. 2) through decision-making and taking actions on local sustainability issues. Hedefalk et al. (2015) define ECEfS as an educational approach that integrates knowledge about how ecosystems function, direct experience in nature, and authentic participation

1 Environmental Education will be used in this paper as a broad construct to refer to children and nature educational experiences. This is the most common term used in North America, although we recognize other terms such as ESD and Education for Sustainable Development are commonly used in other regions with similar albeit slightly different meanings (Elliott and Davis, 2009; Stevenson et al., 2013; Ernst and Burcak, 2019).

in solving environmental issues; it also emphasizes the interconnected dimensions of sustainability—economic, social, and environmental.

Positive youth development

The PYD literature is consistent with ECEfS notions of children as agents of change. Nature stewardship at an early age could promote in children a positive developmental path, with similar outcomes to PYD programs for teen-aged youth such as engaging youth in community gardening and other means of contribution to one's community (Delia and Krasny, 2018). Lerner et al. (2005) proposed the Six C's framework for PYD: "competence, confidence, connection, character, caring, and contribution to the community and civil society" (p. 23). The sixth C ("contribution") refers to youth engagement in community service, local decision-making, and other activities where youth actively create positive change in their community. Several studies have linked youth contribution to outcomes for youth, including wellbeing and eco-literacy (Eccles and Gootman, 2002); ecological place meaning (Kudryavtsev et al., 2012); place-identity (Armstrong, 2022); social connections, sense of belonging and leadership (Delia and Krasny, 2018); civic skills (Russ and Gaus, 2021); academic attainment (Volk and Cheak, 2003); and connection to nature (Schusler et al., 2009).

When investments are made in adapting PYD programs for younger children, participants may experience the social and cognitive benefits that have been demonstrated for adults and youth who participate in community-based environmental stewardship or nature-restoration activities (Delia and Krasny, 2018; Russ and Gaus, 2021; Armstrong, 2022). For example, Schusler et al. (2009) found that educators who guide youth participatory stewardship and related participatory programs observe in youth increased affection for nature, recognition of social justice issues, self-esteem, self-efficacy, and citizenship skills. We contend it would be worth exploring similar participatory stewardship programs with young children.

Young children can be nature stewards

We now turn to our perspective arguing for the importance of young children as nature stewards. In so doing, we present several arguments for children as stewards while integrating our perspective into critiques of the existing literature.

According to Serriere (2019), civic engagement at an early age occurs when children participate in improving their local context, and this participation becomes the foundation for a "lifetime of civic engagement and empowerment" (p. 384). By age four, children are capable of recognizing feelings, dispositions, abilities, and actions among their peers and adults in familiar settings, which are key social skills that enable them to cooperate with others (Flekkøy and Kaufman, 1997; Mar et al., 2010). Furthermore, preschoolers are able to use information from intentional observation and involvement to learn cause-effect relations (Kushnir et al., 2008). According to socio-cultural approaches to learning, by age five children develop through their dynamic and growing participation in the socio-cultural activities of their communities (Rogoff, 2003). In sum, young children have the capacity to participate in civic engagement activities, including stewardship, and this participation could facilitate healthy development.

In fact, early childhood is a critical time to engage in stewardship. Early childhood is the ontogenetic stage where humans learn to interact with others in their socio-cultural context and to create "humanlike social and cultural activities" (Tomasello et al., 2005, p. 676). Further, because humans learn the foundational knowledge, skills, behaviors, and values that will accompany them through life during childhood (Young and Mundial, 1996; Samuelsson, 2011), and because in an era of environmental crises learning positive ways to relate to nature should be considered a basic skill (Ärlemalm-Hagseér, 2013; Cutter-Mackenzie et al., 2014; Buil et al., 2019; Ernst and Burcak, 2019), early childhood is an ideal period for humans to learn to use their body, mind, and emotions to connect to the larger community of life through stewardship. By doing so, children can become embedded in a culture of nature caring and restoration instead of nature extraction, ethically and empathetically connect to and familiarize themselves with nature, understand the interdependency between humans and nature, and advance their social, cognitive, and wellbeing capacities, while contributing to the flourishing of the natural world.

In arguing that the early years are a decisive period for learning about and creating social and cultural practices aimed at restoring and regenerating nature, we recognize that nature play and post-humanist EE do not address children's contribution. Current guidelines for early childhood EE focus on free playtime in nature rather than on young children responding to the environmental challenges of their communities (Ärlemalm-Hagseér, 2013; Cincera et al., 2017; Ardoin and Bowers, 2020), thus positioning children as passive agents and removing them from opportunities for civic engagement to help resolve environmental crises. Ernst and Burcak (2019) argue that cognitive skills promoted in nature-based preschools are key to solving future sustainability issues. However, scholars have challenged the assumption that young children playing in or experiencing nature will lead to stewardship and have promoted children's direct participation in addressing environmental problems (Elliott and Davis, 2009; Davis, 2010; Blanchard and Buchanan, 2011; Cutter-Mackenzie et al., 2014; Davis and Elliott, 2014; Gill, 2014) and in practicing civic environmental skills (Ärlemalm-Hagseér, 2013). Yet, the

nature-play to nature-stewardship paradigm has prevailed in EE (Ardoin and Bowers, 2020).

In addition, as post-humanist EE gains in popularity and continues to promote non-stewardship pedagogies, its proponents will need to examine questions such as children's adaptive response to current ecological threats, and the impact of children's actions on earth systems. In our view, stewardship and relational values can find common ground. Children should learn about and adopt ecocentric values and relational approaches to relate to non-human nature, which guide restorative and regenerating practices (stewardship) of non-human nature.

Further, post-humanist EE ignores the uniqueness of humans' socio-cognition (Tomasello, 2019; Laland and Seed, 2021), which evolved in reaction to ecological threats that obliged humans to cooperate to gather food and protect their possessions from other groups. Human distinctive socio-cognitive skills emerge from cooperating and exchanging information and ideas while engaging in socio-cultural endeavors with other humans (Tomasello, 2019). Children inherit the sociocultural context (e.g., symbols, institutions) and their unique capacities to fully mature would be hindered without this context (Tomasello, 2019). Unfortunately, children also receive socio-cultural practices that deplete the Earth. To counteract these practices, children must participate in socio-cultural practices where they learn to be and become citizens who regenerate and positively transform their socio-ecological system. In short, we consider children *taking action* essential.

Having challenged notions about children as *future* nature stewards and non-stewardship pedagogies and having introduced our perspective about young children as social actors and agents of change, we next turn to examples of children contributing to their community.

Young children's contributions in Santo Domingo

The Park Guide project, conducted by kindergarteners (4–6-year-olds) and facilitated by the first author in SD, Dominican Republic, provides an example of children's participatory stewardship. Children participating in the 9-month project explored, played in, and researched six urban parks, and then designed, wrote, and published "*Guía de Parques Divertidos*" (*Fun Park Guide*), a new public resource and that added value to the community. A key attribute of this project was the use of reflection, such as collective journaling and exploring art-based tools, in conjunction with children's direct experiences in the park. This process helped to broaden children's thinking, interpretations, and communication about their park experiences, while writing the guide.

The SD Forest Exploration Project engaged pre-K and kindergarten children over two academic years in planned educational experiences, including roleplay in imaginary wooded settings, playing and exploring in a small wooded area in a botanic garden, and reflection activities, such as drawing, painting, composition, and journaling about forests. By the end of the first year, a group of four children had written a fictional story about animals saving the forest from a dangerous entity, called "Hombre-árbol" (Man-tree). In the second year, children decided to compose and perform a screenplay for a short film, which was recorded in the botanic garden woods. This was the first movie written by Dominican children, and it was presented at the 6th Dominican Global Film Festival.

In both projects, children had the opportunity of free play. Play is the leading interest and pursuit for 3–6-year-old children (Bredekamp, 2004; Karpov, 2005; Paley, 2009) and adults' mediation in children's play promotes children's mental processes (Bredekamp, 2004; Karpov, 2005). Nature stewardship should be designed as a play-based pedagogy, honoring both children's free play and adult mediation to promote children's contribution and reflection.

These and other projects that use direct experiences and reflection to connect children to nature and enable them to contribute to their community represent an investment in young children's ability to be productive members of society. The children's accomplishments, including producing a park guide and a film, are the return on investment. Although we did not conduct research on the project outcomes for children, the first author's observations and the literature would suggest additional returns on investment, including children's development of socio-emotional, cognitive, and academic skills, connection to nature, and sense of contribution.

Components of a young children's stewardship project

Providing the affordances for children to become agents of change requires time and strong ethics. For example, educators should familiarize themselves with the community's socio-cultural and historical context and develop a trusting relationship and rapport with the children. Additionally, adults must be well equipped to facilitate children's authentic participation and decision-making and to design adequate educational experiences based on children's needs and interests. Further, three components—reflection, non-objectification of nature, and a shared strong image of a child—are crucial investments in stewardship programs that yield returns for communities and children.

Reflection

To guide young children in stewardship will require not only an investment in planning and implementing age-appropriate

hands-on activities, but also in designing age-appropriate means for young children to reflect on those activities. Reflection is the process of (re)constructing participation, practice, knowledge, or issue with the aim of impacting the mental schema of an individual, and therefore, promoting behavioral change (Korthagen et al., 2001). Reflection activities can allow children to connect stewardship to broader understanding and an awareness of the importance of their actions. When children share their reflections with adults, adults recognize young children's perspectives, knowledge, and learning processes, and support them to effect change.

Non-objectification of nature

Stewardship programs should teach children about nature's agency and nature as a teacher (Elliott and Davis, 2009; Cutter-Mackenzie-Knowles et al., 2020). Reflection prompts in stewardship programs could relate to this shared agency: How did you care for nature today? How is nature taking care of you today? What did we learn from non-human nature today?

A shared strong image of the child

According to Malaguzzi (1994), adults have "images of the child" (p. 1) that mediate the way they connect with a child, which in turn impacts the child's image of the way adults act toward, get to know, hear, and pay attention to a child. Salamon and Harrison (2015) add that early childhood educators' images of children guide their pedagogies, and therefore, facilitate or limit children's experiences. The SD projects described above were only possible due to the preschool community's shared support and ethos about the image of the child as capable, full of potential, and with the right to participate in authentic and joyful learning experiences.

Final remarks

To what extent do these interventions support the development of contribution, connection to nature, and children's understanding of their ability to regenerate nature? This is a question to be answered in further research. Researchers might examine children's learning, the quality of the children-nature interaction, and environmental and other outcomes. Longitudinal or retrospective studies also will promote understanding of the influence of stewardship on children throughout the lifespan.

Young children can be nature stewards *now*. They can be Dr. Seuss's (1971) Lorax who "speaks for the trees" or the child that received the seed and the message from the Lorax: "UNLESS someone like you Cares a whole awful lot, Nothing is going to get better. It's not." Children have agency and the right to participate and should not have to wait until their youth or adulthood to engage in nature conservation and restoration initiatives.

Author contributions

ED: substantial contributions to the conception or design of the work, or the acquisition, analysis or interpretation of data for the work, and drafting the work or revising it critically for important intellectual content. MK: drafting the work or revising it critically for important intellectual content, provide approval for publication of the content, agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. Both authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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References

Ardoin, N. M., and Bowers, A. W. (2020). Early childhood environmental education: A systematic review of the research literature. *Educ. Res. Rev.* 31:100353. doi: 10.1016/j.edurev.2020.100353

Ärlemalm-Hagseér, E. (2013). Respect for Nature-a Prescription for Developing Environmental Awareness in Preschool. *CEPS J.* 3, 25–44. doi: 10.26529/cepsj.249

Armstrong, A. K. (2022). *Resisting Place Stigma on The Bronx River*. [Ph.D thesis] Ithaca, NY: Cornell University.

Blanchard, P. B., and Buchanan, T. K. (2011). Environmental stewardship in early childhood. *Child. Educ.* 87, 232–238. doi: 10.1080/00094056.2011.10523184

Bredekamp, S. (2004). "Play and school readiness," in *Children's Play: The Roots of Reading*, eds E. F. Zigler, D. G. Singer, and S. J. Bishop-Josef (Washington, DC: ZERO TO THREE), 159–174.

Buil, P., Roger-Loppacher, O., and Tintoré, M. (2019). Creating the habit of recycling in early childhood: A sustainable practice in Spain. *Sustainability* 11:6393. doi: 10.3390/su11226393

Chawla, L. (1998). Significant Life Experiences Revisited: A Review of Research on Sources of Environmental Sensitivity. *J. Environ. Educ.* 29, 369–382. doi: 10.1080/00958969809599114

Chawla, L. (1999). Life Paths into Effective Environmental Action. *J. Environ. Educ.* 31, 15–26. doi: 10.1080/00958969909598628

Chawla, L. (2009). Growing up green: Becoming an agent of care for the natural world. *J. Dev. Process.* 4, 6–23.

Christie, B., and Higgins, P. (2012). The impact of outdoor learning experiences on attitudes to sustainability: A Review of Literature. Field Studies Council Report-University of Edinburgh. Available online at: https://www.research.ed.ac.uk/en/publications/the-impact-of-outdoor-learning-experiences-on-attitudes-to-sustai

Cincera, J., Kroufek, R., Simonova, P., Broukalova, L., Broukal, V., and Skaliik, J. (2017). Eco-School in kindergartens: The effects, interpretation, and implementation of a pilot program. *Environ. Educ. Res.* 23, 919–936. doi: 10.1080/13504622.2015.1076768

Cutter-Mackenzie, A., Edwards, S., Moore, D., and Boyd, W. (2014). *Young Children's Play and Environmental Education in Early Childhood Education*. Berlin: Springer Science & Business Media.

Cutter-Mackenzie-Knowles, A., Malone, K., and Barratt Hacking, E. (2020). "Childhoodnature: Nabi [begin]," in *Research Handbook on Childhoodnature: Assemblages of Childhood and Nature Research*, eds A. Cutter-Mackenzie-Knowles, K. Malone, and E. Barratt Hacking (Berlin: Springer), doi: 10.1007/978-3-319-67286-1

Davis, J. (2010). Early childhood education for sustainability: Why it matters, what it is, and how whole centre action research and systems thinking can help. *J. Action Res. Today Early Child.* 2010, 35–44.

Davis, J., and Elliott, S. (eds) (2014). *Research in Early Childhood Education for Sustainability: International Perspectives and Provocations*. Milton Park: Routledge.

Delia, J., and Krasny, M. E. (2018). Cultivating positive youth development, critical consciousness, and authentic care in urban environmental education. *Front. Psychol.* 8:2340. doi: 10.3389/fpsyg.2017.02340

Eccles, J., and Gootman, J. A. (2002). *Community Programs to Promote Youth Development*. Washington, D.C.: National Academies Press.

Elliott, S., and Davis, J. (2009). Exploring the resistance: An Australian perspective on educating for sustainability in early childhood. *Int. J. Early Child.* 41, 65–77. doi: 10.1007/BF03168879

Ernst, J., and Burcak, F. (2019). Young children's contributions to sustainability: The influence of nature play on curiosity, executive function skills, creative thinking, and resilience. *Sustainability* 11:4212. doi: 10.3390/su13137443

Flekkøy, M. G., and Kaufman, N. H. (1997). *The Participation Rights of the Child: Rights and Responsibilities in Family and Society*. London: Jessica Kingsley Publishers.

Gill, T. (2014). The benefits of children's engagement with nature: A systematic literature review. *Child. Youth Environ.* 24, 10–34. doi: 10.7721/chilyoutenvi.24.2.0010

Hägglund, S., and Samuelsson, I. P. (2009). Early childhood education and learning for sustainable development and citizenship. *Int. J. Early Child.* 41, 49–63. doi: 10.1007/BF03168878

Hedefalk, M., Almqvist, J., and Östman, L. (2015). Education for sustainable development in early childhood education: A review of the research literature. *Environ. Educ. Res.* 21, 975–990. doi: 10.1080/13504622.2014.971716

Heggen, M. P., Sageidet, B. M., Goga, N., Grindheim, L. T., Bergan, V., Krempig, I. W., et al. (2019). Children as eco-citizens? *Nord. Stud. Sci. Educ.* 15, 387–402. doi: 10.5617/nordina.6186

Hoover, K. S. (2021). Children in nature: Exploring the relationship between childhood outdoor experience and environmental stewardship. *Environ. Educ. Res.* 27, 894–910. doi: 10.1080/13504622.2020.1856790

Karpov, Y. V. (2005). *The neo-vygotskian approach to child development*. New York, NY: Touro College.

Korthagen, F. A., Kessels, J., Koster, B., Lagerwerf, B., Wubbels, T. (2001). *Linking Practice and Theory: the Pedagogy of Realistic Teacher Education*. Mahwah: Lawrence Erlbaum Associates Publishers.

Kudryavtsev, A., Krasny, M. E., and Stedman, R. C. (2012). The impact of environmental education on sense of place among urban youth. *Ecosphere* 3, 1–15. doi: 10.1890/ES11-00318.1

Kushnir, T., Wellman, H. M., and Gelman, S. A. (2008). The role of preschoolers' social understanding in evaluating the informativeness of causal interventions. *Cognition* 107, 1084–1092. doi: 10.1016/j.cognition.2007.10.004

Laland, K., and Seed, A. (2021). Understanding human cognitive uniqueness. *Annu. Rev. Psychol.* 72, 689–716. doi: 10.1146/annurev-psych-062220-051256

Lerner, R. M., Lerner, J. B., Almerigi, C., Theokas, E., Phelps, S., and Gestsdottir, S. (2005). Positive youth development, participation in community youth programs, and community contributions of fifth-grade adolescents: Findings from the first wave of the 4-H study of positive youth development. *J. Early Adolesc.* 25, 17–71. doi: 10.1177/0272431604272461

Louv, R. (2008). *Last Child in the Woods: Saving Our Children from Nature-Deficit Disorder*. Chapel Hill, NC: Algonquin books.

Malaguzzi, L. (1994). Your image of the child: Where teaching begins. *Child Care Inform. Exchange* 3, 52–52.

Mar, R. A., Tackett, J. L., and Moore, C. (2010). Exposure to media and theory-of-mind development in preschoolers. *Cogn. Dev.* 25, 69–78. doi: 10.1016/j.cogdev.2009.11.002

McClain, C., and Vandermaas-Peeler, M. (2016). Outdoor Explorations with Preschoolers: An Observational Study of Young Children's Developing Relationship with the Natural World. *Int. J. Early Child. Environ. Educ.* 4, 37–53.

Paley, V. G. (2009). *a Child's Work*. Chicago, IL: University of Chicago Press.

Rice, C S., and Torquati, J. (2013). Assessing Connections between Young Children's Affinity for Nature and Their Experiences in Natural Outdoor Settings in Preschools. *Child. Youth Environ.* 23, 78–102. doi: 10.7721/chilyoutenvi.23.2.0078

Rogoff, B. (2003). *the Cultural Nature of Human Development*. Oxford: Oxford university press.

Rosa, C. D., and Collado, S. (2019). Experiences in nature and environmental attitudes and behaviors: Setting the ground for future research. *Front. Psychol.* 10:763. doi: 10.3389/fpsyg.2019.00763

Russ, A., and Gaus, M. B. (2021). Youth civic engagement in urban agriculture education: A rapid scoping review. *Front. Sustain. Food Syst.* 5:707896. doi: 10.3389/fsufs.2021.707896

Salamon, A., and Harrison, L. (2015). Early childhood educators' conceptions of infants' capabilities: The nexus between beliefs and practice. *Early Years* 35, 273–288. doi: 10.1080/09575146.2015.1042961

Samuelsson, I. P. (2011). Why we should begin early with ESD: The role of early childhood education. *Int. J. Early Child.* 43, 103–118. doi: 10.1007/s13158-011-0034-x

Schusler, T. M., Krasny, M. E., Peters, S. J., and Decker, D. J. (2009). Developing citizens and communities through youth environmental action. *Environ. Educ. Res.* 15, 111–127. doi: 10.1080/13504620802710581

Serriere, S. C. (2019). "Social Studies in the Early Years," in *The Wiley Handbook of Early Childhood Care and Education*, eds C. B. Brown, M. B. Mclullen, and N. File (Hoboken, NJ: Wiley Blackwell), 377–401.

Stevenson, R. B., Brody, M., Dillon, J., and Wals, A. E. J. (2013). "Introduction: An orientation to the Environmental Education and the Handbook," in *International Handbook of Research on Environmental Education*, eds R. B. Stevenson, M. Brody, J. Dillon, and A. E. J. Wals (Milton Park: Taylor & Francis Group), 1–12.

Stevenson, R. B., Mannion, G., and Evans, N. (2020). "Childhoodnature Pedagogies and Place: An Overview and Analysis," in *Research Handbook on Childhoodnature: Assemblages of Childhood and Nature Research*, eds A. Cutter-Mackenzie-Knowles, K. Malone, and E. Barratt Hacking (Berlin: Springer)1401–1421. doi: 10.1007/978-3-319-67286-1

Taylor, A. (2017). Beyond stewardship: Common world pedagogies for the Anthropocene. *Environ. Educ. Res.* 23, 1448–1461. doi: 10.1080/13504622.2017.1325452

Tomasello, M. (2019). *Becoming Human: a Theory of Ontogeny*. Cambridge, MA: Harvard University Press.

Tomasello, M., Carpenter, M., Call, J., Behne, T., and Moll, H. (2005). Understanding and sharing intentions: The origins of cultural

cognition. *Behav. Brain Sci.* 28, 675–691. doi: 10.1017/S0140525X05470120

Volk, T. L., and Cheak, M. J. (2003). The effects of an environmental education program on students, parents, and community. *J. Environ. Educ.* 4, 12–12. doi: 10.1080/00958960309603483

Wells, N. M., and Lekies, K. S. (2006). Nature and the life course: Pathways from childhood nature experiences to adult environmentalism. *Child. Youth Environ.* 16, 1–24.

Young, M. E., and Mundial, B. (1996). *Early child development: Investing in the Future*. Washington, DC: World Bank.

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Residential green space associated with the use of attention deficit hyperactivity disorder medication among Dutch children

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Several studies have observed an inverse relationship between attention deficit hyperactivity disorder (ADHD)-related behavior of children, as reported by parents or teachers, and the amount of green space in their residential environment. Research using other, more objective measures to determine ADHD prevalence is scarce and could strengthen the evidence base considerably. In this study, it is investigated whether a similar beneficial association will be observed if the use of ADHD-related medication is selected as an outcome measure. More specifically, registry data from a health insurance company on the reimbursement of ADHD-related medication in 2011 were available for 248,270 children between 5 and 12 years of age. Amounts of green space within 250 and 500 m of the home address were calculated. Multilevel logistic regression analyses for the prevalence of use were conducted, including the following covariates: sex, age, urbanity of the neighborhood, neighborhood socioeconomic status (SES), and percentage of people with a non-Western migration background in the neighborhood population. Results showed that the amount of green space was inversely related to the prevalence of use of ADHD medication. Moreover, the relationship was strongest among children living in the least wealthy neighborhoods and absent among those living in the wealthiest neighborhoods. Results also show that in less wealthy neighborhoods, there is, on average, less green space available nearby: children who are likely to benefit most from nearby green space tend to have the least of it.

KEYWORDS

residential environment, green space, children, ADHD, medication, socioeconomic status, ethnicity, registry data

Introduction

Due to increasing urbanization, daily contact with nature is becoming less common, also for children (Seltenrich, 2015). A systematic review suggests that this may have detrimental consequences for the mental health of children, especially when it comes to hyperactivity and inattention problems (Vanaken and Danckaerts, 2018). According to a recent international consensus statement, attention deficit hyperactivity disorder (ADHD) is rarely caused by a single genetic or environmental risk factor, but most cases of ADHD are caused by the combined effects of many genetic and environmental risks, each having a very small effect (Faraone et al., 2021). A lack of contact with nature might be one of them. Conversely, cross-sectional studies show beneficial associations between the amount of or access to residential green space and ADHD-related issues in children (Amoly et al., 2014; Balseviciene et al., 2014; Flouri et al., 2014; Markevych et al., 2014; Lee et al., 2019). A causal interpretation of the aforementioned cross-sectional findings is supported by an experimental study showing that a walk in a green environment improved the ability to concentrate in children diagnosed with ADHD, at least for a short time (Faber-Taylor and Kuo, 2009).

This latter result is consistent with a much larger body of experimental evidence, mainly based on research on adults, showing that contact with nature has attention-restoring and stress-reducing effects (Hartig et al., 2014; Markevych et al., 2017). Theoretically, these experiments are predominantly based on the attention restoration theory (ART) and/or the stress reduction theory (SRT). The ART states that natural environments tend to require less directed attention than built-up environments, allowing restoration of this resource when it previously has been depleted (Kaplan and Kaplan, 1989). The SRT states that because of the humankind's evolutional history, exposure to unthreatening natural settings has immediate calming effects on stressed individuals, physiologically as well as emotionally (Ulrich, 1981). Thus, according to the two theories, contact with nature may have a calming effect on children with ADHD and increase their ability to concentrate and decrease impulsive behavior. This may be facilitated by an ample supply of opportunities for such contacts in the residential environment of the children. Nearby green space may also promote active outdoor play and burning off excess energy in the process (see, e.g., Lachowycz et al., 2012). Based on a web-based survey among parents and guardians, Faber-Taylor and Kuo (2011) concluded that children officially diagnosed with ADHD who played outside in a natural environment displayed less severe symptoms than those who played indoors or in a predominantly built-up environment.

The cross-sectional studies mentioned previously make use of ADHD-related behavior, as reported by parents or teachers [for more recent examples, see Yang et al., 2019; Dzhambov et al., 2022, looking (also) at the school environment]. On the one hand, parents and teachers offer a valuable source of information, with reports being based on direct and long-term observation of the children's behavior. On the other hand, self-selection may occur, and reporting biases may exist, especially in medically untrained people. Confirmation of these earlier findings using a different source of information on the prevalence of ADHD will strengthen the evidence base considerably. One such source is administrative data on the use of ADHD medication. In this study, we use reimbursement data from a large health insurance company in the Netherlands. It may be noted that displaying ADHD-related behavior and the reimbursement of ADHD medication do not have a one-on-one relationship: the former does not necessarily lead to the second. The observation by its parents (or its teacher) that a child displays ADHD-related symptoms may lead them to visit their family doctor. The family doctor may or may not arrive at the conclusion that the child has ADHD and, if so, may subsequently prescribe ADHD medication, such methylphenidate (see **Figure 1**). In addition, health insurance data concern the reimbursements of prescribed medicines. Parents may not ask for reimbursement. However, since requesting reimbursement is in their own (financial) interest, we expect reimbursement rates to closely resemble prescription rates.

Parents may respond differently to the display of the same type of behavior. Furthermore, to the extent that a child spends more time playing outdoors, its parents may also be confronted less with (indoor) behavior that they consider annoying or undesirable, which may lower the probability that they will bring this behavior to the attention of their family doctor. Although this is not a well-researched topic, there are studies showing cultural differences in whether or not parents consider ADHD-related behavior problematic and whether or not they will take this issue to their family doctor. In the Netherlands, parents with a non-Western migration background perceive similar ADHD-type behavior as less problematic than their autochthonous counterparts, and their children also visit healthcare professionals less often with this type of problem (Bevaart et al., 2012, 2014). Although in the Netherlands, general practitioners are formally not qualified to diagnose ADHD, they frequently do so. Such informal diagnosis is not always subsequently confirmed (or rejected) by a psychiatrist or pediatrician. This implies that there may be differences between general practitioners in how they record symptoms or diagnose the same kind of behavior. They may also differ in their prescription behavior.

Materials and methods

The study involves a secondary data analysis, in which registry data of a Dutch health insurance company are enriched with characteristics of the residential environment at the level of individual children. The two datasets were linked by the health insurance company by means of the six-digit post code of the

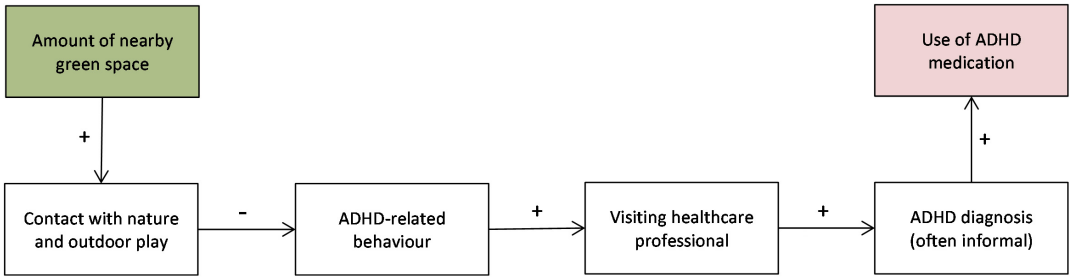

FIGURE 1
Conceptual model relating green space to use of ADHD medication by children.

home address of the child, which was removed before handing the dataset over for conducting the analyses. To get approval to make use of the registry data, beforehand the privacy of the children involved had to be guaranteed. This was carried out by keeping the number of environmental characteristics small, thereby precluding the identification of an individual child due to an unique combination of values in the joined dataset.

Attention deficit hyperactivity disorder medication

Medication data were provided by Achmea, the main Dutch health insurance company in the central part of the Netherlands at the time of the research. According to Smeets et al. (2011), the Achmea Health Database (formerly Agis) is not completely representative for the entire Dutch population but does represent the urbanized area of the Netherlands. From this database, all children between 5 and 12 years of age (in 2011) were selected, regardless of whether they had used AHDH medication or not. Only children who were insured by Achmea during the whole of 2011 and 2012 were included (n = 274.698). Records on reimbursements for ADHD-related medication, such as methylphenidate, were aggregated by child to determine usage in 2011 (yes/no). For children, this type of medicine [Anatomical Therapeutic Chemical (ATC) code N06BA**] is almost exclusively prescribed for AD(H)D-related symptoms. To the best of our knowledge, this type of information has not been used before in studies looking at the relationship between residential green space and ADHD among children. Although Aerts et al. (2022) did use ADHD medication prescription data, they did so for adults (and not at an individual level). In addition to age, sex, and family doctor (and home address), no background characteristics of the child were available in the Achmea Health Database.

Residential green space

Residential greenness was assessed using two methods. The first method was to look at all green types of land use, based on a national land-use database (Hazeu et al., 2014). In this database, the dominant type of land use for each 25 × 25-m raster cell is recorded in 39 categories. Version 7 of this database (LGN7) is mainly based on data from the year 2012. Green types of land use include agricultural areas (codes: 1–6, 61, and 62), forests (codes: 11, 12, 40, and 43), nature areas (30–39, 42, and 45), and urban green areas (codes: 20, 22–24, and 28). Using the center of the six-digit post code of the residential address, the most detailed spatial identifier nationally available at that time, the percentages of green area within 250 and within 500 m were calculated. On average, in 2012, about 17 households shared the same six-digit post code, with the size of the area depending on the local population density. This green space indicator has been used before in Dutch research on green space and human health, although with larger buffer sizes (see, e.g., Maas et al., 2009; Van den Berg et al., 2010). In the current study, smaller distances were chosen because of the limited radius of action of school-aged children when it comes to autonomous outdoor play. The same two distances have been used by Amoly et al. (2014).

The second method involved the use of normalized difference vegetation index (NDVI) scores, based on satellite imagery. NDVI scores indicate the amount of green biomass present. In the present study, the average NDVI scores for 25 May and 25 July 2012 was used, two cloudless days. Originally, NDVI scores range from −1 to + 1, with scores above 0 indicating the presence of green biomass. Scores below 0 may indicate water surfaces. To avoid water and vegetation averaging each other out, the original NDVI scores were recoded: scores above 0 were multiplied by 250, and scores of 0 and below were recoded to 1. Average-recoded NDVI scores were calculated for the same two distances: 250 and 500 m. NDVI scores have also been used before in studies on green space and ADHD, although not in the Netherlands (Amoly et al., 2014; Balseviciene et al., 2014). However, we calculated the average for only those raster cells within the buffer that were identified as built-up/sealed surface area within the LGN7 land-use database. This was performed to make the two greenness indicators complementary, rather than strongly overlapping. Due to being limited to the built-up area, these average NDVI scores are considered to indicate

the presence of very small green areas or natural elements, such as home gardens and street trees, within the built-up part of the environment. In this study, next to the percentage of green area, we used these average NDVI values for the built-up part of the buffers. To prevent specific combinations of the two greenness characteristics for the two buffers to be uniquely linked to a six-digit post code, and thereby compromise the privacy of clients, they were recoded into broader classes. For the percentages of green space, this were twenty 5% classes. For the two NDVI scores, these were seven classes. The two extreme classes were less than 80 and more than 130, with in between five equal-interval classes of 10 points wide each.

Additional characteristics

In addition to the two greenness indicators, each for two buffers, several characteristics of the neighborhood in which the six-digit postcode was located were added to the environmental database. The 2012 values for these characteristics were available at Statistics Netherlands (CBS) and included the level of urbanity (five levels, based on address density), the percentage of children between 0 and 14 years of age within the population (twenty 5%-classes), the percentage of inhabitants with a non-Western migration background (twenty 5%-classes), and the average residential property value (WOZ-value) (CBS, 2016). The latter was used as an indicator of the socioeconomic status (SES) of the neighborhood. Property values were recoded into seven classes. The two extreme classes were less than € 145,000 and more than € 345,000, with in between five equal-interval classes of € 40,000 wide each. The percentage of children < 15 years was included as a covariate based on the assumption that the availability of playmates in the neighborhood might increase the likelihood of outdoor play. As mentioned before, Achmea linked the environmental data to their healthcare data by using the six-digit post code, after which this post code was removed to protect the privacy of their clients. Also, the code for the family doctor was pseudonymized by Achmea. Children who moved during 2011 or 2012 (about 10%) were excluded, as were children without a valid post code or code for the family doctor. After also removing cases with missing values on any of the variables used in the analyses, 248,270 cases were available for analysis. Due to the client base of Achmea being mainly located in the middle of the Netherlands, the sample cannot the considered representative for all Dutch children in the selected age category.

Statistical analyses

Several children are likely to live in the same neighborhood and/or be registered with the same family doctor. Thus, the dataset has a nested structure, which calls for multilevel analyses. The first level consists of children. Neighborhood and family doctor are cross-classified: children living in the same neighborhood may be listed as patients registered with a different family doctor, and vice versa. Given the large number of possible combinations of neighborhood and family doctor, both these higher levels cannot be taken into account simultaneously. To start with, separate analyses have been performed, with either neighborhood or family doctor as the second level. Based on the first results, to be reported later on, additional analyses were only performed with neighborhood as the second level. The dependent variable was whether or not the children used ADHD medication in 2011. Therefore, logistic regression analyses were performed. Regression models were built up in several steps. In the first model, only the available covariates, at either the individual or the neighborhood level, were included in the model: age, sex (categorical), urbanity (categorical), average real estate property value (categorical), percentage of non-Western immigrants, percentage of children younger than 15 years. In the second model, one of the greenness indicators was added: the percentage of green area within either 250 or 500 m or the mean NDVI score for the built-up area within one of those distances. In the third model, both the percentage of green area and the average NDVI score for the same distance were included in the model. In a fourth step, different moderators were tested one by one, by introducing interaction terms. This was carried out for average residential property value, sex, and age. For the average residential property value, interaction terms were created by first reducing the number of categories to three, by combing the lowest two, the middle three, and the upper two categories, respectively. For age, this was performed by means of a multiplicative interaction term (with both variables centered beforehand). The multilevel analyses were performed by MLwiN, versions 2.32 and 3.05, and the more descriptive analyses by SPSS, version 22.

Results

Table 1 shows the characteristics of the sample. The sex distribution was almost 50/50. The prevalence of use of ADHD medication in 2011 was 3.7%. The children are quite evenly distributed over the 50 urbanity levels.

Correlations between greenness indicators

Before regression analyses were performed, correlations between the different greenness indicators were calculated. The percentage of green area and the average NDVI score correlate $r = 0.66$ for the 250-m buffer and $r = 0.67$ for the 500-m buffer. This indicates residential environments with much green

area also tend to have quite many smaller natural elements within the built-up part of the environment. However, the correlations are not that high that using both in the same regression analysis will cause multicollinearity problems. On the other hand, percentages for the 250- and 500-m buffers correlate with $r = 0.90$, and the average NDVI scores for those two distances $r = 0.91$. Thus, neither the two percentages nor the two NDVI scores can be used in the same analysis.

Multilevel logistic regression analyses

The basic model, with only covariates, is presented in Table 2 (model 1). Boys have a higher prevalence of the use of ADHD medication than girls, and older children have a higher prevalence than younger children. Furthermore, the prevalence becomes lower with higher average property values for the neighborhood, as well as with increasing percentages of non-Western immigrants among the neighborhood population. On the other hand, the prevalence becomes higher with increasing percentage of children < 15 years in the neighborhood. Finally, in very highly urban neighborhoods, the prevalence is lower than in non-urban neighborhoods, while it is highest in moderately urban neighborhoods.

TABLE 1 Characteristics of the sample at the level of the child (n = 248,270).

Characteristic	pct./mean ± *SD*
Sex: boys	51.4%
Age	8.6 ± 2.3
Prevalence of use of ADHD-medication in 2011	3.7%
Urbanity of neighborhood (based on address density)	
Very high	16.4%
High	23.8%
Moderate	20.2%
Low	20.3%
Not urban	19.3%
Average property value (in Euros)	
<145,000	11.2%
145,000–185,000	21.8%
185,000–225,000	24.5%
225,000–265,000	21.6%
265,000–305,000	10.4%
305,000–345,000	4.9%
>345,000	5.5%
Percentage of non-Western migrants (in 20 classes)	2.7 ± 2.9
Percentage of children < 15 years of age (in 20 classes)	4.3 ± 1.1
Percentage of green area within 250 m (in 20 classes)	7.8 ± 3.8
Percentage of green area within 500 m (in 20 classes)	9.2 ± 3.0
Average NDVI-score built-up area within 250 m (7 classes)	3.9 ± 1.7
Average NDVI-score built-up area within 500 m (7 classes)	3.9 ± 1.7

The logistic regression analyses in which the greenness indicators for the 250-m buffer are added to the basic model (one by one) show that the percentage of green space is significantly associated with the prevalence of ADHD medication use, with the prevalence being lower when the percentage of green area is higher (Table 2, model 2). The average NDVI score for the built-up area is not significantly associated with the prevalence (OR = 0.988; 95% CI: 0.971–1.006). We also ran a model with both the percentage of green space and the average NDVI score for the built-up area included, checking that multicollinearity did not constitute a problem (VIF for percentage = 2.2, VIF for NDVI = 1.9). Also, when added after the percentage of green area is already included in the model, the predictive contribution of the average NDVI score for the built-up area within the 250-m buffer is not significant (OR = 1.002; 95% CI: 0.0983–1.022), whereas the parameter for the percentage of green area remains the same: OR = 0.986 (95% CI: 0.976–0.996; $p < 0.01$).

The regression results for the greenness indicators for 500-m buffer are quite similar to those for the 250-m buffer (not in table). Also, the parameter for the percentage of green area is significant, and the association is negative: OR = 0.985 (95% CI: 0.976–0.995; $p < 0.01$). The parameter for the average NDVI score of the built-up area within 500 m added to model 1 is not significant (OR = 0.989; 95% CI: 0.970–1.009), and neither it is significant when added to the model that already includes the percentage of green area (OR = 1.004; 95% CI: 0.983–1.026), whereas also the parameter for the percentage of green area stays virtually the same: OR = 0.984 (95% CI: 0.975–0.994); $p < 0.01$).

The analyses were repeated with family doctor as the second level, rather than neighborhood. The results were quite similar, with the same green space parameters being significant (not in table). The between variance for family doctor was somewhat smaller than that for neighborhood. For example, for the basic model (model 1), it was 0.140 (SE = 0.014).

Additional analyses

Given the similar results for 250 and 500-m buffers, and neighborhood being a larger source of variation than family doctor, additional analyses were only performed for the 250-m green area percentage with neighborhood as the second level. First, we checked for non-linearity by adding a quadratic term for the percentage of green area (centered beforehand, added to model 2 in Table 2). This quadratic green area parameter was not significant (OR = 0.999; 95% CI: 0.997–1.001). Based on two earlier studies showing that the relationship between green space and ADHD-related behavior depended on SES (Balseviciene et al., 2014; Flouri et al., 2014), we explored moderation by SES. We tested for an interaction between the percentage of green space and the average residential property value. The results show that the interaction is significant (see Table 2, model 3). The negative relationship between green space and

TABLE 2 Logistic regression models for prevalence of ADHD medication with interaction between percentage of green area within 250 m and average property value (in three categories); neighborhood as second level (n = 248,270).

	Odds ratio (95% confidence interval)		
	Model 1	**Model 2**	**Model 3**
Constant			***0.019 (0.017–0.022)***
Sex			
Boy	***3.511 (3.337, 3.695)***	***3.511 (3.337, 3.695)***	***3.511 (3.337, 3.695)***
Girl (ref.)	-	-	-
Age	***0.763 (0.755, 0.770)***	***0.763 (0.755, 0.770)***	***0.763 (0.755, 0.770)***
Avg. property value[joint Chi^2 (df)]			***171.6 (6); $p < 0.001$***
<145,000 (ref.)	–	–	–
145,000–185,000	0.969 (0.875, 1.072)	0.954 (0.860, 1.059)	0.928 (0.836, 1.029)
185,000–225,000	***0.829 (0.746, 0.922)***	***0.814 (0.732, 0.905)***	***0.796 (0.715, 0.887)***
225,000–265,000	***0.675 (0.604, 0.755)***	***0.665 (0.595, 0.744)***	***0.647 (0.577, 0.724)***
265,000–305,000	***0.594 (0.523, 0.675)***	***0.589 (0.518, 0.671)***	***0.570 (0.500, 0.650)***
305,000–345,000	***0.586 (0.500, 0.686)***	***0.589 (0.503, 0.691)***	***0.548 (0.463, 0.649)***
>345,000	***0.561 (0.484, 0.650)***	***0.567 (0.490, 0.657)***	***0.527 (0.449, 0.617)***
Pct. non-Western migrants (1–20)	***0.964 (0.949, 0.979)***	***0.965 (0.950, 0.980)***	***0.960 (0.945, 0.975)***
Pct. children < 15 (1–20)	***1.062 (1.033, 1.091)***	***1.063 (1.034, 1.092)***	***1.069 (1.040, 1.099)***
Urbanity of neighborhood[Joint Chi^2 (df)]			***39.7 (4); $p < 0.001$***
Very high	**0.844 (0.752, 0.947)**	***0.754 (0.661, 0.860)***	***0.761 (0.666, 0.870)***
High	*1.097 (1.011, 1.192)*	1.006 (0.914, 1.107)	1.018 (0.925, 1.121)
Moderate	**1.131 (1.044, 1.226)**	1.051 (0.961, 1.150)	1.062 (0.968, 1.164)
Low	1.023 (0.944, 1.109)	0.964 (0.882, 1.053)	0.971 (0.889, 1.061)
Non-urban (ref.)	–	–	–
Pct. green area 250 m (1–20)		***0.986 (0.978, 0.994)***	***0.970 (0.957, 0.984)***
Pct. green area × Avg. prop. value[Joint Chi^2 (df)]			**10.9 (2); $p < 0.01$**
Pct green × <185,000 (ref.)			–
Pct green × 185,000–305,000			**1.021 (1.005, 1.037)**
Pct green × >305,000			**1.031 (1.011, 1.052)**
Variance at neighborhood level (standard error)	0.197(0.016)	0.199(0.016)	0.198(0.016)

NB, percentages in 5% classes; all non-categorical variables centered beforehand.
Significance levels: italic, 0.05 level, bold, 0.01 level; italic and bold, 0.001 level.

the prevalence of the use of ADHD medication is strongest in the neighborhoods with the lowest average residential property value and becomes weaker to non-existent when this property value rises. Following Markevych et al. (2014), we also explored moderation by sex using a separate model (i.e., instead of residential property value). The interaction between the percentage of green space and the sex of the child was not significant (OR = 0.998; 95% CI: 0.984–1.012). Also, the interaction between age and percentage of green space was not significant (OR = 1.001; 95% CI: 0.999–1.003).

The significant interaction between the percentage of green space and property values makes it of interest to look at the relationship between the presence of green space and the average residential property value within the neighborhood. The seven property value classes differ significantly ($p < 0.001$) in the amount of green area present. The relationship is predominantly linear in nature: the percentage of green area within 250 m increases with the property value (see **Table 3**). Translating the green area classes back to the original percentages, in the lowest residential property value class, the average percentage lies between 30 and 35%, whereas in the highest residential property value class, it lies between 45 and 50%, signifying an average difference in the green area percentage of at least 10% points.

Discussion

The use of ADHD medication by children is negatively related to the amount of residential green space. This is the case for the percentage of green area within a buffer of 250 m and, to a similar extent, for that within a buffer of 500 m. The relationship differs by the average residential property value within the neighborhood. It is strongest in the category of lowest property value neighborhoods and non-existent in the category of highest property value neighborhoods. In the lowest property value neighborhoods (<145,000 Euro in 2012), a difference of 20% points of green space (25 vs. 45%) is associated with an over 10% lower probability of the child using ADHD medication. The observed beneficial association is in line with the outcomes of previous as well as more recent studies on green space and ADHD-related symptoms among children as reported by their parents/guardians and/or teachers, as well as with those of a

TABLE 3 Amount of green area within 250 m by category of average of residential property value within the neighborhood (n = 248,270).

Category of residential property value (in euros)	Percentage of green space (in 20 5%-classes)	Standard deviation	Number of children
<145,000	6.8	4.2	27,838
145,000–185,000	7.0	2.9	54,218
185,000–225,000	7.4	3.2	60,823
225,000–265,000	7.9	3.5	53,653
265,000–305,000	8.7	4.3	25,924
305,000–345,000	9.8	5.2	12,048
>345,000	10.4	5.1	13,766
Total	7.8	3.8	248,270

study using a formal ADHD diagnosis as outcome measure (Markevych et al., 2018; Sakhvidi et al., 2022; Yuchi et al., 2022). It is also in line with the more general finding that there is a beneficial association between greenness exposure and the neuropsychological development and mental health of children (Luque-García et al., 2021). Less is known about the moderation of these associations by SES, which was observed in this study. Although (a proxy of) SES is usually included as a covariate, including it also as a moderator is not standard practice. A recent study that did look into this, using different measures for all three variables involved, did not observe such a moderating effect (Dzhambov et al., 2022). In fact, in that study, distance to nature in the residential environment was detrimentally associated with having behavioral problems.

Assuming causality for a moment, we briefly discuss the wider implications of a lower prevalence of ADHD. Le et al. (2014) estimated the societal costs in the Netherlands for children and adolescent to range between 9,860 and 14,483 Euro per case (2012 values). More recent U.S. figures are somewhat lower. According to Schein et al. (2022a), the societal economic burden of ADHD is US$ 6,799 per child annually. During adolescence, the burden is higher: US$ 8,349 per adolescent. In adulthood, the costs increase further to 14,092 per adult (Schein et al., 2022b). The latter is mainly of consequence of the negative impact of ADHD on long-term academic outcomes (Arnold et al., 2020), affecting earning capacity in adulthood. For example, in an U.S.-based study, children with formally diagnosed ADHD and receiving treatment, usually including medication, were estimated to earn even 1.27 million US$ less over their working lifetime than otherwise comparable individuals (Pelham et al., 2020). In Denmark, Jennum et al. (2020) also observed substantially lower earned incomes of people with ADHD after diagnosis (and presumably getting some form of treatment) than matched controls. Beyond these economic consequences, the quality of life of children diagnosed with ADHD is impaired, often also still in adulthood (Di Lorenzo et al., 2021; Faraone et al., 2021). Nigg et al. (2020) conclude that despite the availability of ever more sophisticated treatments, long-term outcomes are largely unchanged and deeply concerning. All in all, the societal costs of ADHD are substantial, making it worthwhile to consider investing in preventive measures. Increasing the amount of green space in poor neighborhoods with low levels of green space at present might be one way of prevention. Assessing the cost-to-benefit ratio of a 20% point increase in green area in deprived neighborhoods to achieve a 10% decrease in ADHD prevalence is beyond the scope of this article. However, it is important to note that urban greening is not only likely to beneficially affect ADHD prevalence but also that of other disorders and diseases (Maas et al., 2009). Furthermore, beyond generating health and wellbeing benefits, it may also contribute to climate change adaptation and urban biodiversity (Butt et al., 2018).

Given the cross-sectional nature of the study, the causality of this association is open to discussion. However, we did try to rule out likely alternative explanations by including several covariates in our statistical analyses, such as level of urbanity and average property values. The percentage of non-Western immigrants proved to be an important factor in this respect because it is negatively associated with both the average residential property value and the prevalence of use of ADHD medication, whereas the residential property value itself is also negatively associated with the prevalence of use. The relationship between ethnicity and the use of ADHD medication seems to be at least partly due to a cultural difference in the perception of the same type of ADHD-related behavior (Bevaart et al., 2012). It may be noted that to the extent that such behavior is indeed indicative of an actual disorder, affecting the quality of life of the child negatively, the present results may underestimate the relationship between green space and ADHD.

As for which type of green space is most likely to be beneficial, green elements within the residential environment outside green areas did not show a similar relationship with the prevalence of use of ADHD medication, neither when it was the only greenness indicator in the regression model nor when added after the percentage of green area was already included. Therefore, the presence of green areas seems to be more important than that of smaller elements such as street trees and domestic gardens. This might be taken as an indication that it is especially by outdoor play that the relationship occurs (see Amoly et al., 2014; Flouri et al., 2014), with (at least some)

green areas offering attractive opportunities for this type of activity (see, e.g., Grigsby-Toussaint et al., 2011). According to Chaudhury et al. (2019), neighborhood public open spaces are preferred local destinations for children, especially as play areas (see also Brockman et al., 2011). In addition, they conclude that for autonomous play, unsupervised by parents, parents' consent is important. To a large extent, this consent is based on the safety of the green area, as well as that of the route to that area, as perceived by parents (Qiu and Zhu, 2021; Visser and van Aalst, 2022). Furthermore, not only officially designated (green) playgrounds are likely to be relevant but also informal playgrounds (Visser and van Aalst, 2022), including undeveloped green areas, at least when trees are present (Janssen and Rosu, 2015). Furthermore, it is likely that such green areas do not need to be very large. Lachowycz et al. (2012) concluded that small green areas may be more important for outdoor play in this age category than (larger) parks. All in all, especially small (but not too small) nearby green areas that allow and afford play activities and are considered safe by parents (and children) may be relevant if the observed association is indeed mediated by time spent on outdoor play in such areas. Note that we do not mean to imply that it is (only) the physical activity associated with the outdoor play that is of importance. Also, the exposure to nature as such may play a role.

The pattern of the amount of nearby green space being stronger beneficially associated with the mental wellbeing of children living in less wealthy neighborhoods is consistent with the findings of Balseviciene et al. (2014) and Flouri et al. (2014). Also, it fits a more general pattern of beneficial associations between nearby green space and human health and wellbeing being stronger for less affluent people (Rigolon et al., 2021). At the same time, our additional analyses also showed that children living in less affluent neighborhoods tend to have less nearby green space. This finding is also consistent with the more generally observed pattern of people with a low SES having poorer access to green space (Schüle et al., 2019; De Vries et al., 2020). Differently speaking, those who are likely to benefit most from having green space nearby tend to have the least in their residential environment.

Strengths and limitations of the study

A strength of the study is that it makes use of administrative data. This precludes a self-selection bias with regard to participating in the study. Another strength is that the data were available at the individual child, rather than only at a spatially aggregated level. Furthermore, the large number of children in the database made it possible to test more complex models, for example, with urbanity as a categorical covariate and an interaction between average residential property values and the percentage of green area. An additional advantage is that the study employs medication use as an indicator and thereby complements previous studies which have been largely based on (possibly quite subjective) ratings of the children's behavior by their parents. This does not mean that the present study has no limitations. To begin with, as already mentioned, the children in the Achmea Health Database cannot be considered representative of all Dutch children. A more specific limitation in this regard is that only children who (a) are brought to the attention of the family doctor (or a pediatrician/other specialist), (b) are diagnosed with ADHD, and (c) are subsequently prescribed ADHD-related medication have been identified as suffering from ADHD. This was already acknowledged in the Introduction (see **Figure 1**). Starting with the last step in the chain (c), when a broad definition of ADHD is used (ICPC-codes P20, P21, P22), in 2012, 5.9% of the Dutch children aged between 0 and 17 years were registered as having ADHD by their family doctors (Prins and Van Dijk, 2015). Of these children, 25.5% were prescribed ADHD medication by the family doctors. Although that age range (0–17 years) is much wider than the one used here (5–12 years) and the ADHD prevalence differs by age, and that this type of medication may also have been prescribed by a specialist, the latter percentage strongly suggests that in the Netherlands, a considerable proportion of children diagnosed with ADHD do not get ADHD medication prescribed. Of the children with clinically diagnosed ADHD, those with more severe hyperactivity/impulsivity symptoms are more likely to be prescribed ADHD medication (Mowlem et al., 2019). To our knowledge, representative figures regarding the preceding two steps (a) and (b) are not available for the Netherlands. However, ethnicity was included as a confounder in our analyses because of an observed lower inclination of people with a non-Western ethnic background to seek medical assistance when a child displays ADHD-related behavior. These issues obviously affect the representativeness of our data with regard to all (Dutch) children with ADHD. However, given the steps needed to prescribe ADHD medication, with symptom severity playing an important role, the children who do get them prescribed are likely to constitute the more severe cases. One could argue that this makes the observed association between the percentage of green area and prevalence of use of ADHD medication even more interesting. Furthermore, if contact with nature reduces severe ADHD symptoms, it is not unlikely that children with less severe ADHD symptoms will also benefit from such contacts. Another limitation was that the Achmea Health Database contained limited information on the background characteristics of the children. For this reason, we used sociodemographic characteristics of the neighborhood relating to SES and ethnicity as proxies. It would be an improvement to (also) have information on such characteristics at the individual level of the child or the household.

Furthermore, as already mentioned, the study is cross-sectional in nature, limiting the ability to arrive at firm conclusions regarding the causality of the observed relationships. In addition to this, we also only looked at green

space in the residential environment and did so in a static way (Helbich, 2018). During the course of the day, children may also move into other environments, for example, when attending school, making these environments relevant as well (see, e.g., Yang et al., 2019; Dzhambov et al., 2022). Furthermore, data on mediating factors, such as the use of green spaces for outdoor play, were not available. Such data would have helped assess the plausibility of a causal interpretation. Finally, given that contact with nature, mainly in the form of outdoor play, is assumed to be an important mediating factor, the green space indicator that was used is also quite crude. Not all green areas are suited for (autonomous) outdoor play. A "playability" qualification of green areas would bring more nuance in comparing residential neighborhoods (see also Janssen and Rosu, 2015).

Despite these limitations, we feel that this study adds to the evidence base that contact with nature is important for the health and wellbeing of children, especially those living in deprived neighborhoods.

Data availability statement

The datasets presented in this article are not readily available because data can only be made available upon request and under certain conditions after approval by relevant Zilveren Kruis (formerly Achmea) Health Database governance bodies. Requests to access the datasets should be directed to corresponding author.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the participants or their legal guardian/next of kin was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

Both authors listed have made a substantial, direct, and intellectual contribution to the work, and approved it for publication.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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References

Aerts, R., Vanlessen, N., Dujardin, S., Nemery, B., Nieuwenhuyse, A., Bauwelinck, M., et al. (2022). Residential green space and mental health-related prescription medication sales: An ecological study in Belgium. *Environ. Res.* 211:113056. doi: 10.1016/j.envres.2022.113056

Amoly, E., Dadvand, P., Forns, J., López-Vicente, M., Basagaña, X., and Julvez, J. (2014). Green and blue spaces and behavioral development in Barcelona schoolchildren: The BREATHE project. *Environ. Health Perspective.* 122:1351. doi: 10.1289/ehp.1408215

Arnold, L. E., Hodgkins, P., Kahle, J., Madhoo, M., and Kewley, G. (2020). Long-term outcomes of ADHD: Academic achievement and performance. *J. Atten. Disord.* 24, 73–85.

Balseviciene, B., Sinkariova, L., Grazuleviciene, R., Andrusaityte, S., Uzdanaviciute, I., and Dedele, A. (2014). Impact of Residential Greenness on Preschool Children's Emotional and Behavioral Problems. *Int. J. Environ. Res. Public Health* 11, 6757–6770. doi: 10.3390/ijerph110706757

Bevaart, F., Mieloo, C. L., Jansen, W., Raat, H., Donker, M. C., and Verhulst, F. C. (2012). Ethnic differences in problem perception and perceived need for care for young children with problem behaviour. *J Child Psychol. Psychiatry* 53, 1063–1071.

Bevaart, F., Mieloo, C. L., Wierdsma, A., Donker, M. C., Jansen, W., and Raat, H. (2014). Ethnicity, socioeconomic position and severity of problems as predictors of mental health care use in 5-to 8-year-old children with problem behaviour. *Soc. Psychiatry Psychiatr. Epidemiol.* 49, 733–742. doi: 10.1007/s00127-013-0761-4

Brockman, R., Jago, R., and Fox, K. R. (2011). Children's active play: Self-reported motivators, barriers and facilitators. *BMC Public Health* 11:461. doi: 10.1186/1471-2458-11-461

Butt, N., Shanahan, D. F., Shumway, N., Bekessy, S. A., Fuller, R. A., Watson, J. E., et al. (2018). Opportunities for biodiversity conservation as cities adapt to climate change. *Geo Geography Environ.* 5:e00052. doi: 10.1111/gcb.15645

CBS (2016). *Toelichting Kerncijfers Wijken en Buurten; Versie 2016-03-31. Den Haag/Heerlen: Statistics Netherlands*. Available online at: https://www.cbs.nl/-/media/cbs/dossiers/nederland-regionaal/wijk-en-buurtstatistieken/_pdf/toelichtingvariabelenkwb20032012versie20160331.pdf (accessed August 1, 2022).

Chaudhury, M., Hinckson, E., Badland, H., and Oliver, M. (2019). Children's independence and affordances experienced in the context of public open spaces: A study of diverse inner-city and suburban neighbourhoods in Auckland. *N. Z. Child. Geogr.* 17, 49–63.

De Vries, S., Buijs, A. E., and Snep, R. P. (2020). Environmental justice in The Netherlands: Presence and quality of greenspace differ by socioeconomic status of neighbourhoods. *Sustainability* 12:5889.

Di Lorenzo, R., Balducci, J., Poppi, C., Arcolin, E., Cutino, A., Ferri, P., et al. (2021). Children and adolescents with ADHD followed up to adulthood: A systematic review of long-term outcomes. *Acta Neuropsychiatr.* 33, 283–298.

Dzhambov, A. M., Lercher, P., Rüdisser, J., Browning, M. H., and Markevych, I. (2022). Home gardens and distances to nature associated with behavior problems in alpine schoolchildren: Role of secondhand smoke exposure and biomarkers. *Int. J. Hyg. Environ. Health* 243:113975. doi: 10.1016/j.ijheh.2022.113975

Faber-Taylor, A., and Kuo, F. E. (2009). Children with attention deficits concentrate better after walk in the park. *J. Atten. Disord.* 12, 402–409.

Faber-Taylor, A., and Kuo, F. E. (2011). Could exposure to everyday green spaces help treat ADHD? Evidence from children's play settings. *Appl. Psychol. Health Well-Being* 3, 281–303.

Faraone, S. V., Banaschewski, T., Coghill, D., Zheng, Y., Biederman, J., Bellgrove, M. A., et al. (2021). The world federation of ADHD international consensus statement: 208 evidence-based conclusions about the disorder. *Neurosci. Biobehav. Rev.* 128, 789–818. doi: 10.1016/j.neubiorev.2021.01.022

Flouri, E., Midouhas, E., and Joshi, H. (2014). The role of urban neighbourhood green space in children's emotional and behavioural resilience. *J. Environ. Psychol.* 40, 179–186.

Grigsby-Toussaint, D. S., Chi, S. H., and Fiese, B. H. (2011). Where they live, how they play: Neighborhood greenness and outdoor physical activity among preschoolers. *Int. J. Health Geogr.* 10:66. doi: 10.1186/1476-072X-10-66

Hartig, T., Mitchell, R., de Vries, S., and Frumkin, H. (2014). Nature and health. *Annu. Rev. Public Health* 35, 207–228.

Hazeu, G.W., Schuiling, C., Dorland, G.J., Roerink, G.J., Naeff, H.S., and Smidt, R.A. (2014). *Landelijk Grondgebruiksbestand Nederland Versie 7 (LGN7)* Available online at: https://edepot.wur.nl/311353 (accessed August 1, 2022).

Helbich, M. (2018). Toward dynamic urban environmental exposure assessments in mental health research. *Environ. Res.* 161, 129–135. doi: 10.1016/j.envres.2017.11.006

Janssen, I., and Rosu, A. (2015). Undeveloped green space and free-time physical activity in 11 to 13-year-old children. *Int. J. Behav. Nutr. Phys. Act.* 12:26. doi: 10.1186/s12966-015-0187-3

Jennum, P., Hastrup, L. H., Ibsen, R., Kjellberg, J., and Simonsen, E. (2020). Welfare consequences for people diagnosed with attention deficit hyperactivity disorder (ADHD): A matched nationwide study in Denmark. *Eur. Neuropsychopharmacol.* 37, 29–38. doi: 10.1016/j.euroneuro.2020.04.010

Kaplan, R., and Kaplan, S. (1989). *The Experience of Nature: A Psychological Perspective*. New York, NY: Cambridge University Press.

Lachowycz, K., Jones, A. P., Page, A. S., Wheeler, B. W., and Cooper, A. R. (2012). What can global positioning systems tell us about the contribution of different types of urban greenspace to children's physical activity? *Health Place* 18, 586–594. doi: 10.1016/j.healthplace.2012.01.006

Le, H. H., Hodgkins, P., Postma, M. J., Kahle, J., Sikirica, V., Setyawan, J., et al. (2014). Economic impact of childhood/adolescent ADHD in a European setting: The Netherlands as a reference case. *Eur. Child Adolesc. Psychiatry* 23, 587–598. doi: 10.1007/s00787-013-0477-8

Lee, M., Kim, S., and Ha, M. (2019). Community greenness and neurobehavioral health in children and adolescents. *Sci. Total Environ.* 672, 381–388.

Luque-García, L., Corrales, A., Lertxundi, A., Díaz, S., and Ibarluzea, J. (2021). Does exposure to greenness improve children's neuropsychological development and mental health? A Navigation Guide systematic review of observational evidence for associations. *Environ. Res.* 206:112599. doi: 10.1016/j.envres.2021.112599

Maas, J., Verheij, R. A., de Vries, S., Spreeuwenberg, P., Schellevis, F. G., and Groenewegen, P. P. (2009). Morbidity is related to a green living environment. *J. Epidemiol. Community Health* 63, 967–973.

Markevych, I., Schoierer, J., Hartig, T., Chudnovsky, A., Hystad, P., Dzhambov, A. M., et al. (2017). Exploring pathways linking greenspace to health: Theoretical and methodological guidance. *Environ. Res.* 158, 301–317. doi: 10.1016/j.envres.2017.06.028

Markevych, I., Tesch, F., Datzmann, T., Romanos, M., Schmitt, J., and Heinrich, J. (2018). Outdoor air pollution, greenspace, and incidence of ADHD: A semi-individual study. *Sci. Total Environ.* 642, 1362–1368. doi: 10.1016/j.scitotenv.2018.06.167

Markevych, I., Tiesler, C. M. T., Fuertes, E., Romanos, M., Dadvand, P., and Nieuwenhuijsen, M. J. (2014). Access to urban green spaces and behavioural problems in children: Results from the GINIplus and LISAplus studies. *Environ. Int.* 71, 29–35. doi: 10.1016/j.envint.2014.06.002

Mowlem, F. D., Rosenqvist, M. A., Martin, J., Lichtenstein, P., Asherson, P., and Larsson, H. (2019). Sex differences in predicting ADHD clinical diagnosis and pharmacological treatment. *Eur. Child Adolesc. Psychiatry* 28, 481–489.

Nigg, J. T., Sibley, M. H., Thapar, A., and Karalunas, S. L. (2020). Development of ADHD: Etiology, heterogeneity, and early life course. *Annu. Rev. Dev. Psychol.* 2:559.

Pelham, III. W. E., Page, T. F., Altszuler, A. R., Gnagy, E. M., Molina, B. S., and Pelham, W. E. Jr. (2020). The long-term financial outcome of children diagnosed with ADHD. *J. Consult. Clin. Psychol.* 88:160.

Prins, M., and Van Dijk, L. (2015). *Helft van kinderen en een derde van volwassenen met ADHD krijgt ADHD-medicatie via huisarts. Utrecht (NL): NIVEL*. Available online at: https://www.nivel.nl/sites/default/files/bestanden/factsheet_ADHD_medicatie_via_huisarts.pdf (accessed August 1, 2022).

Qiu, L., and Zhu, X. (2021). Housing and Community Environments vs. Independent Mobility: Roles in Promoting Children's Independent Travel and Unsupervised Outdoor Play. *Int. J. Environ. Res. Public Health* 18:2132. doi: 10.3390/ijerph18042132

Rigolon, A., Browning, M. H., McAnirlin, O., and Yoon, H. V. (2021). Green space and health equity: A systematic review on the potential of green space to reduce health disparities. *Int. J. Environ. Res. Public Health* 18:2563. doi: 10.3390/ijerph18052563

Sakhvidi, M. J. Z., Knobel, P., Bauwelinck, M., Keijzer, C., Boll, L. M., Spano, G., et al. (2022). Greenspace exposure and children behavior: A systematic review. *Sci. Total Environ.* 824:153608.

Schein, J., Adler, L. A., Childress, A., Cloutier, M., Gagnon-Sanschagrin, P., Davidson, M., et al. (2022a). Economic burden of attention-deficit/hyperactivity disorder among children and adolescents in the United States: A societal perspective. *J. Med. Econ.* 25, 193–205. doi: 10.1080/13696998.2022.2032097

Schein, J., Adler, L. A., Childress, A., Gagnon-Sanschagrin, P., Davidson, M., Kinkead, F., et al. (2022b). Economic burden of attention-deficit/hyperactivity disorder among adults in the United States: A societal perspective. *J. Manag. Care Spec. Pharm.* 28, 168–179. doi: 10.18553/jmcp.2021.21290

Schüle, S. A., Hilz, L. K., Dreger, S., and Bolte, G. (2019). Social inequalities in environmental resources of green and blue spaces: A review of evidence in the WHO European region. *Int. J. Environ. Res. Public Health* 16:1216. doi: 10.3390/ijerph16071216

Seltenrich, N. (2015). Just what the doctor ordered. Using parks for children's health. *Environ. Health Perspect.* 123, 254–259.

Smeets, H. M., Wit, N. J., and Hoes, A. W. (2011). Routine health insurance data for scientific research: Potential and limitations of the Agis Health Database. *J. Clin. Epidemiol.* 64, 424–430. doi: 10.1016/j.jclinepi.2010.04.023

Ulrich, R. S. (1981). Natural versus urban scenes: Some psychophysiological effects. *Environ. Behav.* 13, 523–556.

Van den Berg, A. E., Maas, J., Verheij, R. A., and Groenewegen, P. P. (2010). Green space as buffer between stressful life events and health. *Soc. Sci. Med.* 70, 1203–1210.

Vanaken, G. J., and Danckaerts, M. (2018). Impact of green space exposure on children's and adolescents' mental health: A systematic review. *Int. J. Environ. Res. Public Health* 15:2668. doi: 10.3390/ijerph15122668

Visser, K., and van Aalst, I. (2022). Neighbourhood Factors in Children's Outdoor Play: A Systematic Literature Review. *Tijdschrift Voor Economische en Sociale Geografie* 113, 80–95. doi: 10.3390/ijerph19105906

Yang, B. Y., Zeng, X. W., Markevych, I., Bloom, M. S., Heinrich, J., and Knibbs, L. D. (2019). Association between greenness surrounding schools and kindergartens and attention-deficit/hyperactivity disorder in children in China. *JAMA Netw. Open* 2:1917862. doi: 10.1001/jamanetworkopen.2019.17862

Yuchi, W., Brauer, M., Czekajlo, A., Davies, H. W., Davis, Z., Guhn, M., et al. (2022). Neighborhood environmental exposures and incidence of attention deficit/hyperactivity disorder: A population-based cohort study. *Environ. Int.* 161:107120.

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When are you taking us outside? An exploratory study of the integration of the outdoor learning in preschool and primary education in Quebec

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Introduction: Recent research investigating the benefits of being outdoors and contact with nature in children showed strong associations with children's health and development. More teachers are choosing to integrate outdoor learning (OL) into their practice in Quebec, but few studies have focused on OL in the school environment, particularly in Canada and more specifically in Quebec, despite the fact that the school context lends itself favorably to this practice.

Objective: The purpose of this study was to portray OL in preschool and primary schools in Québec by identifying three key elements: (1) teachers' perception of the outdoors, (2) the uses of OL in schools, and (3) teaching strategies and factors that influence teachers' integration of OL.

Methodology: Semi-structured group interviews (n=4) conducted with 14 teachers and participant observations (n=4) were used for data collection. Inclusion criteria were to be a preschool or primary school teacher, to have taught at least eight sessions of OL in the past year, and to have no connection or contact with the research team prior to the start of the study.

Results: First, the results showed that teachers commonly understood the outdoors as being in the open air, practicing a physical activity, having the presence of nature, providing physical freedom and targeting a pedagogical intention. Second, teachers appeared to incorporate a variety of pedagogical intentions in OL (e.g., environmental awareness, interdisciplinary learning), in a variety of settings (e.g., city parks, woodlands), and with a variety of academic subjects (e.g., French, mathematics) and learning tasks (e.g., walking, nature shelter building). Third, teachers used a wide range of teaching strategies in OL (e.g., flexible planning, well-established routines). Participants also identified multiple factors specific to their setting that appeared to facilitate (e.g., parental support) or limit (e.g., storage of materials) their integration of OL into the school environment.

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Conclusion: This study provided a better understanding of the current use of the OL in the Quebec school environment by identifying the common characteristics, limitations and winning strategies of its use in schools. Teachers and schools interested in OL could benefit from the results of this study, particularly those interested in adopting a *Forest School* or *Udeskole* approach.

KEYWORDS

outdoor education, outdoor learning, nature, preschools, primary schools

Introduction

The outdoors for children's health and learning

Benefits associated with outdoor activities in children are now well established in scientific literature (McCormick, 2017; Schneller et al., 2017; Mann et al., 2022). Particularly, being outdoors would provide benefits not only for physical, psychological, and social health, but also for the practice of physical activity, and for the educational success of children (5–17 years). It appears that being outdoors strengthens their immune system, decreases stress experienced in daily life (Kuo et al., 2019), promotes their interpersonal relationships (Seeland et al., 2009; Keniger et al., 2013; Larouche et al., 2016) and makes them happier (Barrera-Hernández et al., 2020). It also helps to promote the practice of physical activity in children (Alvarez-Bueno et al., 2017; Santana et al., 2017; Bølling et al., 2021) while playing a positive role in their academic performance (Kuo et al., 2019). In addition, being outdoors is reportedly positively related to increased perseverance, self-discipline, attention, problem solving, critical thinking, and interest in school (Kuo et al., 2019). To date, we have not found many studies that showed no effect of the outdoors on children. However, Mann et al. (2022) explains that at this point, it is difficult to know whether it is contact with nature or simply teaching methods that have an impact when comparing outdoor versus indoor education.

Despite all the demonstrated benefits, disconnection from nature seems to be an increasing phenomenon among children in recent years (Louv, 2008; Strife and Downey, 2009; Cardinal, 2010; Silverman and Corneau, 2017), more specifically in the school environment (Waite, 2010) and several studies reveal that actions need to be taken to address this issue (Chawla, 2015; Soga and Gaston, 2016; Kahn and Weiss, 2017). In this respect, several studies indicate that the school setting appears to be an ideal context for encouraging outdoor activities among youth (Hills et al., 2015; Bentsen et al., 2021). Thus, integrating the outdoors in education appears to be part of a complementary health promotion strategy that would allow children to benefit from all of these effects (Nielsen et al., 2016).

The lack of research on outdoor education in Quebec

In Quebec, there is a growing interest in integrating the outdoors into the school environment (Maziade et al., 2018; Gadais et al., 2021a; Ayotte-Beaudet et al., 2022). To this end, results from a survey conducted by the Fondation Monique-Fitz-Back (2018) indicate that 75% of school-based practitioners conduct educational projects in outdoor settings in Quebec schools. In addition, in 2017, the Ministry of Education published a scientific report promoting the inclusion of outdoor activities in the school program (Ministère de l'Éducation et de l'Enseignement supérieur du Québec, 2017) and now indirectly encourages it through initiatives such as *15,023 À l'école, on bouge au cube*! Despite the government's efforts and the perceived excitement, Quebec teachers still face many challenges in integrating the outdoors in preschool and primary school (Ayotte-Beaudet et al., 2022).

The results available to date indicate that there are few studies on the use of the OL by preschool and primary school teachers in Quebec. Indeed, scientific literature reveals little information regarding preschool and primary teachers' perceptions of OL and there appears to be no scientific consensus regarding the definition of the outdoors (Gadais et al., 2021b). In addition, studies that focus on the organization of current outdoors initiatives, as well as on the description of effective outdoor pedagogies, appear to be lacking (Ayotte-Beaudet et al., 2017). Only a few Quebec studies have identified factors that limit or facilitate (Maziade et al., 2018; Sport et loisir de l'Île de Montréal, 2019; Ayotte-Beaudet et al., 2022) OL in preschool and primary schools. Finally, there is a lack of available didactic tools and existing pedagogical approaches to support teachers in their integration of OL in their practice (Maziade et al., 2018). Therefore, it seems relevant to study existing OL practices in preschool and primary schools in order to better understand the characteristics that determine OL in Quebec and to offer effective and accessible theoretical anchors to teachers who wish to use it.

The choice to study OL in preschool and primary schools (4 to 12 years) is based on several factors. First, preschools and primary schools act as a favorable environment for the adoption of healthy lifestyle habits. During this period of time, lifestyle

habits are formed and can have a positive long-term influence, such as maintaining physical activity practice until adulthood (Janz et al., 2005). Second, it is also during this period of their lives that children derive maximum benefits from contact with nature (Moens et al., 2019), that can have lifelong repercussions (Townsend et al., 2015; WHO, 2016). Third, positive experiences with nature during childhood could promote continued engagement with nature and the promotion of pro-environmental attitudes (Sachs et al., 2020).

Foundations and pedagogical approaches of outdoor learning

OL is a broad field that employs a variety of approaches depending on regions and cultures (Gadais et al., 2021a). In this study, we drew on different approaches to better situate current teaching practices in relation to one another and through the conceptual framework of the Educational Intervention Model in the Context of outdoors (IECPA – *intervention éducative en contexte de plein air*) (Gadais et al., 2021a). This model, also referred to as the intentions to use the outdoors matrix, is designed to conceptualize the various intentions and contexts of the outdoor use. This model aims to define the variety of outdoor activities (e.g., orienteering, bicycle), and activity practices *in* the outdoors (e.g., *Udeskole*) *via* the outdoors (e.g., *Adventure Education, Forest School*), and *for* the outdoor environment (e.g., *Environmental Education*). In painting a picture of the integration of OL by preschool and primary school teachers, it was possible to identify the conditions favorable to expanding the implementation of OL and to put forward recommendations to promote its development in the Quebec school environment. Figure 1 presents the intentions to use the outdoors matrix.

Thus, we use the term *Environmental Education* to refer to a stream of thought and action that aims primarily to promote the emergence of eco-citizens by responding to environmental, educational and pedagogical issues (Sauvé, 2015). In the Anglo-Saxon culture, we find *Adventure Education*, which is an experiential type of educational approach that immerses the participant in a sense of uncertainty or insecurity in order to encourage them to surpass themselves and achieve personal development (Sibthorp, 2003; Priest and Gass, 2018). *Forest school*,

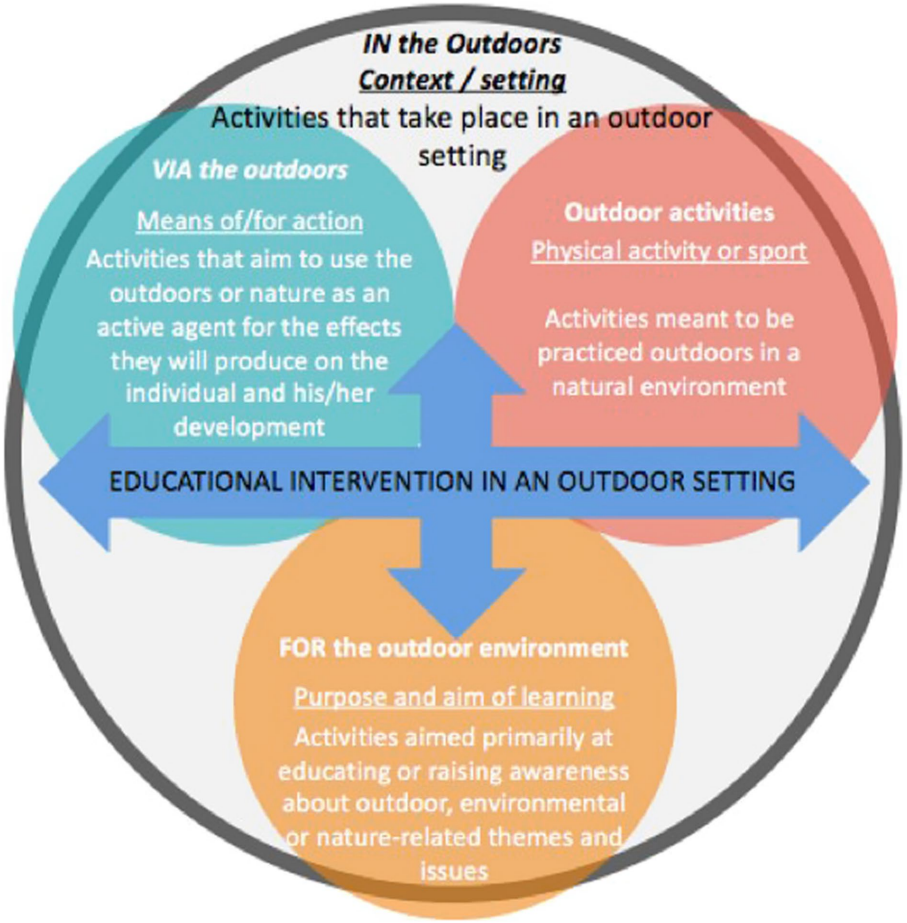

FIGURE 1
Intentions to use the outdoors by Gadais et al. (2021b).

TABLE 1 Synthesis of outdoor education approaches.

Approaches	Concepts	Main effects
Adventure education (AE)	A form of experiential education that focuses on the development of the person by immersing them in a sense of uncertainty or insecurity in order to challenge them (Sibthorp, 2003; Priest and Gass, 2018).	- Decrease mental stress, promote self-efficacy, mindfulness and well-being, strengthen group cohesion and individual responsibility towards others, help solve problems such as truancy and depression (Harper, 2017).
Environmental education (EE)	Aims primarily to foster the emergence of eco-citizens who live a conscious, creative and committed citizenship by addressing environmental, educational and pedagogical issues (Sauvé, 2015).	- Promotes a critical approach (Sauvé, 1997); - Allows the development of environmental knowledge, will and power to act (Sauvé, 2015).
Forest school (FS)	Aims for children to spend the majority of their days in nature, often in the forest and in a variety of weather conditions by encouraging learning through free play, motor skills development, exploration of nature, collaboration among learners, and risk taking (Elliot et al., 2014; Coates and Pimlott-Wilson, 2019).	- Improved creative, problem-solving, self-directed and collaborative learning skills, increased physical activity practice, creation of stronger social support networks, recognition of personal, social and environmental responsibilities, development of resilience, development of social skills such as conflict management, negotiation and diplomacy (Coates and Pimlott-Wilson, 2019);
Udeskole	Characterized by mandatory and regular educational activities outside of school buildings, especially in natural and cultural settings (e.g., forests, parks, local communities, factories and farms) (Bentsen and Jensen, 2012).	- Optimize students' physical activity practice; - Promote pro-social behaviors (Bølling et al., 2019); - Increase academic motivation (Bølling et al., 2018); - have a positive effect on social behaviors, attitudes toward teaching and toward learning and physical activity practice (Mygind, 2009)

also referred to as nature-based pedagogy, uses nature as a learning environment and vehicle to provide children with socioconstructivist and inclusive learning experiences (Maynard, 2007; Coates and Pimlott-Wilson, 2019). Finally, in Scandinavia, there is *Udeskole*, which translates to school outside, by focusing on mandatory and regular educational activities outside the school walls (Bentsen and Jensen, 2012). Other streams and approaches to OL exist, but those selected for this study as the most likely to support the three research objectives. Table 1 provides a synthesis of these four known approaches in OL.

Current research on teaching strategies

The teaching strategies (pedagogical and didactic strategies) presented in the following section are directly derived from Legendre's SOMA model (Legendre, 2005), which summarizes the pedagogical and didactic situation in education (Figure 2). This model aims to shed light on the educational relationships that exist between the three poles of the pedagogical relationship in education, i.e., between the agent or the resources (teacher), the subject or the learner (student) and the content (e.g., knowledge, learning), with the goal of supporting the development of the individual while considering his or her needs and the setting context. The didactic relationship (between the teacher and the knowledge) and the teaching relationship (between the teacher and the student) are investigated in this study as teaching strategies. They are defined as any intervention that is used to support learning. The scientific gap on these strategies used in OL prompts us to study those that seem the most relevant to OL and to explore them further in relation to the objectives of this study.

The teaching strategies studied include, first, the pedagogical relationship, which represents all the exchanges, reciprocal influences, actions and reactions between the teacher and the student (Weigand and Hess, 2007). As a fundamental condition for educational effectiveness (Cosmopoulos, 1999), studying the pedagogical relationship in OL will allow a better understanding of teachers' practices in OL. Secondly, there is group management, which is the set of educational practices that the teacher puts in place to allow optimal teaching and learning conditions (Doyle, 1986). According to a recent Quebec study (Ayotte-Beaudet et al., 2022), student management is one of the avenues to be explored further in OL. Third, teacher planning is based on the perception of students' needs (Tochon, 1993), which is used in education to organize teaching-learning content (Yinger and Clark, 1982, 1983). It seems relevant to study the planning methods used by teachers in order to better understand how they can support OL. Finally, the environment, which is a central space that can represents the setting context in which teaching and learning take place (Legendre, 2005). Focusing on the environments used by teachers in OL will provide a better understanding of their

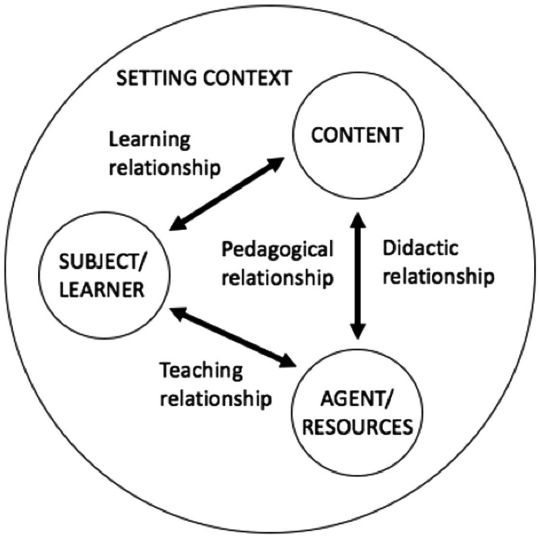

FIGURE 2
SOMA model (Legendre, 2005) (p.1240).

characteristics and uses. Table 2 presents a synthesis of the teaching strategies used in this study and the associated concepts.

Limiting factors of outdoor learning integration

Several factors influencing the integration of OL into the teaching environment have been unanimously identified in the literature. These include the lack of teacher confidence and expertise (Higgins et al., 2006; Barfod, 2018; Edwards-Jones et al., 2018; Van Dijk-Wesselius et al., 2020), the lack of time to prepare and conduct activities (Edwards-Jones et al., 2018; Van Dijk-Wesselius et al., 2020), the lack of access to outdoor sites (Higgins et al., 2006; Waite, 2010), the lack of funding (Waite, 2010) the lack of support for OL (Ruether, 2018), the difficulty to get started (Van Dijk-Wesselius et al., 2020), the physical constraints (Van Dijk-Wesselius et al., 2020) and weather conditions (Ruether, 2018). To date and in Quebec specifically, studies support these observations (Maziade et al., 2018; Sport et loisir de l'Île de Montréal, 2019).

Objectives of the present study

The purpose of this study is to provide a portrait of the integration of OL in preschool and primary school settings by answering the following question: What are the teaching strategies (conceptions, uses, teaching strategies and influencing factors) that preschool and primary school teachers in Quebec use to integrate OL into their practice? More specifically, the objectives are to: (1) collect and characterize preschool and primary school teachers' perception of the outdoors, (2) list the uses of OL by preschool and primary school teachers; (3) identify the teaching strategies and factors that influence OL by preschool and primary school teachers.

Methodology

Research design

This study used an exploratory qualitative design to meet the three research objectives. A qualitative approach is used in this study since it allows the identification of the reality of the practices and the specific needs of the target population (Dano et al., 2004). It seeks to produce new knowledge on OL in the preschool and primary school setting, a field that has been just little studied in Quebec (Trudel et al., 2006). Data were collected through group interviews ($n = 4$), from groups of three to five teachers ($n = 14$), and through participant observations with several teachers ($n = 4$). A triangulation of the data (Van der Maren, 1996) was then carried out using two types of data: the field notes from the logbook and the data from the group interviews. A cross-tabulation of the data was finally carried out in order to address the three research objectives.

Recruitment of participants

To be included in the study, participants had to meet the following inclusion criteria: (1) to be a preschool or primary school teacher in the province of Quebec, (2) to have use OL for at least eight sessions in the last school year, and (3) to have no connection or contact with the research team prior to the start of the study. First, teachers were recruited *via* the Internet, through the dissemination of a message to the mailing lists of the Federation of Physical Educators Teachers of Quebec (FEEPEQ – *Fédération des éducateurs et éducatrices physiques enseignants du Québec*), the Quebec School Services Center (*Centre de services scolaires du Québec*), and through a network of contacts in the OL community to re-distribute the message by e-mail. They were automatically selected if they met the inclusion criteria and were available to participate in the study. Then, in a second phase, four teachers were selected for an observation session. A total of 14 preschool and primary teachers were recruited to provide a comprehensive picture and to achieve data saturation (Gainer, 1995). At the primary level, five health and physical education teachers and three classroom teachers were recruited, while at the preschool level, six classroom teachers were recruited for this study. Ten of the teachers worked at Quebec School Services Center schools and one in a private sector school. In total, nine women and five men teachers were recruited. Years of experience in OL of the participating teachers ranged from 0–5 years (7 teachers), 5–10 years (3 teachers), 10–15 years (1 teacher), 15–20 years (2 teachers), and over 20 years (1 teacher). Most participants had an average of 0–10 years of teaching experience

TABLE 2 Synthesis of the teaching strategies (pedagogical and didactic) used in this study and associated concepts.

Strategies		Associated concepts
Pedagogical	Pedagogical relationship	- Exchanges, reciprocal influences, actions and reactions between the teacher and the student (Weigand and Hess, 2007); - Benevolence and empathy (Visioli, 2019).
	Group management	- All the educational practices put in place to allow teaching and learning conditions (Doyle, 1986); - Optimal internalization of the rules (Méard and Bertone, 2009).
	Environment	- The outdoors as an authentic educational context (Ayotte-Beaudet et al., 2020); - Three levels of use: inspiration, pedagogical tool, interdisciplinary learning (Moffet, 2019).
Didactic	Planning	- Juxtaposition of content related to students' perceived needs (Tochon, 1993); - Simplifies and organizes teaching-learning (Yinger and Clark, 1982, 1983); - Place of predictability and unpredictability (Tochon, 1993); - Routines (Yinger, 1979).

in OL. Participants socio-demographic characteristics are presented in Table 3.

Procedure

First, four semi-structured group interviews were conducted with the teachers. The average length of the interviews was approximately 90 min in order to obtain meaningful data (Dano et al., 2004). A total of 14 teachers were interviewed, in subgroups of three or five preschool and primary teachers. An audio recorder was used and the transcripts were done manually and confidentially in verbatim form. Group interviews were used as a data collection tool to avoid subjecting teachers to the principal investigator's questions alone, to open up dialog and to welcome emergent data from participants (Morrissette, 2022). The interviews was divided into three categories, which represent the three objectives: (1) the perception of the outdoors, (2) the use of the outdoors and (3) the teaching strategies and the factors that influence OL (see Supplementary file for the full version of the group interview guide).

Second, observations of participants (Paré, 2014; Chevalier et al., 2018) lasting between 60 and 180 min were conducted with four teachers who also participated in group interviews. These participant observations allowed for full immersion in the teachers' practices in OL. They were used to enrich the answers related to the three research objectives and to confirm the data through concrete observations directly in the field. All three observations took place in urban settings. Observation 1 and 2 took place with 10–11 years old students, but observation 1 was in a forest away from the school, while observation 2 took place in a municipal park near the school. Observations 3 and 4 were both conducted with 5–6 years old students, with observation 3 being on the schoolyard and observation 4 being in a forest away from the school. These observations were collected by taking pictures and making quick notes using key words in a handwritten logbook (Paré, 2014). These notes were then analyzed, as were the transcripts of the group interviews. Table 4 presents the data collection process according to the two instruments used.

Data analysis

Following the data collection, the qualitative data from the group interviews (verbatim) and participant observations (logbook) were transcribed and analyzed using NVivo 12.6 Software. For the analysis, the deductive grid was constructed prior to data collection based on the three research objectives. The data were analyzed using content analysis (L'Écuyer, 2011) in three steps: (1) preliminary reading and listing of statements, (2) selection and definition of classification units, and (3) categorization process. First, the verbatim and the logbook were read twice by the principal investigator to become familiar with the content. This step allowed the principal investigator to obtain an overall picture of the information and identify key trends. Second, the principal investigator proceeded to identify the meaning units, which represented the categories used to address the research objectives. In this step, the principal investigator focused on the information present in the verbatim and grouped it into categories according to the defined objectives and certain emerging categories. The fidelity of this step was ensured by consensus validation between the principal investigator and a member of the research team to make the choice of statements. Third, each unit of meaning was coded and classified into broad categories and specific subcategories. This was an open-ended and semi-inductive categorization (based primarily on the categories in the interview guide). The coding was validated by a member of the research team, through a process of confrontation of the interpretations and reaching a consensus for further analysis. This

TABLE 3 Profile and characteristics of participating teachers.

ID	Sex	Teaching area	Level	School service center	Experience in OL (years)	Frequency of use
P_1	M	Health and physical education	Primary	Marguerite-Bourgeoys	15–20	+
P_ 2	M	Health and physical education	Primary	des Affluents	0–5	+/−
P_3	M	Health and physical education	Primary	Kamouraska Rivière-du-Loup	15–20	+/−
P_4	M	Health and physical education	Primary	des Samares	20+	+
P_5	F	Class teacher	Primary	des Affluents	5–10	+/−
P_6	M	Health and physical education	Primary	des Trois-Lacs	10–15	+/−
P_7	F	Class teacher	Primary	Marguerite-Bourgeoys	5–10	+
P_8	F	Class teacher	Preschool	des Hauts-Bois-de-l'Outaouais	0–5	++
P_9	F	Class teacher	Preschool	des Appalaches	0–5	++
P_10	F	Class teacher	Preschool	de la Rivières-du-Nord	0–5	++
P_11	F	Class teacher	Preschool	des Affluents	0–5	+/−
P_12	F	Class teacher	Preschool	des Navigateurs	0–5	N.A.
P_13	F	Class teacher	Primary	Private	5–10	++
P_14	F	Class teacher	Preschool	des Rives-du-Saguenay	0–5	++

The four colors are used to represent the four interviews conducted with the participating teachers. For example, blue for interview 1 with P_1 to P_5.
++: every day; +: several times a week; +/−: once a week; −: a few times a year

TABLE 4 Data collection process.

Months	Data collection							
	Group interviews				Participant observations			
	Interview 1	Interview 2	Interview 3	Interview 4	Observation 1	Observation 2	Observation 3	Observation 4
November 2021								
December 2021								

The months of the year when the measuring instruments were used for data collection are in gray.

categorization allowed for the emergence of definitive themes and categories, while drawing on the initial categories of the interview guide and the logbook. During this process, a consensus was reached around four emerging categories and their subcategories (Stake, 1995).

Ethical considerations

An ethics certificate (2022–4,152) was obtained from the Research Ethics Committee for Student Projects (CERPE plurifacultaire – *Comité d'éthique de la recherché pour les projets étudiants*) of Université du Québec à Montréal. Written informed consent to participate in this study was provided by the participants. Written consent was also provided for the photo taking by the teacher who was observed and by the parents of the students observed.

The ethics committee waived the requirement of written informed consent for participation. Written informed consent to participate in this study was provided by the participants. Written consent was also provided for the photo taking by the teacher who was observed and by the parents of the students observed.

Results

The results from the verbatim and logbook records are organized into three main sections to echo the objectives of this

research: (1) teachers' perception of the outdoors, (2) teachers' uses of OL, and (3) teaching strategies and factors that influence OL. A synthesis of the findings is presented in Figures 3, 4.

Teachers' perception of the outdoors

In order to address the first objective of this research, data were collected regarding teachers' perception of the outdoors. In general, all of the teachers interviewed and observed approached the outdoors from fairly similar perspectives. Five main elements emerged: (1) being outdoors, (2) having the presence of nature, (3) practicing a physical activity, (4) providing physical freedom, and (5) targeting a pedagogical intention.

Being outdoors

Teachers' perception of the outdoors was almost unanimous about being outdoors ($n = 13/14$), as most of them mentioned that the outdoors was associated with being in the open air, being outside, or outside the walls. Nearby, remote, or biodiverse environments also seemed to be perceived as outdoors by the majority of the teachers.

> "(...) outdoors, it's really just outdoors. But we can be outside in the schoolyard, we can be outside at the park next door or go to the great outdoors further away." (P_1)

Having the presence of nature

Although most teachers felt that outdoors could be done in any setting outside the walls, the presence of nature also seemed to be important in their perception of outdoors, as several ($n = 5/14$) named it.

> "Outdoors means (...) being outside, but maybe not outside in a mall parking lot. There's the nature, environment aspect too in the word outdoors." (P_5)

However, one teacher emphasized the possibility of bringing outdoors indoors, by bringing nature in.

> "I would even add, you know, it's not just outside. You know, nature can be brought inside in all kinds of ways." (P_9)

Thus, outdoors seems to be associated with elements of nature or the outdoor environment by teachers.

Practicing a physical activity

Several teachers ($n = 4/14$) associated outdoors with being physically active or being in motion.

> "Q: I would like to know now what the term outdoors means to you? We can finish the interview well with this.
> (...)

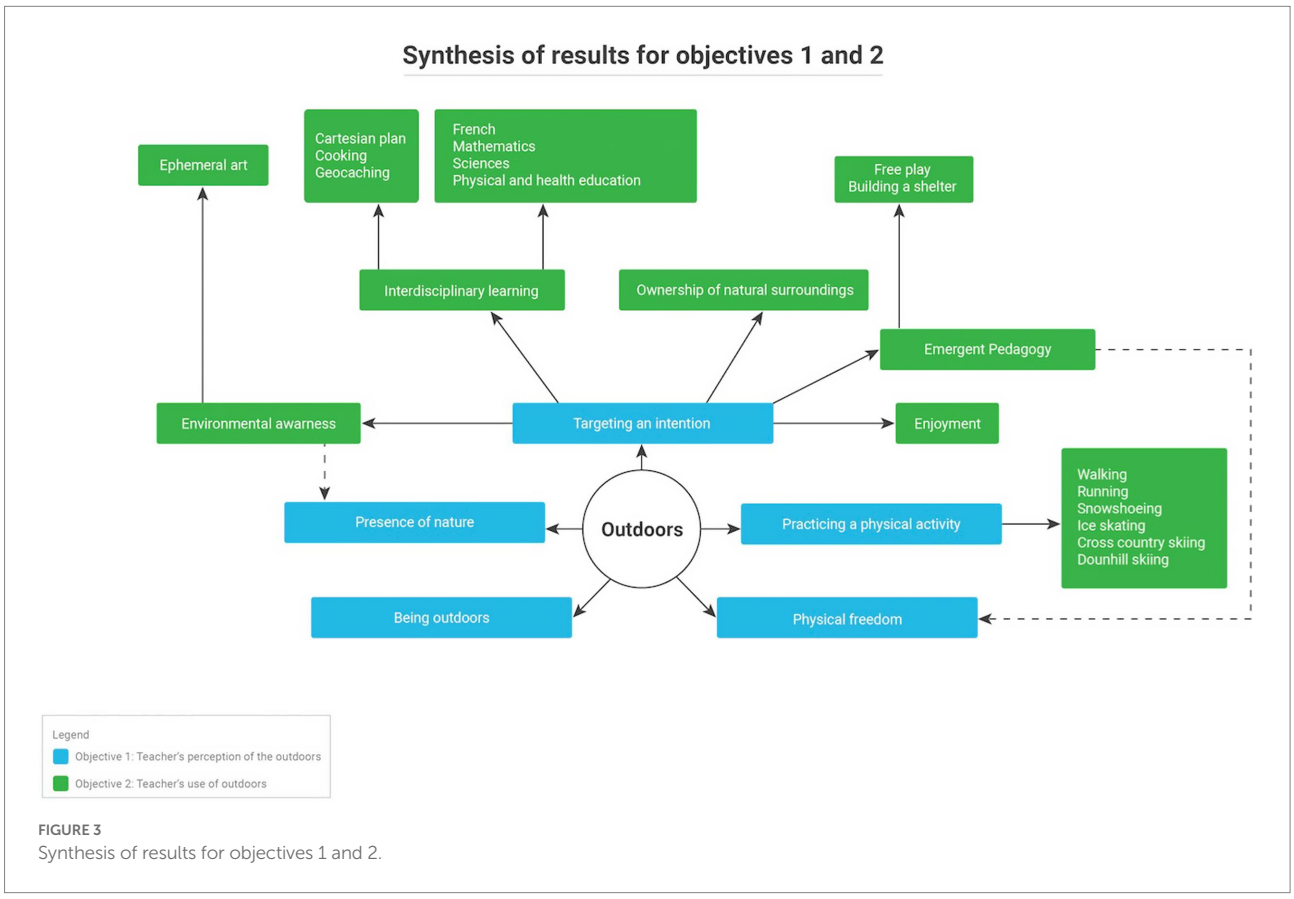

FIGURE 3
Synthesis of results for objectives 1 and 2.

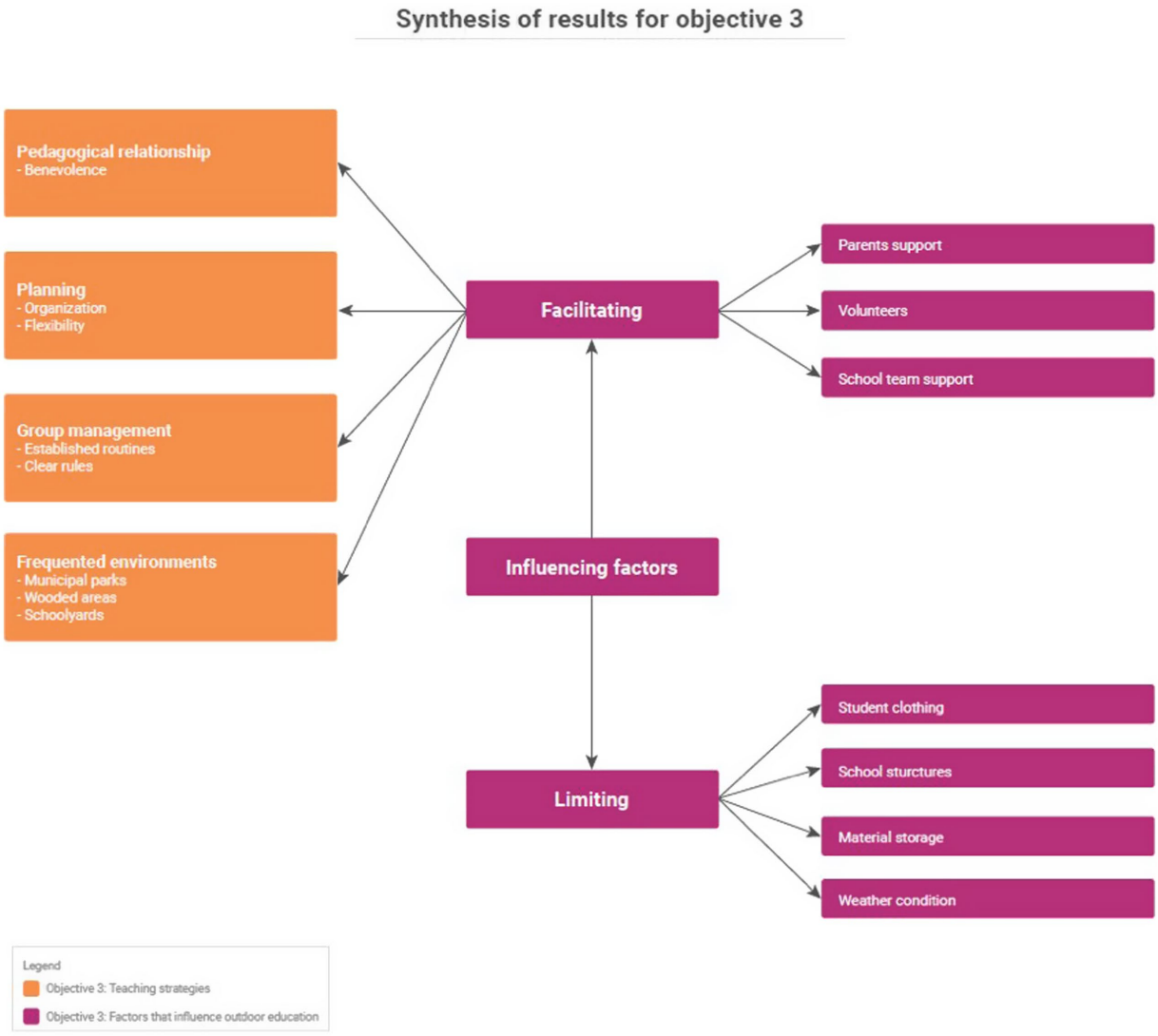

FIGURE 4
Synthesis of results for objective 3.

> P_12: Moving (...). I would go with that.

Providing physical freedom

Also, several teachers ($n = 4/14$) associated outdoors with the physical freedom it provides to the students while the learning sessions.

> "I think it's freedom, it's really freedom. You know, in the classroom, we're there all the time, don't make too much noise, there are classes next door. Now, it's like hey, it's really the freedom aspect where I find that the kids are always being asked to stop talking, to sit down, to get in line, to get back in line, to get back in line again it's recreation, it's recess, to get back in line again it's physical education, to get back in line, get back in line... But now, there's no line." (P_13)

Targeting a pedagogical intention

Finally, a few teachers ($n = 3/14$) mentioned that a pedagogical intention was needed to guide the activities in OL, as they need to generate learning to be considered in OL.

"I think there has to be an intention, whatever the intention is. If you go outside and do not do anything.... (...). So, your intention has to be to go listen to the birds, that's okay. You have an intention, you have a goal in mind (P_7).

Teachers' uses of outdoor learning

In order to address the second research objective, data on teachers' uses of OL were collected in order to inventory them. These include a variety of intentions, school subjects, learning tasks, frequented environments and material used.

Pedagogical intentions

The pedagogical intentions used by teachers consisted of the intended goals of using OL and were expressed through the results of this study in five forms: (1) ownership of the natural surroundings, (2) environmental awareness, (3) emergent pedagogy, (4) enjoyment, and (5) interdisciplinary learning.

Ownership of natural surroundings

Several teachers ($n = 6/14$) mentioned that they wanted to encourage students to take ownership of the natural surroundings they were visiting, whether it was to make them aware of the environment around them or to encourage them to return to these environments outside the school context.

> "Basically, one of the goals of the outdoor program, which I did not mention earlier, is to help students discover the neighborhood. The school, there's a super beautiful city. There are really extraordinary places that the children do not use, parks that they do not know. The point of that is to really discover the entire environment around them." (P_6)

Few teachers ($n = 3$) also wanted students to develop a sense of place or neighborhood, so they could learn about their surroundings.

> "There are really several spaces. There's the church, there are markets, the convenience store, so we go there too. We went to get a pumpkin recently. We went by bike, we went to the market to get a pumpkin. This week, we're going to ride our bikes to the post office to mail a letter to Santa Claus. That's what's fun about the village, we're still close. Last year we went to the municipality to get trees. Then, we went to plant them in the forest. There is a greenhouse that gave us soil, we have a sponsorship. We have a hardware store not far away that we are able to go to get materials, we have a painting project right now. So we're really using the environment." (P_14)

Environmental awareness

Several teachers ($n = 6/14$) appeared to be doing activities that aimed at having a connection with the environment, develop a greater sensitivity to the environment, or have a better understanding of the environment around the students. When this intention is used, nature seems to be the very object of learning.

> "There is a very environmental side that I want to develop in children. So how do we protect things that we don't know about? You take care of what you know and then what you love. So if they have a link with nature, they will know how nature works. We're going to know that our actions have a consequence, since we're all interrelated, that humans are also animals." (P_10)

Emergent pedagogy

On the other hand, emergent pedagogy seems to be part of the pedagogical intentions used in OL by several teachers ($n = 5/14$).

> "(...) I couldn't tell you, I'm doing this or that because it's really... I'm starting from the children's interests, so it's really emergent pedagogy, so I'm going to do a lot of things." (P_10)

The logbook also corroborated this intention, with key words such as "emergent learning," "discoveries," and "exploration" (observation 4).

Enjoyment

Pleasure ($n = 5/14$) or enjoyment was a preferred pedagogical intention of several of the teachers interviewed and observed.

> "I try as much as possible to have fun all the time. My classes aren't always great, but what I mean is that they need to have fun outdoors." (P_1)

The logbook corroborated this with terms such as "intentions: free play, fun" for observation 3.

Interdisciplinary learning

Interdisciplinarity ($n = 2/14$ and one participant observation) was also an intention advocated by few teachers during OL activities.

> "I have the classroom teacher who walks us through this. We try to do almost every project. We try to do interdisciplinarity. We do mapping, we work on a cartesian plane, we go on our snowshoeing trip, the kids have to look for the animals, they have to give an oral presentation on the animals, they had the iPad, they film themselves. After that, the teacher makes an assessment outline for an oral presentation. So, we really... we try in almost all our activities to integrate interdisciplinarity. Like recipes today, we are working on proportions, fractions, so we work... we work with all that too." (P_6)

Notes from the logbook corroborated the use of interdisciplinarity as a pedagogical intention, through key words such as "geocaching," "French," and "math" in the same session (observation 2).

School subjects and learning tasks used

This study identified different ways to teach in OL. These can be divided into (1) school subjects and (2) learning tasks, which include both the *moyens d'action* (Méard and Bertone, 2009) and the learning tasks (Durand and Durand, 2001). The most often taught school disciplines in OL by teachers were French, more specifically writing ($n = 8/14$) and reading ($n = 5/14$), mathematics ($n = 8/14$) and science ($n = 4/14$). Physical and health education ($n = 5/14$) is also taught by the physical and health education

teachers specialists who participated in this study. The most common learning activities used in OL by all teachers were walking ($n = 7/14$), free play ($n = 6/14$), nature shelter building ($n = 6/14$), ephemeral art ($n = 4/14$), running ($n = 4/14$) and cooking ($n = 3/14$). Several ($n = 4/14$) also mention starting fires with their students, in the forest or on the school grounds, on which they cook. Figure 5 shows students in the fourth participant observation session participating in a shelter construction in the forest as part of an outdoor class.

> "I do all kinds of things. It can be art, math, art, science, reading, writing. Really, anything you can do as a subject in primary school." (P_7)

> "We're going to set up the native tent with the little wood stove inside otherwise, it's also fires outside in the forest. So everything to do with cooking outside. We're going to cook everything that's native, we're going to make bannock bread. (P_9)

The logbook corroborated these school subjects and learning tasks, with key words such as "math" and "walking" (observation 1), "science" and "free play" (observation 3), and "shelter building" and "free play" (observation 4).

One preschool teacher also mentioned doing a play-fighting activity, to keep up with the children's needs for more physical play. This could be confirmed using the logbook, which included the keywords "supervised bickering" (observation 4).

FIGURE 5
Outdoor learning on foot in a wooded area.

> "I know it's in the child's development to play-fighting, but here I do it in a supervised way. I ask them to come to me, and then I turn them around to a place where there are no opportunities, there are no obstacles or trees or rocks nearby. Then there I tell them my safety instructions." (P_10)

In addition, most teachers ($n = 8/14$), including several health and education teachers ($n = 5/8$), engaged in physical activities in OL, such as snowshoeing ($n = 7/14$), ice skating ($n = 4/14$), downhill skiing ($n = 3/14$), and cross-country skiing ($n = 3/14$). One teacher also mentioned doing an introductory camping activity in the schoolyard.

> "We do canoeing, running, skating, snowshoeing, introduction to downhill skiing in the schoolyard, we have a little rink in the schoolyard, scootering, biking, Frisbee, as much as possible outside." (P_4)

Materials used

In order to provide optimal outdoor teaching, teachers reported bringing a variety of useful items with them. The most common item brought was a first aid kit ($n = 5/14$), followed by a cart ($n = 4/14$), bins or baskets to hold and transport materials ($n = 4/14$), and extra snacks for students ($n = 3/14$).

> "Me, I can just quickly add what comes to mind is that every time we go on an outdoor field trip, we leave with walkie-talkie, first aid kit, it's clear, we always have that with us." (P_3)

Few ($n = 2/14$, corroborated by 2 participant observations) also reported bringing a transceiver to ensure communication with the school team, extra clothes for their students, a whistle, and even a saw, nails, screws, and hammers for students.

> "We build with saws and hammers and nails. We build animal shelters in the winter." (P_13)

Overall, data from the group interviews indicated that a few teachers ($n = 3/14$) requested that each student have a backpack. The logbook corroborated this with two observations, "every student has a backpack" (observation 1) and "every student has their backpack with their student number" (observation 4).

Teaching strategies and factors influencing the integration of outdoor education

In order to address the third research objective, data were collected related to teaching strategies and factors that influence the integration of OL into the school environment. First,

teaching strategies such as planning, routines, and rules emerged from the group interviews and participant observations and were characterized in OL. Second, factors that facilitate and limit the integration of OL were named by the participating teachers.

Teaching strategies

The results of this study allowed us to better characterize the pedagogical and didactic strategies used by the teachers, namely the pedagogical relationship, planning, group management and the frequented environments.

Pedagogical relationship

Although the teachers participating in the group interviews did not specifically elaborate on the pedagogical relationship they implement in OL, the four participant observations indicated that it is marked by "closeness between the teacher and the students," "benevolent pedagogy" (observation 1), "mutual trust" (observation 2), "benevolence" and "calmness" (observation 2 and observation 4).

Planning

Teachers expressed that the two greatest strengths of optimal planning in OL are (1) that it is well organized ($n = 7/14$ and 2 observations) and (2) that it is flexible ($n = 8/14$). By organized, teachers meant always thinking about what will be taught ahead of time, preparing materials ahead of time, having a Plan B, and reserving time if needed.

> "Yes, you have to be organized, you have to have planned. You have to know where you're going and then you have to organize ahead of time, you can't be last minute." (P_7)

The logbooks of the four participant observations corroborated organization for optimal planning and session flow through themes such as "organized" and "structured."

Flexibility or adaptability through planning was also an important element for teachers. They named the possible contingencies and the importance of being able to react and adapt quickly to any eventuality.

> "I would say that you have to adapt, you have to be able to adapt as well. It might not go as planned so I think you have to have the ability to adapt quickly. There are times when we do activities that don't go the way we thought it would." (P_7)

Group management

The internalization of rules by students seems to be part of useful pedagogical strategy for optimal group management in OL. Several rules were named by the teachers, but those related to geographical boundaries ($n = 10/14$) and those related to safety ($n = 7/14$) seemed to represent the two main categories of the most used rules.

First, rules related to geographic boundaries often referred to expected student behavior or landmarks that should not be crossed.

> "But yeah, otherwise me, what I really like to do is always show them the boundaries before I leave them. No matter what I do when we get there, this is our place, and then these are our boundaries. You can never go beyond these limits, and after that I don't often have to repeat them. (P_11)

The logbook of the second observation corroborated the rules about geographical limits, through the following key words: "pre-established limits (street names)."

Next, teachers indicated that safety instructions refer to what students must follow in order to ensure the safety of all during the activity. For example, not climbing trees, not throwing objects, or not putting anything in your mouth are rules that have been named.

> "I don't want them to climb trees, throw... they are very small so the branches, you leave them on the ground. There's no one playing with swords, there's no one throwing rocks at each other, it's really basic rules, safety rules." (P_8)

Two participant observations noted that building on student autonomy seems to be part of an effective group management strategy in OL. The logbook indicated "autonomous students" (observation 1 and observation 2), "emphasis on student accountability and autonomy, teacher does not have much to do" (observation 3), and "free and autonomous students, effective classroom management" (observation 4).

On the other hand, routines also seemed to be part of an effective group management. Several ($n = 5/14$) said that they did the morning routine with the students inside, just before going out. Next, they named different types of routines used in OL education, including the routine for rallying students ($n = 4/14$). To do this, they used various means, such as a song or animal call, to get students' attention and bring them back to a place.

> "Then my routine too is at the wolf howl they come back to the assembly point." (P_10)

To this end, the logbook from observation 1 corroborated the routine for rallying by presenting terms such as "the teacher says 1, 2, 3, LEGO to bring them back." Observation 4 corroborated the rallying routine with key words such as "wolf howl for gathering and moving."

Finally, two preschool teachers also associated a routine with a time of connection to nature and the environment, where spiritual values seem to be emphasized.

> "There's also a routine of gratitude. We say hello to the sun, we appreciate, thank you. A lot of native values too, we go, we really go but it's like everything is alive. The rock, we become aware of it." (P_10)

Frequented environments

The most frequently visited environments by teachers were municipal parks ($n = 12$), wooded areas ($n = 12$) and schoolyards ($n = 10$). These were environments close to the schools and therefore within walking distance. Figure 6 shows students participating in an educational walk in the woods as part of an OL course observed during the first participant observation session.

The logbook corroborated this data with some key words. For use of city parks, we note "use of park within five-minute walk" (observation 2). For use of wooded areas, we note "walking in the forest" (observation 1) and "use of the forest behind the library" (observation 4). For schoolyard use, "use schoolyard" (observation 1) and "use park in schoolyard" (observation 3).

Skating rinks ($n = 7/14$) and bodies of water (river, lake, or stream) ($n = 6/14$) are also used by several teachers interviewed. It is interesting to note that churches ($n = 2/14$), libraries ($n = 1/14$), cemeteries ($n = 1/14$), businesses such as markets, convenience stores or hardware stores ($n = 1/14$), post offices ($n = 1/14$) and municipal offices ($n = 1/14$) were also environments frequented in OL by few study participants.

Factors that influence outdoor education

Factors that influence the integration of OL in the school setting were categorized into two perspectives: factors that help or facilitate the integration of OL and factors that limit or hinder the integration of OL.

Facilitating factors

The factors most mentioned as helping teachers integrate OL into their practice were the support of parents ($n = 10/14$), the presence of volunteers ($n = 9/14$) and the support of the school team ($n = 9/14$).

> "Simply put, it's school-family-community. If you have those three opportunities with you, it'll go well and you'll have resources and then you'll be able to do all these ideas if those three spectrums work with you." (P_4)

FIGURE 6
Students build a shelter as part of an outdoor class.

The logbook also reports the presence of volunteers, with these key words: "very supportive parent-volunteers" (observation 2).

Several teachers ($n = 6/14$) also mentioned having material or financial support and a few ($n = 4/14$) mentioned being paired with a colleague or having a schedule that allows them time to teach OL. Finally, fun was also mentioned as an important, even helpful, element in OL ($n = 3/14$).

> "The challenge is to equip them to want to go by themselves. That they realize that it is fun and that yes, we have fun as P_1 said. It's a goal that you have to keep, but you have to have fun. You have to have fun doing it too. It will snowball." (P_4)

Limiting factors

The limiting factors that were named were student clothing ($n = 5/14$), school structures ($n = 4/14$), storage of materials ($n = 4/14$), and weather ($n = 4/14$). Teachers found Service Center or school rules to be barriers of going outside. They also find that OL equipment requires large spaces for storage.

> "One of the things also that is a problem sometimes is, I don't want to get too long, I'll go fast, the School Service Center sometimes they can get in the way. It's often the big machines, it's often hard to get them to move, but when you're persistent, when you've proven yourself a little, when the school board or the service center sees that you're serious about what you're doing, you can open doors and get things changed." (P_1)

Finally, a preschool teacher pointed out the presence of many training opportunities, which however do not seem to be in line with her needs.

> "That's it, but I find that there is like a great offer of training. But I don't know? Then maybe, you seem to have taken some good ones but it seems like there is too much training. Sometimes, I am doing it, yes, but I already do that. I went to the preschool training, I said, okay, but now I really want to go to a workshop where is it when I read the description, but I'm already doing it, I don't want help to start, yeah there's a lot of it, but it's how to start." (P_11)

Emerging data

Additional findings emerged from the group interviews and participant observations that are worth mentioning. First, teachers named their motivations for incorporating OL into their practice. The reasons most given were (1) getting students outside ($n = 6/14$),

(2) the COVID-19 pandemic ($n = 5/14$), (3) getting students to transfer learnings in OL to home ($n = 3/14$), and (4) fostering integration of immigrants ($n = 2/14$). Second, several teachers discussed the perceived positive effects of OL on their students. They named (1) feeling free ($n = 7/14$), (2) being more physically active ($n = 5/14$ and 2 observations), and (3) calming ($n = 5/14$ and one observation). Third, teachers named the perceived positive effects of OL for themselves as (1) stronger bonding with students ($n = 4/14$), (2) enjoyment ($n = 4/14$ and one observation), (3) feeling free ($n = 3/14$), and (4) two-way learning ($n = 3/14$). Teachers highlighted many benefits for their students and themselves.

Discussion

The purpose of this study was to provide a recent portrait of the integration of OL in preschool and primary school teaching in Quebec. First, it appears that teachers' perception of OL includes five major elements that are fairly unanimous (e.g., being outdoors and having the presence of nature). Secondly, teachers seem to aim for various pedagogical intentions in OL (e.g., environmental awareness, interdisciplinary learning), with different school subjects (e.g., French, mathematics) and learning activities (e.g., walking, doing ephemeral art) and in different settings (e.g., schoolyard, municipal park). Finally, various facilitating (e.g., parental support, volunteer support) and limiting factors (e.g., storage of materials, administrative structures), as well as teaching strategies (e.g., flexible planning, established routines), appear to influence teachers' integration and organization of OL in the school setting.

The outdoors as an educational approach

Teachers perceive OL as a pedagogical approach with five characteristics: (1) being outdoors, (2) having the presence of nature, (3) practicing a physical activity, (4) providing physical freedom, and (5) targeting a pedagogical intention. To the best of our knowledge, few studies in the scientific literature have focused on preschool and primary school teachers' OL design. This research has therefore made it possible to better characterize it, at least for Quebec. Although the authors do not seem to be unanimous in their definition of OL (Auger et al., 2021), some highlight two central characteristics that are consistent with the results of this study: (1) the presence of a natural environment and (2) a certain amount of physical effort related to the activity practiced (Auger et al., 2021). The results of the present study also point to more specific characteristics of OL, such as being outdoors, providing physical freedom, and targeting a pedagogical intention related to an outdoors activity. This last characteristic, intention, seems to be part of a conception of outdoors that is specific to OL, through the intended learning intention. It seems, therefore, that for teachers, outdoors can take shape in different ways depending on the individual who uses it.

Interdisciplinary intentions

We note that the majority of participating teachers seem to have several pedagogical intentions at the same time, such as aiming for more ownership of natural settings by students (e.g., discover the neighborhood), situating learning according to students' emerging interests (e.g., learn the names of the birds you hear), and environmental awareness (e.g., learn the life cycle of a tree). The results indicate that teachers do not only seem to use outdoors as a setting context where learning and teaching take place (Legendre, 2005), but also as a pedagogical tool and as a lever for the integration of interdisciplinary learning (Moffet et al., 2019). Indeed, the participating teachers seem to conceive and use outdoors in an interdisciplinary way by crossing, varying, and connecting learning from different disciplines. In particular, basic school subjects such as mathematics or French seem to be part of an interrelated dynamic with environmental awareness or physical and health education content (e.g., work on a cartesian plane in a physical education course). Furthermore, beyond the educational opportunity, teachers seem to be well informed about the positive effects of outdoors for themselves and their students. OL appears to be implemented by several teachers to contribute favorably to children's development and health, while optimizing their learning experience.

Diversified and contextualized school subjects and learning tasks

This study identified various school subjects and learning tasks used in OL Regarding the most used school disciplines, this study supports data from the recent report by Ayotte-Beaudet et al. (2022), in which French, mathematics, physical and health education, and science are among the most taught areas in OL. In addition, this study identified learning activities specific to preschool and primary OL, such as walking, free play, building a shelter in nature, ephemeral art, running, lighting a fire, and cooking. We note that the school subjects and learning tasks used by the teachers are diversified and contextualized to outdoors. Some learning tasks also seem to have been transposed or adapted to the outdoor environment used (e.g., ephemeral art, cooking), or to be achievable only outdoors (e.g., building a shelter in nature). Furthermore, the teachers seem to go beyond the academic framework prescribed by the program and adapt their learning content according to their knowledge and skills in outdoors. A few preschool teachers also seemed to integrate spiritual and First Nation communities' values in their outdoor practice, such as cooking bannock bread, setting up a native tent or performing a gratitude ritual.

Accessible outdoor settings

In the present study, the school subjects and learning tasks used by teachers in OL were predominantly conducted in settings that were close to the school and therefore within walking distance. The settings most used by participating teachers were: (1) city parks, (2) school grounds, and (3) woodlands. These results are consistent with those of the research report on teaching practices in OL (Ayotte-Beaudet et al., 2022), which also names these three settings as the most accessible according to the teachers. Thus, we see that accessibility seems to play a major role in teachers' use of the outdoor environment. Therefore, there seems to be a need to ensure that different outdoor settings are accessible within walking distance of schools in order to encourage their use in OL.

Association of results with the intentions to use the outdoors matrix

The results that emerged from the group interviews and participant observations allow for the association of the studied teaching practices with the intentions to use the outdoors matrix (Gadais et al., 2021a). First, all of the participating teachers are engaged *in* the outdoors, as they all take their classes outside (Gadais et al., 2021a). Similarly, a few teachers seem to draw on the *Udeskole* approach in their practice, as they implement mandatory and regular educational activities outside the school walls (Bentsen and Jensen, 2012), including walking around the surrounding neighborhood or visiting cultural venues or markets. These practices are carried out *via* and *for* the outdoor environment, as they appear to have an intention of awareness or reconnection to nature or the environment (Gadais et al., 2021a) and as they use nature for learning purposes. Second, the results indicate that outdoor activities are used by a majority of physical and health education teachers, such as snowshoeing, skiing, or skating, practiced in woodlands or city parks near the school. These activities are designed and intended to be practiced outdoors (Gadais et al., 2021a), such as rock climbing or kayaking, which are characterized by movement in an outdoor environment (Testevuide, 1996; Schnitzler and Saint Martin, 2021). Third, three preschool teachers have pedagogical intentions that are achieved *via* the outdoors, as they use nature as a means to a specific end or for the effects produced on students (Gadais et al., 2021a). In their practices, nature is used for learning purposes, exploring, discovering, or experimenting in a natural setting, such as making a shelter in the forest. Similarities are present between their practice and the *Forest School* approach, as they spend the majority of their days in the forest, in a variety of weather conditions, and encourage learning through free play and risk taking (Elliot et al., 2014; Coates and Pimlott-Wilson, 2019). Fourth and last, many teachers appear to be doing activities *for* the outdoor environment, as they have a pedagogical intention that is directly related to the environment (Gadais et al., 2021a), and thus aligns with the aims of *Environmental Education* (Sauvé, 2015). Through activities such as learning about the tree cycle, or developing the no-trace principle in outdoors, teachers aim for children to have a greater understanding, sensitivity, and connection to the environment.

Finally, the results of this study allow for an open dialogue about the intentions to use the outdoors matrix (Gadais et al., 2021a). First, it seems important to consider that the intentions to use the outdoors should not be considered exclusive to each of the spheres, as proposed by Gadais et al. (2021a), but should rather reflect the intentions of the teachers, which are often multiple. The different spheres of the matrix should thus intersect in order to allow the association of several intentions with a single task or activity. Secondly, we observe that many teachers use elements of nature (e.g.: leaves, branches, rocks, etc.) for learning purposes (e.g.: ephemeral art, discovery, etc.), without necessarily having an outdoor goal. These learnings often follow a logical progression, which does not seem to have been considered in the model of Gadais et al. (2021a). Furthermore, some of the activities presented by teachers, such as learning about the tree cycle, seem to be more in line with an intention *about* the environment. This proposed nuance between an activity having an intention *for* and *about* the outdoor environment would merit further investigation to determine if there are characteristics specific to each intention that can be supported by the scientific literature.

Implicit and libertarian teaching

Findings from interviews and participant observations indicate that many preschool teachers appear to be many to use implicit pedagogy in their practice, that is, pedagogy that places the student in a situation of autonomy, without the teacher clearly integrating the learning content outdoors (Gauthier et al., 2013; Visioli, 2019). They do this through emergent pedagogy, which is a pedagogic style that encourage children to see themselves as the creators of their own learning (Dalke et al., 2007). In order to do this, teachers aim for student autonomy, by placing their interests at the heart of their learning process (Visioli, 2019). At the primary level, teachers seem more inclined to use explicit pedagogy with students, where the teacher acts as a guide in the development of their learning (Gauthier et al., 2013; Visioli, 2019).

Furthermore, the majority of participating teachers, both preschool and primary, appear to adopt a libertarian teaching style (Visioli, 2019) in OL. This teaching style seems to be reinforced when teachers are outside of the school perimeter, either in a wooded area or a nearby city park. The logbook supports this idea, believing that these settings would allow teachers to establish a framework, rather than total control, over the students' learning process. Outdoor environments attended outside of the school perimeter would therefore allow for greater latitude in terms of student decision-making and autonomy (Visioli, 2019).

Benevolent pedagogical relationship

Participant observations identified a caring and benevolent pedagogical relationship (Visioli, 2019) as well as a relational closeness between teachers (agents) and students (subjects) (Legendre, 2005). OL seems to bring hazards in relation to weather conditions and thus teachers seem to have to often deal with wellness-related issues in their students. This, therefore, seems to push them to engage in caring preventive behaviors before and during their activities. Teachers appear to be approachable, passionate, concerned about students and act as a model for students, four strategies mentioned by Pianta (1999) to foster the teaching relationship. Finally, several teachers also mentioned learning along with their students in OL, a position that would make them co-learners (Bergeron, 2020).

Organized and flexible planning

The results of this study allow us to identify two qualities that are essential to optimal planning in OL, namely organization and flexibility. First, according to Yinger (1979), organization helps to simplify the teaching task. Our study reinforces this idea, since teachers indicate in a consensual manner that organization makes it possible to facilitate the unfolding of outdoor sessions, in addition to facilitating the management of unexpected events. Secondly, the majority of teachers mentioned the importance of flexibility in planning for OL. This flexibility, which they also seem to associate with a good capacity for adaptation, confirms the comments of Tochon (1993), who names the importance of adaptability relative to unpredictable factors in teaching. Finally, it is possible to observe a form of planned improvisation in the planning of the teachers, who seem to be experts and therefore have more than 8 years of experience in OL (Tochon, 1993).

Group management with clear rules and a well-established routine

Teachers appear to adopt several effective instructional strategies to facilitate group management, specifically in OL. First, the use of clear, structured, and well-understood rules by students (Tessier et al., 2013) could be the source of effective group management in OL. For the teachers in this study, establishing rules related to geographic boundaries and student safety seemed to promote student understanding and task flow (Méard and Bertone, 2009). The use of clear and structured rules would therefore allow for a better internalization of the rules on the part of the students and would thus facilitate the conduct of the sessions outdoors. Second, planning and establishing routines would also be part of an effective group management approach in OL. Routines would increase the predictability of the course of action, flexibility and effectiveness of teaching (Yinger, 1979; Tochon, 1993), factors that seem important to consider in OL. To this end, Méard and Bertone (2009) assert that student understanding and task flow are optimized by repeating prescribed rules. The results of this study confirm that, when well planned and integrated, routines seem to ensure that teaching-learning outdoors goes smoothly.

Facilitating factors: Human, material and financial support

This study identified factors that facilitate the use of the OL in preschool and primary settings that had already been identified by the literature, such as (1) support from the educational community for outdoor integration (school team/management/community) (Maziade et al., 2018) and (2) material and financial support (Maziade et al., 2018; Sport et loisir de l'Île de Montréal, 2019). New factors that would facilitate the use of the OL in preschool and primary settings also emerged from this research. Specifically, these included (1) parental support and awareness about OL and (2) volunteer support. Finally, some teachers even indicated that one should not hesitate to go for it, to dare and that fun is part of the recipe in order to share rich and authentic moments with the students in OL.

Limiting factors: Existing structures

Among the limitations that emerged in this study and that confirm those already listed, we find (1) the lack of funding (Waite, 2010; Sport et loisir de l'Île de Montréal, 2019), (2) the lack of time to prepare and carry out activities (Edwards-Jones et al., 2018; Sport et loisir de l'Île de Montréal, 2019; Van Dijk-Wesselius et al., 2020), and (3) weather conditions (Ruether, 2018). The lack of support in learning outdoors (Ruether, 2018; Sport et loisir de l'Île de Montréal, 2019) was qualified by a preschool teacher as a lack of fit between the training offered and the needs of teachers. The lack of material and human resources (Sport et loisir de l'Île de Montréal, 2019) was rather qualified in this study by the lack of volunteer presence and the lack of support for student clothing. Moreover, this study brought to light other limitations among teachers that, to our knowledge, have not been mentioned in the literature: (6) storage of materials and (7) administrative structures. By storage of materials, we mean the space to store equipment related to outdoor activities, which seems to be insufficient for several teachers. By administrative structures, we mean all the administrative procedures and rules in place in schools and Quebec School Services Center with which teachers are often confronted with in their OL practice. Finally, several limitations to the integration of the outdoors in the school setting were named by the participants in this study, but the teachers consensually demonstrated that they were not unavoidable, since they seemed to find workaround solutions.

Strengths and limitations of this study

To our knowledge, this study is the first in Quebec to take such a detailed look at the teaching strategies present in OL and among preschool and primary school teachers. Moreover, the methodological triangulation allows for greater credibility of the research results, which were studied by two different and complementary instruments, namely group interviews and participant observation. Finally, the sample included participants from several regions of Quebec, which allowed for the diversification of the fields of practice outdoors and for a variety of results, in terms of context, pedagogical intentions and settings.

This research project also has certain limitations. First, data collection was primarily conducted during the winter months. Further studies of teaching practices in the fall and spring are needed to provide a more complete picture. This would provide more complexity in characterizing the uses and teaching strategies used in OL. Second, specialist teachers who use outdoors, such as in drama or music, were not included in this study. Studying the teaching practices of all specialist teachers would allow for a greater breadth of results. Third, since some interviews were conducted prior to the observations, there is a possible influence between the two datasets. Therefore, only the primary researcher participated in the data collection and the co-authors served as referees to ensure a more neutral posture in the data analysis.

Conclusion

In conclusion, the purpose of this study was to portray the integration of the outdoors in Quebec in preschool and primary school education by exploring the perception, uses, teaching strategies and influencing factors present in OL.

Main results

The results of this study have allowed new knowledge to emerge with regard to OL in Quebec. First, it revealed the teachers' perception of the outdoors that includes five main elements: (1) being outdoors, (2) having the presence of nature, (3) practicing a physical activity, (4) providing physical freedom, and (5) targeting a pedagogical intention. Second, the results indicate that the uses of the OL in schools are varied, both in terms of school subjects and learning tasks (e.g., French, walking), pedagogical intentions (e.g., environmental awareness, interdisciplinary learning), and in terms of the frequented environments (e.g., woodlands, municipal parks). Third, certain teaching strategies were identified by this study to facilitate teaching outdoors (e.g., structured and flexible planning). We believe that these teaching strategies will have an important contribution for OL practices, as they fill a scientific gap, particularly in terms of group management (Ayotte-Beaudet et al., 2022) and pedagogical tools (Maziade et al., 2018). Finally, the results of this study have brought to light new factors that help (e.g., parental support) or limit (e.g., administrative structures) the integration of the outdoors by teachers and that are complementary to those already raised by the scientific literature.

Future perspectives

In order to recognize the outdoors as a pedagogical tool or as a lever for education in Quebec, it is important to emphasize the diversity of contexts and possible intentions in OL. This study has brought to light new avenues for promoting OL in Quebec, which would benefit from expansion in schools. To echo the reflections of Maziade et al. (2018), we consider that the Quebec Education Program (PFEQ – *Programme de formation de l'école québécoise*) does not currently include the outdoors sufficiently in its pedagogical content, despite the advice issued by the Ministry of Education to promote the inclusion of the outdoors in schools (Ministère de l'Éducation et de l'Enseignement supérieur du Québec, 2017). The burden of administrative structures for OL in teaching could be alleviated with greater inclusion and recognition of its use in the PFEQ. Finally, approaches that have aims *for* or *about* the outdoors should be further studied, as they appear to have significant educational potential in terms of environmental awareness and the development of conscious and engaged eco-citizenship in children (Sauvé, 2015). It is crucial to look into them more seriously in order to develop their critical thinking towards environmental issues and to generate responsibility and proactivity for the environment, especially in response to the climate emergency we are currently experiencing (Agundez-Rodriguez and Sauvé, 2022). Finally, it seems fundamental for scientific research to take a more serious look at the potential of OL as societal change (Smith, 2002; Giroux, 2006; Glassner and Eran-Zoran, 2016; Agundez-Rodriguez and Sauvé, 2022).

Data availability statement

The raw, anonymized data supporting the conclusions of this article will be made available by the authors upon request, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by Comité d'éthique de la recherche pour les projets étudiants impliquants des êtres humains (CERPE - plurifacultaire). Written informed consent was obtained from the minor(s)' legal guardian/next of kin for the publication of any potentially identifiable images or data included in this article.

Author contributions

A-AB and TG were involved in the design of the study and contributed to the review of literature. A-AB conducted analyses and wrote the results section. A-AB wrote the first draft of the manuscript, after which YL, CK, and TG read and contributed to the revision of the manuscript. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2022.955549/full#supplementary-material

References

Agundez-Rodriguez, A., and Sauvé, L. (2022). L'éducation relative au changement climatique: une lecture à la lumière du Pacte de Glasgow. Éducation relative à l'environnement. *Regards Recherches Réflexions* 17, 1–2. doi: 10.4000/ere.8421

Alvarez-Bueno, C., Pesce, C., Cavero-Redondo, I., Sanchez-Lopez, M., Garrido-Miguel, M., and Martinez-Vizcaino, V. (2017). Academic achievement and physical activity: a meta-analysis. *Pediatrics* 140. doi: 10.1542/peds.2017-1498

Auger, D., Roult, R., and Adjizian, J.-M. (2021). *Plein air, Ouvrage réflexif et pratique*. Paris Hermann Éditeurs.

Ayotte-Beaudet, J.-P., Beaudry, M.-C., Bisaillon, V., and Cordeau, P. (2020). *Classes extérieures dans l'enseignement supérieur en contexte de COVID-19 au Canada: Guide pour appuyer les directions lors des premières étapes d'implantation* Quebec, Université de Sherbrooke.

Ayotte-Beaudet, J.-P., Potvin, P., Lapierre, H. G., and Glackin, M. (2017). Teaching and learning science outdoors in schools' immediate surroundings at K-12 levels: a meta-synthesis. *EURASIA J. Math. Sci. Technol. Educ.* 13, 5343–5363. doi: 10.12973/eurasia.2017.00833a

Ayotte-Beaudet, J.-P., Vinuesa, V., Turcotte, S., and Berrigan, F. (2022). *Pratiques enseignantes en plein air en contexte scolaire au Québec: au-delà de la pandémie de COVID-19*. Quebec, Université de Sherbrooke

Barfod, K. S. (2018). Maintaining mastery but feeling professionally isolated: experienced teachers' perceptions of teaching outside the classroom. *J. Adv. Educ. Outdoor Learn.* 18, 201–213. doi: 10.1080/14729679.2017.1409643

Barrera-Hernández, L. F., Sotelo-Castillo, M. A., Echeverría-Castro, S. B., and Tapia-Fonllem, C. O. (2020). Connectedness to nature: its impact on sustainable behaviors and happiness in children. *Front. Psychol.* 11:5. doi: 10.3389/fpsyg.2020.00276

Bentsen, P., and Jensen, F. S. (2012). The nature of udeskole: outdoor learning theory and practice in Danish schools. *J. Adv. Educ. Outdoor Learn.* 12, 199–219. doi: 10.1080/14729679.2012.699806

Bentsen, P., Mygind, L., Elsborg, P., Nielsen, G., and Mygind, E. (2021). Education outside the classroom as upstream school health promotion: 'adding-in' physical activity into children's everyday life and settings. *Scand. J. Public Health* 50, 303–311. doi: 10.1177/1403494821993715

Bergeron, G. (2020). Enseigner à ciel ouvert: qu'est-ce que ça change. *Revue préscolaire, revue professionnelle de l'association d'éducation préscolaire du Québec* 58, 51–52.

Bølling, M., Mygind, E., Mygind, L., Bentsen, P., and Elsborg, P. (2021). The association between education outside the classroom and physical activity: differences attributable to the type of space? *Children* 8:486. doi: 10.3390/children8060486

Bølling, M., Niclasen, J., Bentsen, P., and Nielsen, G. (2019). Association of Education outside the classroom and Pupils' psychosocial well-being: results from a school year implementation. *J. Sch. Health* 89, 210–218. doi: 10.1111/josh.12730

Bølling, M., Otte, C. R., Elsborg, P., Nielsen, G., and Bentsen, P. (2018). The association between education outside the classroom and students' school motivation: results from a one-school-year quasi-experiment. *Int. J. Educ. Res.* 89, 22–35. doi: 10.1016/j.ijer.2018.03.004

Cardinal, F. (2010). *Perdus sans la nature*. Pourquoi les jeunes ne jouent plus dehors et comment y remédier. Québec Amérique.

Chawla, L. (2015). Benefits of nature contact for children. *J. Plan. Lit.* 30, 433–452. doi: 10.1177/0885412215595441

Chevalier, F., Cloutier, L. M., and Mitev, N. (2018). *Les méthodes de recherche du DBA*. Caen, Éditions EMS

Coates, J. K., and Pimlott-Wilson, H. (2019). Learning while playing: Children's forest school experiences in the UK. *7* 45, 21–40. doi: 10.1002/berj.3491

Cosmopoulos, A. (1999). La relation pédagogique, condition nécessaire de toute efficacité éducative. *Revue française de pédagogie* 128, 97–106. doi: 10.3406/rfp.1999.1078

Dalke, A. F., Cassidy, K., Grobstein, P., and Blank, D. (2007). Emergent pedagogy: learning to enjoy the uncontrollable and make it productive. *J. Educ. Chang.* 8, 111–130. doi: 10.1007/s10833-007-9021-2

Dano, F., Hamon, V., and Llosa, S. (2004). La qualité des études qualitatives: principes et pratiques. *Décis. Mark.* 36, 11–25. doi: 10.7193/DM.036.11.25

Doyle, W. (1986). Classroom Organization and Management D. M. C. Witttrock (dir.), *Handbook of Research on Teaching* 3 London Macmillan.

Durand, M., and Durand, M. (2001). *Chronomètre et survêtement: reflets de l'expérience quotidienne d'enseignants d'Éducation Physique*. Paris Éditions Revue EPS.

Edwards-Jones, A., Waite, S., and Passy, R. (2018). Falling into LINE: school strategies for overcoming challenges associated with learning in natural environments (LINE). *Education 3–13* 46, 49–63. doi: 10.1080/03004279.2016.1176066

Elliot, E., Ten Eycke, K., Chan, S., and Müller, U. (2014). Taking kindergartners outdoors: documenting their explorations and assessing the impact on their ecological awareness. *Child. Youth Environ.* 24, 102–122. doi: 10.7721/chilyoutenvi.24.2.0102

Fondation Monique-Fitz-Back (2018). Les initiatives d'éducation extérieure et de classes extérieures: Rapport d'analyse d'un sondage Web mené auprès des intervenants du milieu de l'éducation du Québec. Available at: http://www.fondationmf.ca/fileadmin/user_upload/documents/sondages/Rapport_final_Sondage_Enseigner_dehors_avril_2018.pdf (Accessed September 22, 2022).

Gadais, T., Lacoste, Y., Daigle, P., Beaumont, J., and Bergeron, N. (2021a). L'intervention éducative en contexte de plein air comme objet de recherche et d'enseignement en milieu universitaire au Québec. *Nature* 10, 61–73.

Gadais, T., Parent, A.-A., Bernard, P., Beauchamp, A.-A., and Clouâtre, C. (2021b). Activité physique et plein air. Dans D. Auger, R. Roult and J.-M. Adjizian (dir.), *Plein air: Manuel réflexif et pratique*. Paris Hermann.

Gainer, B. (1995). Ritual and relationships: interpersonal influences on shared consumption. *J. Bus. Res.* 32, 253–260. doi: 10.1016/0148-2963(94)00050-O

Gauthier, C., Bissonnette, S., Richard, M., and Castonguay, M. (2013). *Enseignement explicite et réussite des élèves: La gestion des apprentissages*. ERPI Quebec

Giroux, H. A. (2006). Academic freedom under fire: the case for critical pedagogy. *Coll. Lit.* 33, 1–42. doi: 10.1353/lit.2006.0051

Glassner, A., and Eran-Zoran, Y. (2016). Place-based learning: action learning in MA program for educational practitioners. *Act. Learn. Res. Prac.* 13, 23–37. doi: 10.1080/14767333.2015.1115967

Harper, N. J. (2017). Wilderness therapy, therapeutic camping and adventure education in child and youth care literature: a scoping review. *Child Youth Serv. Rev.* 83, 68–79. doi: 10.1016/j.childyouth.2017.10.030

Higgins, P., Nicol, R., and Ross, H. (2006). Teachers' approaches and attitudes to engaging with the natural heritage through the curriculum. *Scott. Nat. Herit.* 31–48.

Hills, A. P., Dengel, D. R., and Lubans, D. R. (2015). Supporting public health priorities: recommendations for physical education and physical activity promotion in schools. *Prog. Cardiovasc. Dis.* 57, 368–374. doi: 10.1016/j.pcad.2014.09.010

Janz, K. F., Burns, T. L., and Levy, S. M. (2005). Tracking of activity and sedentary behaviors in childhood: the Iowa bone development study. *Am. J. Prev. Med.* 29, 171–178. doi: 10.1016/j.amepre.2005.06.001

Kahn, P. H., and Weiss, T. (2017). The importance of children interacting with big nature. *Child. Youth Environ.* 27, 7–24. doi: 10.7721/chilyoutenvi.27.2.0007

Keniger, L. E., Gaston, K. J., Irvine, K. N., and Fuller, R. A. (2013). What are the benefits of interacting with nature? *Int. J. Environ. Res. Public Health* 10, 913–935. doi: 10.3390/ijerph10030913

Kuo, M., Barnes, M., and Jordan, C. (2019). Do experiences with nature promote learning? Converging evidence of a cause-and-effect relationship. *Front. Psychol.* 10, 1–6. doi: 10.3389/fpsyg.2019.00305

Larouche, R., Garriguet, D., Gunnell, K. E., Goldfield, G. S., and Tremblay, M. S. (2016). Outdoor time, physical activity, sedentary time, and health indicators at ages 7 to 14: 2012/2013 Canadian health measures survey [rapport](82-003-X). *Health Rep.* 27, 3–13.

L'Écuyer, R. (2011). *Méthodologie de l'analyse développementale de contenu*. Quebec Presse de l'Université du Québec

Legendre, R. (2005). *Dictionnaire actuel de l'éducation* Marseille, Guérin.

Louv, R. (2008). *Last child in the woods: Saving our children from nature-deficit disorder*. Chapel Hill Algonquin books.

Mann, J., Gray, T., Truong, S., Brymer, E., Passy, R., Ho, S., et al. (2022). Getting out of the classroom and into nature: a systematic review of nature-specific outdoor learning on school Children's learning and development. *Front. Public Health* 10:877058. doi: 10.3389/fpubh.2022.877058

Maynard, T. (2007). Encounters with Forest School and Foucault: a risky business? *Education 3–13* 35, 379–391. doi: 10.1080/03004270701602640

Maziade, C.-H., Thériault, G., Berryman, T., and Gadais, T. (2018). L'intégration du plein air en enseignement de l'éducation physique et à la santé: trois études de cas. *Staps* 122, 45–71. doi: 10.3917/sta.122.0045

McCormick, R. (2017). Does access to green space impact the mental well-being of children: a systematic review. *J. Pediatr. Nurs.* 37, 3–7. doi: 10.1016/j.pedn.2017.08.027

Méard, J., and Bertone, S. (2009). Analyse des transactions professeurs-élèves en éducation physique: étude de cas. *Staps* 83, 87–99. doi: 10.3917/sta.083.0087

Ministère de l'Éducation et de l'Enseignement supérieur du Québec. (2017). *Au Québec, on bouge en plein air: Avis sur le plein air*. Quebec Gouvernement du Québec

Moens, M. A., Weeland, J., Beute, F., Assink, M., Staaks, J. P., and Overbeek, G. (2019). A dose of nature: two three-level meta-analyses of the beneficial effects of exposure to nature on children's self-regulation. *J. Environ. Psychol.* 65:101326. doi: 10.1016/j.jenvp.2019.101326

Moffet, J. (2019). *Activités pédagogiques extérieures: 3 approches à explorer pour enseigner à ciel ouvert*. Paris Cent degrés

Moffet, J., Pelletier, S., and Fréchette, A. (2019). Guide d'introduction: L'enseignement extérieur, un monde de possibilités pour apprendre. Available at: https://docs.wixstatic.com/ugd/9cc112_563d3360ec824b1a9e117eb30249b63c.pdf (Accessed September 22, 2022).

Morrissette, J. (2022). Ouvrir la boîte noire de l'entretien de groupe. *Recherches qualitatives* 29, 7–32. doi: 10.7202/1085871ar

Mygind, E. (2009). A comparison of childrens' statements about social relations and teaching in the classroom and in the outdoor environment. *J. Adv. Educ. Outdoor Learn.* 9, 151–169. doi: 10.1080/14729670902860809

Nielsen, G., Mygind, E., Bolling, M., Otte, C. R., Schneller, M. B., Schipperijn, J., et al. (2016). A quasi-experimental cross-disciplinary evaluation of the impacts of education outside the classroom on pupils' physical activity, well-being and learning: the TEACHOUT study protocol. *BMC Public Health* 16:1117. doi: 10.1186/s12889-016-3780-8

Paré, A. (2014). *Le journal: Instrument d'intégrité personnelle* Quebec Presses de l'Université Laval.

Pianta, R. C. (1999). *Enhancing Relationships between Children and Teachers* Washington, DC American Psychological Association

Priest, S., and Gass, M. (2018). *Effective Leadership in Adventure Programming, Vol 3. Edn.* Champaign Human Kinetics.

Ruether, S. (2018). Barriers to Teachers' use of environmentally-based education in outdoor classrooms [Thèse doctorale, Walden University]

Sachs, N. A., Rakow, D. A., Shepley, M. M., and Peditto, K. (2020). The potential correlation between nature engagement in middle childhood years and college undergraduates' nature engagement, proenvironmental attitudes, and stress. *Front. Psychol.* 11:2919. doi: 10.3389/fpsyg.2020.540872

Santana, C., Azevedo, L., Cattuzzo, M. T., Hill, J. O., Andrade, L. P., and Prado, W. (2017). Physical fitness and academic performance in youth: a systematic review. *Scand. J. Med. Sci. Sports* 27, 579–603. doi: 10.1111/sms.12773

Sauvé, L. (1997). L'approche critique en éducation relative à l'environnement: origines théoriques et applications à la formation des enseignants. *Revue des sciences de l'éducation* 23, 169–187. doi: 10.7202/031912ar

Sauvé, L. (2015). L'éducation relative à l'environnement. D. P. Dans and A Bourg (dir.), *Dictionnaire de la Pensée écologique* Paris Presses universitaires de France.

Schneller, M. B., Duncan, S., Schipperijn, J., Nielsen, G., Mygind, E., and Bentsen, P. (2017). Are children participating in a quasi-experimental education outside the classroom intervention more physically active? *BMC Public Health* 17:523. doi: 10.1186/s12889-017-4430-5

Schnitzler, C., and Saint Martin, J. (2021). Éduquer aux Activités de Pleine Nature en France: un défi pour l'EPS du XXIe siècle? eJRIEPS. *Ejournal de la recherche sur l'intervention en éducation physique et sport* 49, 36–40. doi: 10.4000/ejrieps.5959

Seeland, K., Dübendorfer, S., and Hansmann, R. (2009). Making friends in Zurich's urban forests and parks: the role of public green space for social inclusion of youths from different cultures. *Forest Policy Econ.* 11, 10–17. doi: 10.1016/j.forpol.2008.07.005

Sibthorp, J. (2003). An empirical look at Walsh and Golins' adventure education process model: relationships between antecedent factors, perceptions of characteristics of an adventure education experience, and changes in self-efficacy. *J. Leis. Res.* 35, 80–106. doi: 10.18666/jlr-2003-v35-i1-611

Silverman, J., and Corneau, N. (2017). From nature deficit to outdoor exploration: curriculum for sustainability in Vermont's public schools. *J. Adve. Educ. Outdoor Learn.* 17, 258–273. doi: 10.1080/14729679.2016.1269235

Smith, G. A. (2002). Place-based education: learning to be where we are. *Phi delta kappan* 83, 584–594. doi: 10.1177/003172170208300806

Soga, M., and Gaston, K. J. (2016). Extinction of experience: the loss of human–nature interactions. *Front. Ecol. Environ.* 14, 94–101. doi: 10.1002/fee.1225

Sport et loisir de l'Île de Montréal. (2019). *Portrait de la pratique du plein air en milieu scolaire sur l'Île de Montréal - 2018*. Sport et loisir de l'Île de Montréal Montreal

Stake, R. E. (1995). *The Art of Case Study Research*. Sage London

Strife, S., and Downey, L. (2009). Childhood development and access to nature: a new direction for environmental inequality research. *Organ. Environ.* 22, 99–122. doi: 10.1177/1086026609333340

Tessier, D., Delas, Y., Gernigon, C., Krumm, C., Mascret, N., Roy, P., et al. (2013). *La motivation*. Kolkata EP&S.

Testevuide, S. (1996). *APPN: quoi et comment évaluer en EPS? Centre régional de documentation pédagogique*. (CRDP de Rouen).

Tochon, F. (1993). Le fonctionnement improvisationnel de l'enseignant expert. *Revue des sciences de l'éducation* 19, 437–461. doi: 10.7202/031641ar

Townsend, M., Henderson-Wilson, C., Warner, E., and Weiss, L. (2015). *Healthy Parks Healthy People: The State of the Evidence 2015*. Victoria, Austalia: Parks Victoria.

Trudel, L., Simard, C., and Vonarx, N. (2006). La recherche qualitative est-elle nécessairement exploratoire. *Recherches Qual.* 5, 38–55.

Van der Maren, J.-M. (1996). *La recherche qualitative peut-elle être rigoureuse? École des hautes études commerciales*, Quebec Chaire d'entrepreneurship Maclean Hunter.

Van Dijk-Wesselius, J. E., Van den Berg, A. E., Maas, J., and Hovinga, D. (2020). Green schoolyards as outdoor learning environments: barriers and solutions as experienced by primary school teachers. *Front. Psychol.* 10. doi: 10.3389/fpsyg.2019.02919

Visioli, J. (2019). La relation pédagogique. *EP&S.* 128:107. doi: 10.3917/sta.128.0107

Waite, S. (2010). Losing our way? The downward path for outdoor learning for children aged 2–11 years. *J. Adv. Educ. Outdoor Learn.* 10, 111–126. doi: 10.1080/14729679.2010.531087

Weigand, G., and Hess, R. (2007). *La relation pédagogique*. *Economica*. 1–290.

WHO. (2016). Urban green spaces and health, a review of evidence. Regional office for Europe Available at: http://www.euro.who.int/__data/assets/pdf_file/0005/321971/Urban-green-spaces-and-health-review-evidence.pdf?ua=1 (Accessed September 22, 2022).

Yinger, R. (1979). Routines in teacher planning. *Theory Pract.* 18, 163–169. doi: 10.1080/00405847909542827

Yinger, R. J., and Clark, C. M. (1982). *Understanding Teachers' Judgments about Instruction: The Task, the Method, and the Meaning*. Quebec Institute for Research on Teaching.

Yinger, R. J., and Clark, C. M. (1983). *Self-reports of Teacher Judgment* East Lansing Institute for Research on Teaching; Michigan State University.

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Hands-on childcare garden intervention: A randomized controlled trial to assess effects on fruit and vegetable identification, liking, and consumption among children aged 3–5 years in North Carolina

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Gardening at childcare centers may have a potent influence on young children's learning about fruits and vegetables and their development of healthy dietary behaviors. This randomized controlled trial examined the effect of a garden intervention on fruit and vegetable (FV) identification, FV liking, and FV consumption among 3–5-year-old children enrolled in childcare centers in Wake County, North Carolina, USA. Eligible childcare centers (serving primarily low-income families) were randomly selected and then randomly assigned to one of three groups: (1) intervention; (2) waitlist-control that served as a control in year 1 and received the intervention in year 2; or (3) no-intervention control. From the 15 participating childcare centers, 285 children aged 3–5 years were consented by their parents or guardians to participate. The intervention comprised six standardized, raised, mulched garden beds, planted with warm-season annual vegetables and fruits, and perennial fruits. A Gardening Activity Guide describing 12 age-appropriate, sequential gardening activities was distributed for teachers to lead hands-on gardening activities during the growing season. Data were gathered between Spring 2018 and Fall 2019. FV identification and liking were measured using an age-appropriate tablet-enabled protocol. FV consumption was measured by weighing each child's fruit and vegetable snack tray before and after tasting sessions. Compared to children receiving no-intervention, children who received the garden intervention showed a greater increase in accurate identification of both fruits and vegetables as well as consumption of both fruit and vegetables during the tasting sessions. Consistent with prior research, the

effects on fruit consumption were greater than on vegetable consumption. There was no significant effect of the garden intervention on children's FV liking. Garden interventions implemented early in life foster learning about FV and promote healthy eating. Early exposure to gardening may yield a return on investment throughout the lifecourse, impacting healthy diet and associated health outcomes, which are particularly important within disadvantaged communities where children's health is challenged by a host of risk factors. Clinical Trials Registration #NCT04864574 (clinicaltrials.gov).

KEYWORDS

childcare, gardening, garden intervention, randomized controlled trial, healthy eating, diet, preschool, children

Introduction

Establishing fruit and vegetable (FV) consumption habits early in life may set children on a trajectory toward healthy eating, helping them to maintain healthy weight and reduce the later risk of obesity and associated health issues (Birch et al., 2007; Schwartz et al., 2011; Grimm et al., 2014). Experiential learning in early childhood is central to child development and, therefore, may be a critical strategy to engage young children in increasing about fruit and vegetables (FV) by tasting and exploring through hands-on activities (Nekitsing et al., 2018; Varman et al., 2021).

Contact with fresh produce is important to enable cognitive and other developmental processes that may help to build a sensory repertoire of food attributes (i.e., textures, flavors, smells, colors, shapes) while individual food preferences evolve (Zeinstra et al., 2007). Children's progressive knowledge of FV may be extended through hands-on experiences across a range of gardening activities: planting, caring, harvesting, preparing, and eating (Parmer et al., 2009). Gardening may be the most effective way for children to participate in food production (Cooke, 2007) which, in turn, has been linked to healthy dietary intake (Savoie-Roskos et al., 2017; Skelton et al., 2019).

Children who grow their own FV are more likely to eat garden produce (Cabalda et al., 2011; Namenek Brouwer and Benjamin Neelon, 2013). Moreover, Langellotto and Gupta (2012) suggest that garden-based learning may have a greater impact on fruit and vegetable consumption than nutrition education programs alone. There are various mediating mechanisms or pathways through which garden-based experiential learning might plausibly affect children's intake of FV. These pathways include accessibility of FV (Cullen et al., 2003); daily exposure (Cooke, 2007); familiarity with local FV (Bevan et al., 2016; Nekitsing et al., 2018); and availability of FV (Jago et al., 2007).

Timing of garden interventions is critical because early introduction of FV may support retention of habitual FV intake (Birch et al., 2007). Review of potential predictors of children's FV consumption (Cooke, 2007) shows age of introduction inversely correlated with FV intake in preschool-age children (Cooke et al., 2004). Early introduction of FV may also minimize food neophobia (i.e., dislike or nonacceptance of new food) in preschool years (Cooke et al., 2004) and the introduction of non-taste sensory learning about fresh produce (e.g., planting, harvesting, etc.) may support familiarity with fruit and vegetables not offered at home (Nekitsing et al., 2018).

In this study, gardening conducted as an early childhood experiential process is considered a potential conduit for establishing healthy food preferences that support FV intake. While prior research suggests that gardening may affect school-age children's learning (Berezowitz et al., 2015; Wells et al., 2015) and diet (Davis et al., 2015; Skelton et al., 2019), few studies have focused on the influence of garden interventions on preschool-age children, when effects may be particularly potent. Moreover, many prior studies face methodological limitations such as short duration, small sample sizes, absence of a control group, or lack of random assignment, which compromise causal conclusions (i.e., internal validity; Ohly et al., 2016; Savoie-Roskos et al., 2017; Landry et al., 2021). The goal of this randomized controlled trial (RCT) is to increase understanding of the impact of hands-on gardening on preschool children's FV knowledge, FV liking, and consumption of FV during snack sessions.

This study examines three key research questions among children aged 3–5 years enrolled in childcare centers: (1) Does the garden intervention affect children's FV identification? (2) Does the garden intervention affect FV preference ("liking")? (3) Does the garden intervention affect FV consumption during tasting events?

Materials and methods

Research design

This randomized controlled trial employed a waitlist-control design to assess the impact of the Preventing Obesity by Design

(POD; Moore and Cosco, 2014) garden intervention on FV identification, FV liking, and FV consumption among children aged 3–5 years, enrolled in 15 childcare centers in Wake County, North Carolina.

The research design is illustrated in Table 1. Fifteen childcare centers were randomly assigned to one of the following groups: Group 1 intervention (5 centers, ~100 children), to receive the garden intervention in Year 1; Group 2 waitlist control or "delayed intervention" (5 centers, ~100 children), to participate as control group in Year 1 and to receive the garden intervention in Year 2; or Group 3, no-intervention control (5 centers, ~100 children) that joined the study in Year 2 and received the garden installation and training resources after completion of data collection.

Data collection occurred in the Spring of Year 1 for Groups 1 and 2. The initial intervention centers (Group 1) received the garden intervention in the summer of Year 1 and both Groups 1 and 2 participated in data collection again in the early Fall, following the intervention. In Year 2, data were collected from Groups 2 and 3 in the Spring. Group 2, comprising the five waitlist control centers, then received the garden intervention in the summer of Year 2. Data were then collected from Groups 2 and 3 in early Fall of Year 2. The trial proceeded without deviation from its design: no modifications or outcome changes were made after the trial commenced and the trial was not stopped or ended prematurely. Protocol details, recruitment strategy, and participant characteristics of this RCT are reported elsewhere (Cosco et al., 2021). The study is registered with ClinicalTrials.gov, #NCT04864574. The research design and methods were approved by the North Carolina State University Institutional Review Board (IRB), protocol approval #5908.

Childcare center recruitment

Study sites were identified in collaboration with the Wake County Smart Start, NC, from a pool of approximately 310 licensed childcare centers within the county. Based on the eligibility criteria, presented in Table 2, Wake County Smart Start invited 23 centers to complete an online application that included verification of eligibility criteria, demographic characteristics of the center, and a statement indicating willingness to work collaboratively with the research team. Of the 23 invited centers, 15 were deemed to meet the requisite criteria. The 15 centers were randomly assigned to Groups 1, 2, and 3, as described above. The study team met with childcare center directors and preschool teachers to review the project aims and expectations and to verify willingness to collaborate. Directors agreed to include their centers in the study by signing a letter that described the garden intervention.

Of the 15 selected centers, nine facilities were owned by the organization, and six were leased. Most centers were well established at their sites showing a tenure range between 5 years and permanent location (10 of the 15 centers declared operating at the current site for 10 years or more). The category of operation was declared as "independent" (10 centers) or "franchise" (5 centers). The average area of center outdoor spaces (8,458 sq. ft.) reflected North Carolina licensing requirements for enrollment size of each selected site. The menus at all childcare centers adhered to the North Carolina Child Care Rules, General Nutrition Standards rule 10A NCAC.0900 (State of North Carolina Office of Administrative Hearings, 2012).

Enrollment data for North Carolina's regulated childcare centers at the time of recruitment (North Carolina Department of Health and Human Services, 2017) indicated an average enrollment of 70 children, 15% of whom received subsidies. Selected study childcare centers had an average enrollment of 63 children, of whom 51% received subsidies (more than three times the state average to match study goals).

A total of 543, 3–5 years old children were eligible from the pool of 15 selected childcare centers. Of those, 285 children were consented by parents to participate in the study. The sample size was determined by a power analysis calculation as described in Cosco et al. (2021). At baseline, mean age of children was 3.26 years (SD = 0.57), BMI was 16.12 (SD = 1.46), and 64.7% were non-white. In Year 2, additional children were recruited to account for the loss of graduating children and unstable enrollment. Attrition of children from the study occurred at a rate of 23% per

TABLE 1 Research design with intervention, waitlist (delayed intervention), and control groups.

	Year 1				Year 2			
Random assignment:	**Winter**	**Spring**	**Summer**	**Fall**	**Winter**	**Spring**	**Summer**	**Fall**
Group 1: intervention (5 sites, 100 children)		O_1	X	O_2				
Group 2: waitlist (5 sites, 100 children)		O_1		O_2		O_3	X	O_4
Group 3: control (5 sites, 100 children)						O_1		O_2

O, observation (data collection). X, garden intervention.

TABLE 2 Childcare center eligibility criteria.

(1) Assigned a 4 or 5 Star Rated License by NC Division of Child Development & Early Education (DCDEE)
(2) Serve a majority of children eligible for the Wake County Childcare Subsidy Program
(3) Contain at least two preschool classrooms (3-5-year-old children)
(4) Enrollment size within the middle third for Wake Co (excluding smallest and largest centers)
(5) Operate a regulated on-site kitchen to prepare food for snacks
(6) Employ cooking staff
(7) Operate a year-round calendar
(8) Own or lease current space for at least 5 years into the future
(9) Do not currently conduct on-site FV gardening but interested in implementing in the future

TABLE 3 COLEAFS randomized group characteristics at baseline, by intervention (I), waitlist (delayed intervention) (W), and control centers (C).

Group	*n*	Age $\bar{x}$ (sd)	% Male	% Non-white	% Subsidy	BMI $\bar{x}$ (sd)
1. Interv	61	3.17 (0.53)	50.80%	58.90%	44.30%	16.13 (1.31)
2. Waitlist	119	3.15 (0.55)	44.90%	62.20%	47.90%	16.20 (1.63)
3. Control	70	3.51 (0.56)	53.60%	71.90%	62.30%	15.97 (1.27)

year. Children who had incomplete data were included in the analyses (as is the convention and advantage of general linear mixed models). Thus, the overall number of children included in analyses was 285.

Participants: Children and RCT groups

At baseline, the sample comprised 250 children, mean age 3.26 years (SD = 0.57); 48.8% male; 64.7% non-white; and mean BMI 16.12 (SD = 1.46). Characteristics of the three randomized groups are summarized in Table 3. Group 1 (Year 1 intervention) comprised 61 children, mean age 3.17 years; 50.80% male; 58.90% non-white; 44.30% receiving subsidies; and mean BMI 16.13. Group 2, the Waitlist control (Year 2 intervention) included 119 children, mean age 3.15 years; 44.90% male; 62.20% non-white; 47.90% receiving subsidies; and mean BMI 16.20. Group 3, the Control group comprised 70 children, mean age 3.51 years, 53.60% male, 71.90% non-white, 62.30% receiving subsidies, and mean BMI 15.97. Non-white children include African American, Asian, Latino, and Multi-racial. Participating children were at healthy weight showing similar BMI means by group.

Constructs and measures

Below, the operationalization of the study's independent and dependent variables is described. Additional details can be found in Cosco et al. (2021).

Independent variable: The garden intervention

The garden intervention (Preventing Obesity by Design (POD) Garden Component), comprised six raised beds, prescribed FV plantings (Figure 1), a seasonal planting regime, garden engagement activities, and weekly technical assistance. The six vegetables (cucumbers, green beans, green peppers, tomatoes, yellow squash, and zucchini) were selected because all have a long harvest season extending into August in the Piedmont region of North Carolina. Five fruits (blackberries, blueberries, cantaloupe, strawberries, and watermelon) were selected. Blueberries (two shrub varieties) and blackberries (two vines on trellis) were planted in-ground. Because the strawberry harvest is early in the year and both blueberries and blackberries have modest yields in the first year after planting, the intervention was augmented with purchased berries for the snack sessions. Although apples were included in the tasting session, they were not included in the garden installation because tree fruits take too long to produce.

As described by Cosco et al. (2021), the intervention also included "The Garden Activity Guide" comprising 12 age-appropriate activities to be led by the teacher, who was instructed to use the Guide to plan their daily outdoor activities. There were four activities in each of three categories: Preparing, Caring, and Harvesting/Eating. The 12 activities ensured that children were regularly engaged with the garden from the preparatory phases of examining and sprouting seeds to harvesting, preparing, snacking, and taking home produce. Teachers delivered up to seven of the 12 activities per week (e.g., examining seeds, preparing beds, watering, weeding, and snacking). Typically, three to four activities occurred each week over a period of 13 weeks. Activities were usually carried out during outdoor time and lasted about 30 min. Childcare centers retained the activity booklets and installed gardens upon completion of the study.

Demographic variables

Several demographic variables were measured at the level of the individual child (i.e., age, gender, and BMI) and at the level of the childcare center (e.g., teacher education, parental education, and staff race/ethnicity).

Dependent variables

Each of the dependent variables described below is calculated for fruit (F), for vegetables (V), and for FV combined.

Fruit & Vegetable Identification. FV identification was measured by asking if the child knew (Yes/No) each of the 12 FV shown on a tablet screen (iPad). The child was then asked, verbally, to name the item and their response was recorded manually by the

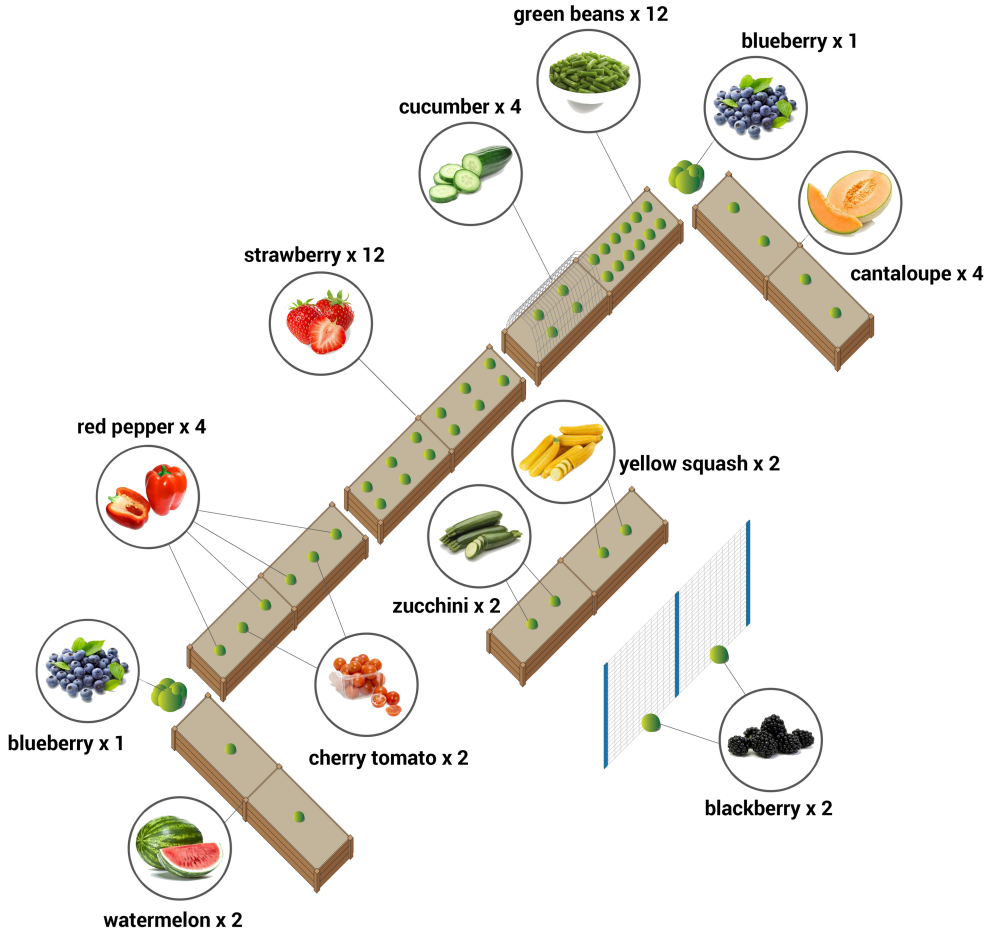

FIGURE 1
Standard garden layout (re-configured on-site to conform to spatial constraints as necessary).

research assistant. This process yields three dependent variables: fruit identification, vegetable identification, and FV identification.

Fruit & Vegetable Liking. FV liking was measured using a digital version of the picture-based survey developed by Carraway-Stage et al. (2014). When presented with an image of a fruit or vegetable, the child is instructed "Tell me if you like or do not like this food by pointing to one of the faces" and responds by pointing at the 5-point emoticon scale presented on a tablet (iPad) where 5 = super yummy, 4 = yummy, 3 = just okay, 2 = yucky, and 1 = super yucky. The original Fruit, Vegetable Preference Measure (Carraway-Stage et al. 2014) has strong internal consistency (alpha = 0.79) and acceptable test–retest reliability (with 7–14 days between administrations) for the 9-item fruit scale ($r = 0.51$), the 10-item vegetable scale ($r = 0.40$) and the combined FV scale ($r = 0.49$). The measure used in the current study includes images of six fruits and six vegetables and yields three dependent variables: Fruit liking (sum of 1–5 ratings for 6 fruits), range 6–30; vegetable liking (sum of 1–5 ratings for 6 vegetables), range 6–30; and FV liking (sum of 1–5 ratings for all 12 FV), range 12–60.

Fruit & Vegetable Consumption. FV consumption was measured (see Cosco et al., 2021), using a protocol derived from that of Witt and Dunn (2012). While they presented children with 1 cup of mixed fruit or mixed vegetables and included a small container of ranch dressing on the day vegetables were eaten, in this study we presented children with 6 individual cups, each containing approximately 50 grams of each fruit or vegetable (without dressing), in two (6′ × 12′) 6-compartment trays (each approximately 300 grams) labeled with child's name and ID number (Figure 2). The vegetable snack session was held 1 day prior to the fruit snack session. Each of the six fruit or six vegetable servings was weighed (grams) on a Tanita HD-357 scale before serving and after the snack period and data entered on the iPad (Figure 3). Uneaten food was composted. Each child's consumption was calculated for fruit, for vegetable, and for FV combined by subtracting the weight remaining on the tray from that served. This yields three consumption measures: F in grams (of approximately 300 grams served), V in grams (of approximately 300 grams served), and FV in grams (of approximately 600 grams served).

The dependent variables were measured on different days within 1 week. On Monday, a storytelling session was held to familiarize the students with the data collection tablets and response options. On Tuesday, FV identification and FV liking

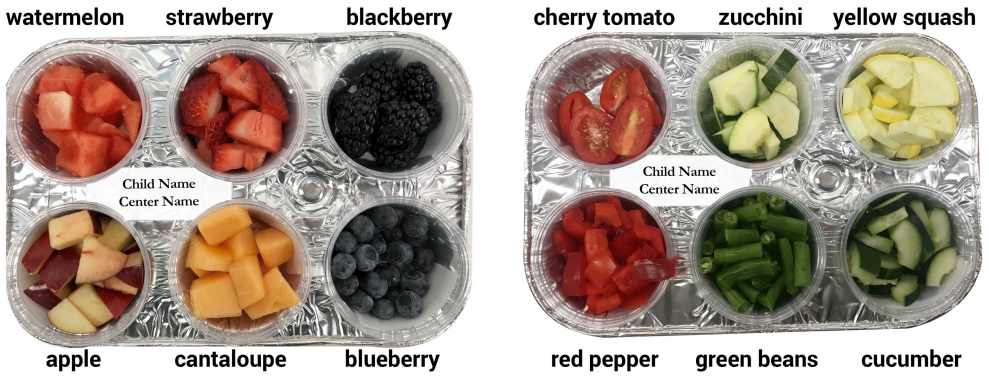

FIGURE 2
Prepared snack trays presenting approximately 300 grams of F or V to each child.

FIGURE 3
Tray preparation and weighing table.

data were gathered using the tablets. On Wednesday and Thursday, respectively, vegetable and fruit snack sessions were held, and V and F consumption data were collected.

Analytic strategy

The three core research questions concern the effect of the childcare garden intervention on (1) FV identification; (2) FV liking; and (3) FV consumption. These questions are addressed by examining 9 key dependent variables, as described above (i.e., F, V, and FV identification; F, V, FV liking; F, V, and FV consumption). For each outcome variable, a linear mixed model approach is used with childcare center random effect and nested child random effect within childcare center to estimate the true mean score of each outcome for Spring (pre-intervention) and Fall (post-intervention) for each year (2018 and 2019; MIXED procedure of SAS software v 9.4, SAS Institute, Inc., Cary NC, United States). An intervention effect for an outcome in a particular year is defined as the difference of the pre-post true mean score changes between groups receiving intervention and those receiving no intervention (i.e., difference-in-difference). An approximate t-test for contrasts in linear mixed models was conducted to test the equality of two intervention effects for each outcome variable of interest in Year 1 and 2 and no statistically significant difference was found. Therefore, we assume equal intervention effects for outcomes and present the estimated intervention effects and their standard errors in Table 4.

Results

Examining the research questions

Table 5 presents the observed pre-post sample means scores and their change for each outcome in Year 1 and Year 2. Note that because of dropouts from enrolled children, the sample mean scores may not be unbiased estimates of the corresponding true mean scores; hence, the observed intervention effect may not be an unbiased estimate of the true intervention effect.

Below, each research question is addressed regarding FV identification, FV liking, and FV consumption. Figures 4–6 illustrate the intervention versus no-intervention observed pre-post change mean scores for FV identification, FV liking, and FV consumption, respectively. The estimated intervention effects for each outcome variable are presented in Table 4.

FV identification

Does the garden intervention affect children's FV identification? As shown in Table 5 and Figure 4, both the intervention and the no-intervention groups show increases in V, F, and the combined FV identification from baseline to follow-up, the increases demonstrated by the intervention group are consistently greater than those of the control (no-intervention) group. Thus, difference-in-difference (i.e., changes in intervention data v. changes in no-intervention data) trends are in line with the hypotheses.

In fact, the estimated intervention effects are statistically significant for all three variables: F, V, and combined FV identification, as presented in Table 4. Compared to children receiving no intervention, children in the intervention group are expected to identify 0.4 more individual fruits, 0.87 more vegetables, and 1.26 more FV combined. This is equivalent to an increase of about half of a fruit and nearly one vegetable identification. These estimated effects are significant at the $p < 0.05$, $p < 0.005$ and $p < 0.005$ level, respectively.

TABLE 4 Estimated intervention effect (standard error) for each outcome variable from a hierarchical linear mixed effect model, with assumption that year 1 and year 2 effects are the same.

Outcome	Est. Effect (SE)	Value of *p*
FV identification		
F_I	0.40 (0.17)	0.022*
V_I	0.87 (0.27)	0.002**
FV_I	1.26 (0.39)	0.001**
FV liking		
F_L	0.14 (0.14)	0.304
V_L	0.07 (0.17)	0.667
FV_L	0.27 (0.25)	0.283
FV consumption: grams ("CG")		
F_CG	24.99 (8.65)	0.004**
V_CG	14.08 (3.68)	<0.001***
FV_CG	37.87 (10.91)	0.001**

*$p < 0.05$, **$p < 0.005$, ***$p < 0.001$.

FV liking

Does the garden intervention affect FV liking? As shown in Table 5 and Figure 5, changes in FV liking show a less consistent pattern than those for FV identification. In Year 1, difference-in-difference trends are in line with the hypotheses, i.e., the intervention group increases from pre- to post-intervention and the control group decreases in F, V, and FV liking. However, in Year 2, the opposite trend is apparent, when the intervention group results decrease from pre- to post-intervention and the no-intervention control group results increase (see Table 5). Thus, because the intervention effects differ from Year 1 to 2, the estimated common effect is not significant for F, V, or FV, as shown in Table 4; with *p*-values of 0.30, 0.67, and 0.28, respectively.

FV consumption

Does the garden intervention affect FV consumption during a tasting event? As shown in Table 5 and Figure 6, the intervention group consistently shows increases in F, V, and FV consumption while the no-intervention group shows decrease in the three variables from pre- to post-intervention.

The difference-in-difference is statistically significant for all three consumption measures. As shown in Table 4, compared to children receiving no intervention, children who received the garden intervention are expected to eat 25 grams more fruit and 14 grams more vegetables during snack time (and about 38 grams more FV combined). These estimated effects are significant at the $p < 0.005$, $p < 0.001$, and $p < 0.005$ level, respectively.

TABLE 5 Pre-post sample mean scores and their change for intervention and no-intervention groups in Year 1 and 2 for each outcome (n=285).

Variables	Year 1 Intervention			Year 1 Control			Year 2 Intervention			Year 2 Control		
	Pre	Post	Change	Pre	Post	Change	Pre	Post	Change	Pre	Post	Change
FV Identification												
F_I	4.86	5.13	0.27	4.84	4.97	0.13	4.66	5.38	0.72	5.29	5.27	−0.02
V_I	3.88	5.13	1.25	3.54	4.15	0.61	3.79	4.96	1.17	4.51	4.55	0.04
FV_I	8.73	10.23	1.50	8.40	9.12	0.72	8.44	10.34	1.90	9.81	9.82	0.01
FV Liking												
F_L	2.47	2.72	0.25	2.56	2.50	−0.06	2.47	2.43	−0.04	2.62	2.60	−0.02
V_L	3.11	3.56	0.45	3.12	2.98	−0.14	3.11	2.96	−0.15	2.91	3.21	0.30
FV_L	5.62	6.27	0.65	5.82	5.50	−0.32	5.63	5.39	−0.24	5.53	5.82	0.29
FV Consumption (grams)												
F_CG	102.78	126.62	23.84	135.32	128.9	−6.43	120.20	128.67	8.47	145.94	116.41	−29.54
V_CG	12.44	22.2	9.76	28.80	26.35	−2.45	27.92	32.15	4.24	32.15	14.30	−17.85
FV_CG	112.23	142.94	30.71	163.48	153.28	−10.20	147.46	148.60	21.14	179.59	128.41	−51.18

F_I, Fruit Identification [0–6]; V_I, Vegetable Identification [0–6]; FV_I, Fruit + Vegetable Identification [0–12]. F_L, Fruit Liking [1–5]. V_L, Vegetable Liking [1–5]; FV_L, Fruit + Vegetable Liking [2–10]; F_CG, Fruit Consumption grams [0–300]; V_CG, Vegetable Consumption grams [0–300]; FV_CG, Fruit + Vegetable Consumption grams [0–600]. Descriptive statistics for illustrative purposes only. Because the center is the sampling unit, and the child is the unit of analysis, regular SE or CI are not reported. For variability of parameters of interest, see Table 4.

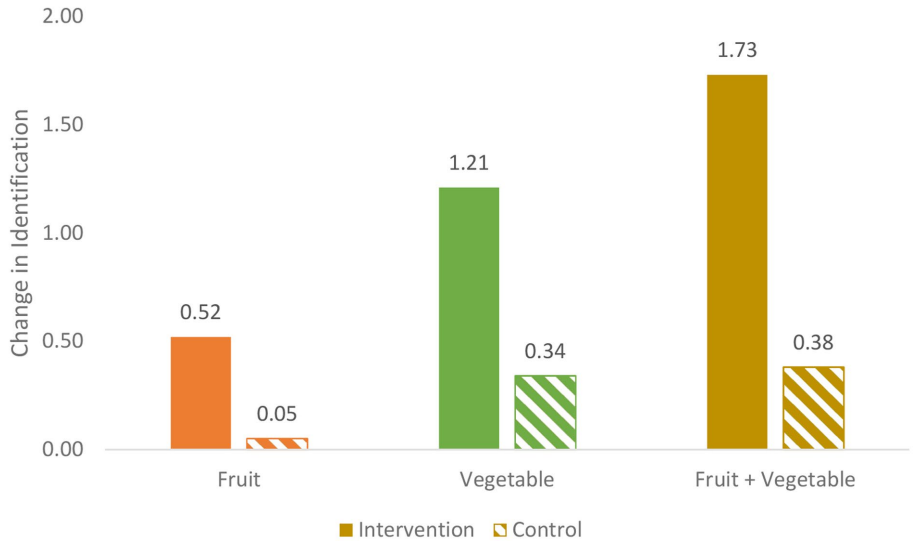

FIGURE 4
Pre-post change for intervention v. no intervention for F, V, and FV identification (number of FV).

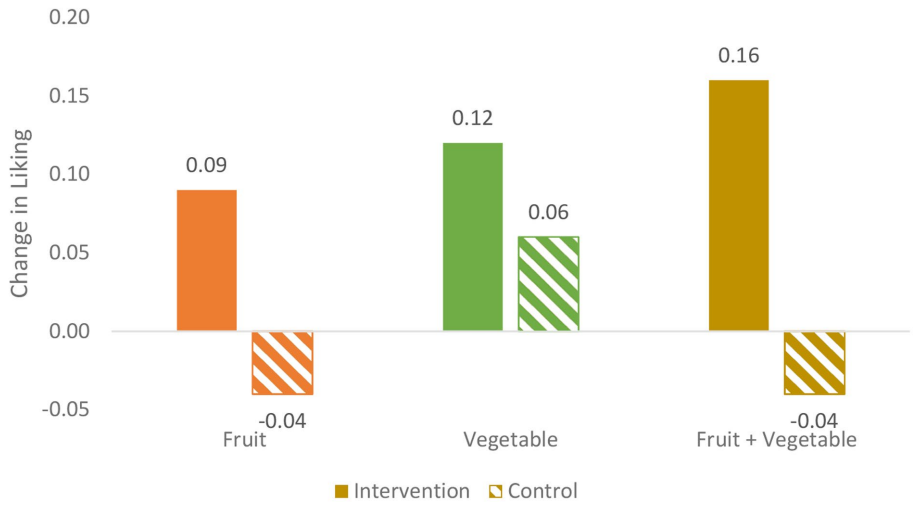

FIGURE 5
Pre-post change for intervention v. no intervention for F, V, and FV liking (ratings 1-5 of 6 F, 6 V).

Discussion

Conclusion and interpretation

The childcare garden intervention had significant positive effects on children's learning to identify both fruit and vegetables and on their consumption of fruit and vegetables during a tasting session. There was no significant effect on children's liking of fruit or vegetables. These findings are largely consistent with prior research. Regarding FV identification, studies conducted primarily with elementary school students (ages 7–10 years), suggest that gardening can bolster children's science learning including FV knowledge (Parmer et al., 2009; Berezowitz et al., 2015; Wells et al., 2015).

The present study extends the evidence to preschool children (ages 3–5 years). With respect to FV consumption, findings align with previous research that suggests hands-on gardening may modestly boost children's FV consumption (Namenek Brouwer and Benjamin Neelon, 2013). Moreover, the current finding that the garden intervention had a stronger effect on fruit rather than on vegetable consumption is consistent with prior evidence suggesting that the impact on fruit consumption is relatively common and increase of

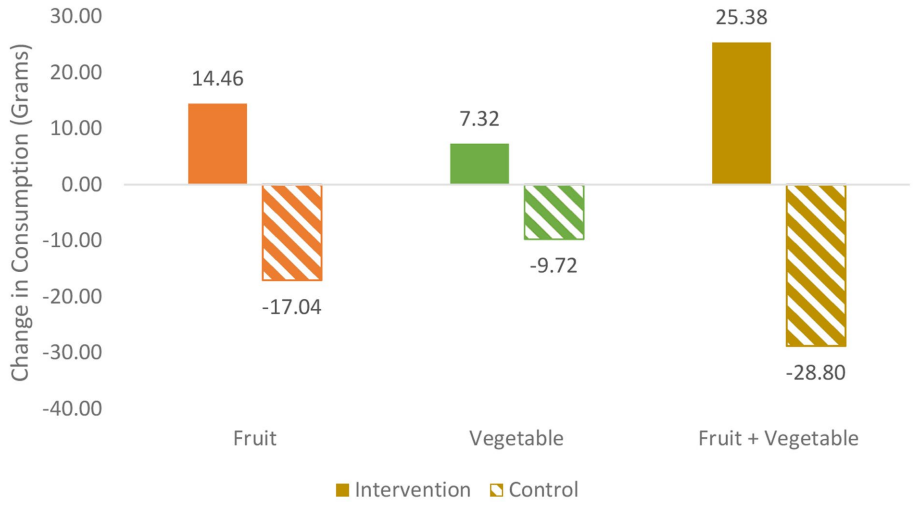

FIGURE 6
Pre-post change for intervention v. no intervention for F, V, and FV consumption in grams during snack sessions (of 300 g. F, 300 g. V served).

vegetable consumption among children harder to achieve (Evans et al., 2012; Savoie-Roskos et al., 2017).

While the finding that snack time consumption increased by 25 grams of fruit and 14 grams of vegetables may seem modest, 25 g is ¼ cup of fruit which equates to one serving for 3–5 year olds according to the Child and Adult Care Food Program (CACFP) guidelines (Food and Nutrition Service and U. S. Department of Agriculture, n.d.). Similarly, 14 g of vegetables is slightly less than1/8 cup, which is equivalent to a half serving of vegetables. If scaled across four daily snacks and meals (morning snack, lunch, afternoon snack, and supper), the total may equate to 4 servings of fruit and 2 servings of vegetables bringing children to recommended daily consumption of three cups of FV daily (U.S. Department of Agriculture, 2021).

The non-significant results regarding FV liking may reflect a common developmental pattern. Research shows that neophobia (the rejection of new tastes) increases gradually between the ages of 2 and 5 years and decreases in subsequent years (Cooke et al., 2003). As children grow, their understanding of what to eat or not eat increases as they are encouraged to taste and make decisions by themselves. With the development of cognitive skills (at about 7 years of age), children are able to make rational choices based on previous experiences (Birch et al., 1987). It may be the case that the gardening intervention does not affect FV liking. Alternatively, the non-significant result regarding FV liking may be explained by limits to construct validity inherent in our measures, described below.

Study strengths and limitations

Strengths

This study makes several contributions. First, it examines hands-on gardening in a vulnerable, under-studied population: children within low-income communities who attend childcare. This population is not only at risk for poor diet (Lorson et al., 2009) and overweight (Robert Wood Johnson Foundation, 2021) but is seldom the focus of research. Moreover, while early interventions have the potential to affect change over the lifecourse (Wethington, 2005; García et al., 2020), environment and behavior studies of preschool children remain a critical gap in the literature.

The internal validity of this study is bolstered by its RCT design, which allows us to rule out multiple alternative explanations or threats to internal validity. An additional strength is construct validity. Established, age-appropriate measures were employed for all dependent variables. FV consumption, which is particularly challenging to measure in young children (Rockett and Colditz, 1997; Warren et al., 2003; Livingstone et al., 2004; Magarey et al., 2011), is objectively measured via pre- and post-snack time weighing of FV, avoiding the quagmire of threats to construct validity associated with self-report dietary data (Livingstone and Robson, 2000).

Limitations

This study is not without limitation. Regarding external validity, it is possible that study findings may not be readily generalizable to other climate or geographical areas. While overall, the construct validity of this study is strong – with the use of valid, reliable, age-appropriate measures – there are still inevitable limitations. The measurement of FV consumption during tasting sessions (snack times) means that the measure may not correspond directly to daily dietary intake of FV. The measure of FV liking, which employed visual images of fruit and vegetables presented on a touch-screen tablet (1 day before tasting vegetables and 2 days before tasting fruit), may have relatively weak construct validity, particularly for such young children who may not have the cognitive ability to remember whether they have eaten the item before and whether they did indeed like it. Thus, the FV

liking measure may have been more effective if it had followed the tasting sessions or was synchronous with tasting. In this way, children might have been more likely to report whether they liked to eat the FV (rather than, perhaps, merely whether they 'liked' the visual image). The construct validity limitations regarding the FV liking may in fact underlie the non-significant effects on FV liking. In other words, the compromised construct validity may, in turn, have affected the statistical (and internal) validity of this facet of the study – making a Type 2 ("miss") more likely with respect to the effects of the intervention on children's liking of FV.

This study did not examine the possible mediating mechanisms that would illuminate the explanatory pathways by which the gardening intervention affects FV outcomes. Similarly, the examination of moderators (or "effect modifiers") was beyond the scope of this study.

Additional limitations are presented by the inherent challenges of working with childcare centers serving low-income families whose working schedules are tightly connected to their services (Sandstrom and Chaudry, 2012; VanLeer et al., 2021). The unstable nature of low-income jobs often has an impact on children's childcare attendance due to relocation, changes in parent schedules, lack of transportation, or other issues. Like most childcare centers serving low-income communities, the centers that participated in this study tended to be understaffed and have high turnover of teachers and leadership (Grunewald et al., 2022). Due to these factors, this study experienced attrition of participating children (Cosco et al., 2021).

Implications

The childcare gardening intervention increased children's dietary intake, modestly but significantly, raising the question: does hands-on gardening infrastructure, and related pedagogical programming, deliver a viable return on investment? The approximate installation cost of each COLEAFS garden was $1,500 for materials and labor (2018 dollars) – a small investment compared to the renovation cost ($50 K – $100 K) of a complete outdoor learning environment using best practices (Moore and Cosco, 2021). Garden-based learning offers a rewarding opportunity for classroom teachers to directly engage children in an adaptable interdisciplinary outdoor pedagogy (STEAM: science, technology, engineering, art, mathematics (Vandermaas-Peeler and McClain, 2015; Linder and Eckhoff, 2020).

An additional upfront cost for training may also be needed to help teachers learn about gardening basics (i.e., choosing fertile soil and appropriate seeds, identifying adequate orientation with sufficient sunlight, preparing containers, and following irrigation schedules). A starter garden can be as modest as tomato and basil plants for a simple salad. The power of experiential garden-based learning during the preoperational preschool years (Zeinstra et al., 2007), is underscored by Piaget's seminal insistence that for children to understand something they "must do their own experimenting, their own research" (Piaget, 1972, p. 27). Skill acquisition (García et al., 2018) and cognitive development (Zeinstra et al., 2007), may support dietary impacts that scale up as a lifecourse health benefit (Wethington, 2005).

Garden interventions in disadvantaged communities may provide an opportunity to reduce disparities in healthy eating, particularly for African American (Sharma et al., 2014) and Latino children (Davis et al., 2011). Knowledge of gardening acquired by young, disadvantaged children attending childcare (Zeinstra et al., 2007) may also help to level the "healthy playing field" to enable the equigenic effect of contact with nature (Mitchell, 2013; Jordan, 2020; Wells, 2021). Because the COLEAFS context was low-resource communities with high percentages of subsidized families and racial minorities, the impacts may be amplified compared to similar interventions in advantaged communities (Elango et al., 2016).

Since U.S. childcare systems are highly regulated and policy sensitive, state-level policy changes can rapidly ripple across systems. If early childhood gardening is considered a potentially influential healthy eating strategy, informing state leadership with change-provoking evidence may be an effective strategy. Policy pathways have already been laid by innovative, US state-level assessment models emphasizing experiential learning and gardening. Included are the NC Foundations for Early Learning (North Carolina Foundations Task Force, 2013), South Carolina Early Learning Standards (South Carolina Early Learning Standards Interagency Stakeholder Group, 2017), and the Texas Prekindergarten Guidelines (University of Texas System and Texas Education Agency, 2015).

Findings from this study add evidence that may support licensing regulations, assessment protocols, accreditation standards, and community college courseware to adopt garden-based learning as a convincing driver for early childhood healthy nutrition. Adoption may scale up childcare systems as an effective health and wellness intervention that considers investment in gardening as a focal target for social return on investment (SROI) (Hamelmann et al., 2017).

Future research

Opportunities for future research are many and varied. With sufficient resources, a longer longitudinal study might follow children after their time in childcare, into elementary school and beyond, to gain a more complete understanding of influence of early gardening experiences on dietary trajectories. Similarly, studies might further embrace the bioecological model (Bronfenbrenner, 1979), to examine the influence of key microsystems and how these contexts interact to affect a child's dietary intake (Story et al., 2008). Prior research suggests that a school garden intervention may have effects that carry over to the home environment (Wells et al., 2018) but there is a need for a broader understanding of the interplay among settings.

Future studies might focus more explicitly on mediating mechanisms to illuminate the explanatory pathways from

intervention to dietary intake. A focus on mediation not only enriches a conceptual understanding of the processes contributing to dietary habits, but also provides practical leverage points, expanding the range of targets for intervention. Possible mediating mechanisms linking a garden intervention to FV consumption include exposure to FV (Cooke, 2007) and the availability (i.e., presence) of FV (Jago et al., 2007). It is plausible that some mediators stretch beyond the childcare center to other contexts of the child's life (Bronfenbrenner, 1979; Wells et al., 2018). For example, parents' awareness of, or involvement in a childcare-based gardening intervention may lead them to become curious about FV or motivated to improve diet at home. Similarly, children, following their exposure to FV via gardening, might increase their "asking skills" related to FV, when eating or shopping with parents (Askelson et al., 2019). Thus, parents and the home environment may be among the possible spokes by which a childcare garden could affect change.

Relationships between FV availability and FV home gardening with children may be a potent research direction. The complex, many-layered process of home food management modeled by Campbell and Desjardins (1989), stresses assessment of the family context as essential for improving nutritional health of low-income families and their children and underscores proximal availability of food as a potentially strong mediator. Gardening at home is a traditional activity of family contexts around the world and has, for example, been associated with Filipino preschool-aged child diet diversity and frequency of vegetable consumption (Cabalda et al., 2011). Hands-on gardening for children at home (even as modest as veggies and herbs in containers) may strengthen proximal availability and provide significant experiential learning, especially if linked to gardening experiences at preschool. Center-home FV synergy may enhance children's familiarity with FV, increase home experience and FV availability, impact positive home consumption, and expand informed FV conversations at the grocery store (Baranowski et al., 2000).

Data for the study reported here were gathered in the Piedmont region of North Carolina, where the warm and cool growing seasons extend through most of the year. Replication in different climatic zones would provide a necessary test of external validity but also may offer valuable information regarding the practicalities of preschool FV gardening under more extreme climatic conditions, including, for example, glazed indoor spaces to extend the growing season in northern latitudes.

Taking advantage of new technologies, big data analyses (crossing pediatric health and demographics data with environmental opportunities for gardening), might offer a pathway to maximize use of existing garden installations or identify locations to create programs in disadvantage communities (Altaweel, 2022; ArcGIS, 2022).

Data availability statement

Full datasets are not readily available because subjects were young children and parent consents did not include permission to share information with researchers beyond the study team. Further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving human participants were reviewed and approved by North Carolina State University Institutional Review Board (IRB) according to the Declaration of Helsinki guidelines on research ethics. Protocol approval #5908. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

NGC, NMW, LSG, MM, and RCM contributed to research design and measurement selection. NGC and NMW led the manuscript preparation and writing. DZ and TX led the data analysis. RCM contributed knowledge on garden design and sustainable practices. NCG oversaw data collection and intervention implementation. MM contributed to the study preparation and Year 1 data collection. All authors contributed to the manuscript and reviewed the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2022.993637/full#supplementary-material

References

Altaweel, M. (2022). *How GIS is Helping Gardening*. Available at: https://www.gislounge.com/gis-gardening/#_ftn3

ArcGIS. (2022). *Mapping the Public Garden: Build a Notification Web App for a Community Garden*. Available at: https://learn.arcgis.com/en/projects/mapping-the-public-garden/arcgis-pro/

Askelson, N. M., Golembiewski, E. H., Meier, C. L., Smith, R., Montgomery, D., Lillehoj, C. J., et al. (2019). Pester power: understanding parent–child communication about fruits and vegetables in low-income families from the child's perspective. *Soc. Mark. Q.* 25, 182–192. doi: 10.1177/1524500419839497

Baranowski, T., Davis, M., Resnicow, K., Baranowski, J., Doyle, C., Lin, L. S., et al. (2000). Gimme 5 fruit, juice, and vegetables for fun and health: outcome evaluation. *Health Educ. Behav.* 27, 96–111. doi: 10.1177/109019810002700109

Berezowitz, C. K., Bontrager Yoder, A. B., and Schoeller, D. A. (2015). School gardens enhance academic performance and dietary outcomes in children. *J. Sch. Health* 85, 508–518. doi: 10.1111/josh.12278

Bevan, A., Hemingway, A., Appleton, K. M., Hartwell, H., Magnante, O., Perez-Cueto, A., et al. (2016). Familiarity and liking of vegetables: is it important for vegetable consumption? *Br. J. Sch. Nurs.* 11, 125–130. doi: 10.12968/bjsn.2016.11.3.125

Birch, L. L., McPhee, L., Shoba, B. C., Pirok, E., and Steinberg, L. (1987). What kind of exposure reduces children's food neophobia? Looking vs. tasting. *Appetite* 9, 171–178. doi: 10.1016/S0195-6663(87)80011-9

Birch, L. L., Savage, J. S., and Ventura, A. (2007). Influences on the development of children's eating behaviours: from infancy to adolescence. *Can. J. Diet. Pract. Res.* 68, s1–s56. doi:10.1542/9781581104202

Bronfenbrenner, U. (1979). *The Ecology of Human Development: Experiments by Design and Nature*. Cambridge, MA: Harvard University Press.

Cabalda, A. B., Rayco-Solon, P., Solon, J. A. A., and Solon, F. S. (2011). Home gardening is associated with Filipino preschool children's dietary diversity. *J. Am. Diet. Assoc.* 111, 711–715. doi: 10.1016/j.jada.2011.02.005

Campbell, C. C., and Desjardins, E. (1989). A model and research approach for studying the management of limited food resources by low income families. *J. Nutr. Educ.* 21, 162–171. doi: 10.1016/S0022-3182(89)80052-4

Carraway-Stage, V., Spangler, H., Borges, M., and Goodell, L. S. (2014). Evaluation of a pictorial method to assess liking of familiar fruits and vegetables among preschool children. *Appetite* 75, 11–20.

Cooke, L. J. (2007). The importance of exposure for healthy eating in childhood: a review. *J. Hum. Nutr. Diet.* 20, 294–301. doi: 10.1111/j.1365-277X.2007.00804.x

Cooke, L. J., Wardle, J., and Gibson, E. (2003). Relationship between parental report of food neophobia and everyday food consumption in 2–6-year-old children. *Appetite* 41, 205–206. doi: 10.1016/S0195-6663(03)00048-5

Cooke, L. J., Wardle, J., Gibson, E. L., Sapochnik, M., Sheiham, A., and Lawson, M. (2004). Demographic, familial and trait predictors of fruit and vegetable consumption by pre-school children. *Public Health Nutr.* 7, 295–302. doi: 10.1079/PHN2003527

Cosco, N. G., Wells, N. M., Monsur, M., Goodell, L. S., Zhang, D., Xu, T., et al. (2021). Research design, protocol, and participant characteristics of COLEAFS: a cluster randomized controlled trial of a childcare garden intervention. *Int. J. Environ. Res. Public Health* 18:13066. doi: 10.3390/ijerph182413066

Cullen, K. W., Baranowski, T., Owens, E., Marsh, T., Rittenberry, L., and de Moor, C. (2003). Availability, accessibility, and preferences for fruit, 100% fruit juice, and vegetables influence children's dietary behavior. *Health Educ. Behav.* 30, 615–626. doi: 10.1177/1090198103257254

Davis, J. N., Spaniol, M. R., and Somerset, S. (2015). Sustenance and sustainability: maximizing the impact of school gardens on health outcomes. *Public Health Nutr.* 18, 2358–2367. doi: 10.1017/S1368980015000221

Davis, J. N., Ventura, E. E., Cook, L. T., Gyllenhammer, L. E., and Gatto, N. M. (2011). LA sprouts: a gardening, nutrition, and cooking intervention for Latino youth improves diet and reduces obesity. *J. Am. Diet. Assoc.* 111, 1224–1230. doi: 10.1016/j.jada.2011.05.009

Elango, S., García, J., Heckman, J., and Hojman, A. (2016). "Early childhood education" in *Economics of Means-Tested Transfer Programs in the United States*. ed. R. Moffitt, vol. *2* (Chicago: University of Chicago Press), 235–297.

Evans, C. E., Christian, M. S., Cleghorn, C. L., Greenwood, D. C., and Cade, J. E. (2012). Systematic review and meta-analysis of school-based interventions to improve daily fruit and vegetable intake in children aged 5 to 12 y. *Am. J. Clin. Nutr.* 96, 889–901. doi: 10.3945/ajcn.111.030270

Food and Nutrition Service and U. S. Department of Agriculture. (n.d.). *Nutrition Standards for CACFP Meals and Snacks, Meal Patterns Tables*. Available at: https://www.fns.usda.gov/cacfp/meals-and-snacks

García, J. L., Heckman, J. J., Leaf, D. E., and Prados, M. J. (2020). Quantifying the life-cycle benefits of an influential early-childhood program. *J. Polit. Econ.* 128, 2502–2541. doi: 10.1086/705718

García, J. L., Heckman, J. J., and Ziff, A. L. (2018). Gender differences in the benefits of an influential early childhood program. *Eur. Econ. Rev.* 109, 9–22. doi: 10.1016/j.euroecorev.2018.06.009

Grimm, K. A., Kim, S. A., Yaroch, A. L., and Scanlon, K. S. (2014). Fruit and vegetable intake during infancy and early childhood. *Pediatrics* 134, S63–S69. doi: 10.1542/peds.2014-0646K

Grunewald, R., Nunn, R., and Palmer, V. (2022). Examining teacher turnover in early care and education. Available at Federal Reserve Bank of Minneapolis: https://www.minneapolisfed.org/article/2022/examining-teacher-turnover-in-early-care-and-education

Hamelmann, C., Turatto, F., Then, V., and Dyakova, M. (2017). *Social Return on Investment: Accounting for Value in the Context of Implementing Health 2020 and the 2030 Agenda for Sustainable Development (Investment for Health and Development Discussion Paper)*. Available at: https://apps.who.int/iris/handle/10665/340348

Jago, R., Baranowski, T., and Baranowski, J. (2007). Fruit and vegetable availability: a micro environmental mediating variable? *Public Health Nutr.* 10, 681–689. doi: 10.1017/S1368980007441441

Jordan, C. (2020). The Equigenic Effect: How Nature Access Can Level the Playing Field for Children. Available at: https://www.childrenandnature.org/resources/the-equigenic-effect-how-nature-access-can-level-the-playing-field-for-children/

Landry, M. J., van den Berg, A. E., Hoelscher, D. M., Asigbee, F. M., Vandyousefi, S., Ghaddar, R., et al. (2021). Impact of a school-based gardening, cooking, nutrition intervention on diet intake and quality: the TX sprouts randomized controlled trial. *Nutrients* 13:3081. doi: 10.3390/nu13093081

Langellotto, G. A., and Gupta, A. (2012). Gardening increases vegetable consumption in school-aged children: a meta-analytical synthesis. *Hort Technol.* 22, 430–445. doi: 10.21273/HORTTECH.22.4.430

Linder, S. M., and Eckhoff, A. (2020). Breaking down STEAM for young children. Available at: https://www.naeyc.org/resources/pubs/tyc/feb2020/breaking-down-steam

Livingstone, M. B. E., and Robson, P. J. (2000). Measurement of dietary intake in children. *Proc. Nutr. Soc.* 59, 279–293. doi: 10.1017/S0029665100000318

Livingstone, M. B. E., Robson, P. J., and Wallace, J. M. W. (2004). Issues in dietary intake assessment of children and adolescents. *Br. J. Nutr.* 92, S213–S222. doi: 10.1079/BJN20041169

Lorson, B. A., Melgar-Quinonez, H. R., and Taylor, C. A. (2009). Correlates of fruit and vegetable intakes in US children. *J. Am. Diet. Assoc.* 109, 474–478. doi: 10.1016/j.jada.2008.11.022

Magarey, A., Watson, J., Golley, R. K., Burrows, T., Sutherland, R., McNaughton, S. A., et al. (2011). Assessing dietary intake in children and adolescents: considerations and recommendations for obesity research. *Int. J. Pediatr. Obes.* 6, 2–11. doi: 10.3109/17477161003728469

Mitchell, R. J. (2013). What is equigenesis and how might it help narrow health inequalities? Available at: https://cresh.org.uk/2013/11/08/what-is-equigenesis-and-how-might-it-help-narrow-health-inequalities/

Moore, R. C., and Cosco, N. G. (2014). Growing up green: naturalization as a health promotion strategy in early childhood outdoor learning environments. *Child. Youth Environ.* 24, 168–191. doi: 10.7721/chilyoutenvi.24.2.0168

Moore, R. C., and Cosco, N. (2021). *Preschool Outdoor Play and Learning Environments: Best Practice Toolkit*. Retrieved from Raleigh, NC

Namenek Brouwer, R. J., and Benjamin Neelon, S. E. (2013). Watch me grow: a garden-based pilot intervention to increase vegetable and fruit intake in preschoolers. *BMC Public Health* 13:363. doi: 10.1186/1471-2458-13-363

Nekitsing, C., Blundell-Birtill, P., Cockroft, J. E., and Hetherington, M. M. (2018). Systematic review and meta-analysis of strategies to increase vegetable consumption in preschool children aged 2–5 years. *Food Agric. Organ. United Nations.* 127, 138–154. doi: 10.1016/j.appet.2018.04.019

North Carolina Department of Health and Human Services. (2017). NC Child Care Snapshot-NC Division of Child Development and Early Education. Available at: https://ncchildcare.ncdhhs.gov/County/Child-Care-Snapshot#Child%20Care%20Highlights

North Carolina Foundations Task Force. (2013). *North Carolina Foundations for Early Learning and Development*. Raleigh, NC: NC Foundations Task Force.

Ohly, H., Gentry, S., Wigglesworth, R., Bethel, A., Lovell, R., and Garside, R. (2016). A systematic review of the health and well-being impacts of school gardening: synthesis of quantitative and qualitative evidence. *BMC Public Health* 16, 286–321. doi: 10.1186/s12889-016-2941-0

Parmer, S. M., Salisbury-Glennon, J., Shannon, D., and Struempler, B. (2009). School gardens: an experiential learning approach for a nutrition education program to increase fruit and vegetable knowledge, preference, and consumption among second-grade students. *J. Nutr. Educ. Behav.* 41, 212–217. doi: 10.1016/j.jneb.2008.06.002

Piaget, J. (1972). "Some aspects of operations" in *Play and development*. ed. M. W. Piers (New York: W.W. Norton)

Robert Wood Johnson Foundation. (2021). *State of childhood obesity: From crisis to opportunity-reforming our nation's policies to help all children grow up healthy*. Available at: https://media.stateofobesity.org/wp-content/uploads/2021/10/12132618/State-of-Childhood-Obesity-10-13-21-Final-WEB.pdf

Rockett, H. R., and Colditz, G. A. (1997). Assessing diets of children and adolescents. *Am. J. Clin. Nutr.* 65, 1116S–1122S. doi: 10.1093/ajcn/65.4.1116S

Sandstrom, H., and Chaudry, A. (2012). 'You have to choose your childcare to fit your work': childcare decision-making among low-income working families. *J. Child. Poverty* 18, 89–119. doi: 10.1080/10796126.2012.710480

Savoie-Roskos, M. R., Wengreen, H., and Durward, C. (2017). Increasing fruit and vegetable intake among children and youth through gardening-based interventions: a systematic review. *J. Acad. Nutr. Diet.* 117, 240–250. doi: 10.1016/j.jand.2016.10.014

Schwartz, C., Scholtens, P. A., Lalanne, A., Weenen, H., and Nicklaus, S. (2011). Development of healthy eating habits early in life. Review of recent evidence and selected guidelines. *Appetite* 57, 796–807. doi: 10.1016/j.appet.2011.05.316

Sharma, S., Hedberg, A., Skala, K., Chuang, R., and Lewis, T. (2014). Feasibility and acceptability of a gardening-based nutrition education program in preschoolers from low-income, minority populations. *J. Early Childh. Res.* 13, 93–110. doi: 10.1177/1476718X14538598

Skelton, K., Herbert, A., and Benjamin-Neelon, S. E. (2019). Garden-based interventions and early childhood health: a protocol for an umbrella review. *Syst. Rev.* 8:310. doi: 10.1186/s13643-019-1229-8

South Carolina Early Learning Standards Interagency Stakeholder Group. (2017). *South Carolina Early Learning Standards*. Available at: https://www.scchildcare.org/media/55097/SC_ELS-second-edit.pdf

State of North Carolina Office of Administrative Hearings. (2012). *Child Care Center Handbook. Chapter 9: Nutrition*. Available at: https://ncchildcare.ncdhhs.gov/Portals/0/documents/pdf/C/center_chp9.pdf

Story, M. T., Kaphingst, K. M., Robinson-O'Brien, R., and Glanz, K. (2008). Creating healthy food and eating environments: policy and environmental approaches. *Annu. Rev. Public Health* 29, 253–272. doi: 10.1146/annurev.publhealth.29.020907.090926

U.S. Department of Agriculture. (2021). *Start Simple with MyPlate Plan: Ages 4 to 8 Years*. Available at: https://myplate-prod.azureedge.us/sites/default/files/2021-08/2020MyPlatePlan_1400cals_Age4-8.pdf

University of Texas System and Texas Education Agency. (2015). *Texas Prekindergarten Guidelines*. Available at: https://tea.texas.gov/sites/default/files/PKG_Final_2015_navigation.pdf

Vandermaas-Peeler, M., and McClain, C. (2015). The green bean has to be longer than your thumb: an observational study of Preschoolers' math and science experiences in a garden. *Int. J. Early Childh. Environ. Educat.* 3, 8–27.

VanLeer, K. F., Crosby, D. A., and Mendez, J. (2021). *Disruptions to Child Care Arrangements and Work Schedules for Low-Income Hispanic Families are Common and Costly*. Available at: www.hispanicresearchcenter.org/research-resources/disruptions-to-child-care-arrangements-and-work-schedules-for-low-income-hispanic-families-are-common-and-costly files/3894/disruptions-to-child-care-arrangements-and-work-schedules-for-low-income-hispanic-families-are-.html

Varman, S. D., Cliff, D. P., Jones, R. A., Hammersley, M. L., Zhang, Z., Charlton, K., et al. (2021). Experiential learning interventions and healthy eating outcomes in children: a systematic literature review. *Int. J. Environ. Res. Public Health* 18:10824. doi: 10.3390/ijerph182010824

Warren, J. M., Henry, C. J. K., Livingstone, M. B. E., Lightowler, H. J., Bradshaw, S. M., and Perwaiz, S. (2003). How well do children aged 5-7 years recall food eaten at school lunch? *Public Health Nutr.* 6, 41–47. doi: 10.1079/phn2002346

Wells, N. M. (2021). "The natural environment as a resilience factor: nature's role as a buffer of the effects of risk and adversity" in *Nature and Psychology: How the Natural World Shapes our Cognition*. eds. A. R. Schutte, J. Stevens and J. C. Torquati (Cham: Springer)

Wells, N. M., Meyers, B. M., Todd, L. E., Henderson, C. R. Jr., Barale, K., Gaolach, B., et al. (2018). The carry-over effects of school gardens on fruit and vegetable availability at home: a randomized controlled trial with low-income elementary schools. *Prev. Med.* 112, 152–159. doi: 10.1016/j.ypmed.2018.03.022

Wells, N. M., Myers, B. M., Todd, L. E., Barale, K., Gaolach, B., Ferenz, G., et al. (2015). The effects of school gardens on children's science knowledge: a randomized controlled trial of low-income elementary schools. *Int. J. Sci. Educ.* 37, 2858–2878. doi: 10.1080/09500693.2015.1112048

Wethington, E. (2005). An overview of the life course perspective: implications for health and nutrition. *J. Nutr. Educ. Behav.* 37, 115–120. doi: 10.1016/S1499-4046(06)60265-0

Witt, K. E., and Dunn, C. (2012). Increasing fruit and vegetable consumption among preschoolers: evaluation of color me healthy. *J. Nutr. Educ. Behav.* 44, 107–113. doi: 10.1016/j.jneb.2011.01.002

Zeinstra, G. G., Koelen, M. A., Kok, F. J., and De Graaf, C. (2007). Cognitive development and children's perceptions of fruit and vegetables; a qualitative study. *Int. J. Behav. Nutr. Phys. Act.* 4, 30–11. doi: 10.1186/1479-5868-4-30

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How a marine debris environmental education program plays to strengths of linguistically diverse learners

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Although environmental education (EE) has increased focus on how to best serve diverse populations, one understudied area is how linguistically diverse learners may engage with EE programming. Linguistic diversity is on the rise across the United States; for instance, nearly one-third of all children between the ages of 0 and 8 have at least one parent who speaks a language other than English in the home. This study evaluated impacts of an EE curriculum designed to promote pro-environmental behavior change with a pre-post, treatment-control experimental design among students from linguistically diverse households. In partnership with teachers, we implemented the curriculum in elementary schools across the state of North Carolina, United States. Over two school years (2018–2020), 36 teachers from 31 schools across 18 counties participated in the study, providing 644 paired pre-post student responses (n=204 control; n=440 treatment). About 10% of the sample (n=49 treatment, n=18 control) reported speaking a language at home other than English. We tested hypotheses that the curriculum would increase pro-environmental behavior change among all students, but particularly among those from linguistically diverse households using multiple linear regression. Results indicate that the curriculum effectively encouraged pro-environmental behaviors for all students on average, but particularly among linguistically diverse students, adding to growing examples of the equigenic effects of environmental and nature-based education. These findings are consistent with research demonstrating that EE can contribute to behavior change among young learners and may be particularly well-suited to resonate with the unique contributions of linguistically diverse learners.

KEYWORDS

linguistically diverse, environmental education, marine debris, pro-environmental behavior, culturally relevant teaching, culturally relevant education

1. Introduction

From its inception, environmental education (EE) has been framed as a public good that is essential for individual and societal flourishing (Tbilisi Declaration, 1977). At the heart of this framing is a recognition that EE can equip people and communities with the knowledge, skills, and motivations they need to shape a future they want (Tbilisi Declaration, 1977). Accordingly, EE design and delivery efforts should acknowledge, respect, and reflect the diverse identities and value systems present around the globe. Encouragingly, the field of EE has attempted to focus on engaging both program providers and participants from diverse backgrounds. Programmatic efforts have expanded to place greater emphasis on funding and creating initiatives to engage participants from systemically excluded groups, and significant momentum is building around EE organizations and programs that serve this charge (Flores and Kuhn, 2018). Latino Outdoors, Outdoor Afro, and LGBT+ Outdoors, for example, are nonprofits that strive to increase participation in outdoor recreation activities for Latinx, Black, and sexually and gender diverse communities, respectively, (Latino Outdoors, 2021; LGBT Outdoors, 2022; Outdoor Afro, 2021). However, there is considerable room for improving inclusion in hiring, retention, and grant selection practices within the environmental movement in general (Green 2.0, 2020), and equity within EE that is inclusive of class, race, ethnicity, and other forms of diverse identities (Haluza-DeLay, 2013; Aguilar et al., 2017; Stapleton, 2020).

The EE research community has responded in parallel with studies to better understand how EE impacts diverse communities (Tuck et al., 2014; Stapleton, 2020; Rodrigues and Lowan-Trudeau, 2021). This is encouraging, as understanding how to best include students from diverse backgrounds is critical to equipping all learners with the skills and dispositions they need to effectively engage in shaping their own futures. For example, students who feel a sense of inclusion and belonging at school experience numerous positive outcomes, including improved learning, academic achievement, motivation, retention, persistence, and attendance at school (Walton et al., 2015; Murphy et al., 2018; Borman et al., 2019; Binning et al., 2020; Williams et al., 2020; Gray et al., 2022). A first step at understanding how to foster such a sense of belonging is to better understand how learners from diverse identities may uniquely engage with EE programming. Relevant EE studies focused on specific identities have examined how factors such as race and ethnicity (Larson et al., 2011; Stevenson et al., 2013; Clark et al., 2020; Szczytko et al., 2020), gender (Stevenson et al., 2021), and learning differences (Szczytko et al., 2018), may shape how various learners benefit from EE opportunities. Key findings across these studies are that EE programming typically benefits those with non-dominant identities as well as, or to a greater degree than, those with dominant identities, leveling the playing field by differentially helping groups who typically fall behind (i.e., producing equigenic impacts: Kuo et al., 2019). For instance, findings from Szczytko et al. (2020) showed that race was not a factor in young people's connection to nature, despite previous assumptions to the contrary, and Clark et al. (2020) found that EE programs centering on fisheries had positive impacts on all learners, not just a certain group. Additionally, multiple studies have reported that EE programming has positive impacts particularly for girls (Stevenson et al., 2021) and children with learning disabilities (Szczytko et al., 2018). Environmental education interventions have also been shown to support environmental behavior among African American learners (Larson et al., 2011; Stevenson et al., 2013) and pro-environmental attitudes among students identifying as Hispanic or African Americans (Stevenson et al., 2013). Likewise, conclusions from a study that analyzed results from 105 EE interventions encouraged intentionality, creativity, and inclusivity when developing and implementing EE programs (Ardoin et al., 2020).

Efforts to understand how to best serve linguistically diverse learners with EE programming are needed for several reasons. Throughout this paper, we use the term "linguistically diverse," rather than "language minority," or "non-dominant language" to avoid negative connotations associated with the word minority and signify the dynamic, contextual nature of a linguistic landscape within any given geographical region. As language represents a fundamental element of human connection (Shannon and Weaver, 1949; Chandler, 2007), research around how linguistically diverse populations interpret EE programming can support efforts to serve an increasingly diversifying and interconnected world. Moreover, scholars suggest that many EE programs may be easily positioned to build-in strategies that respond to learners' linguistic diversity (Arreguín-Anderson and Kennedy, 2013). For instance, linguistic diversity is on the rise across the United States, and especially among student populations, as young children who have at least one parent who speaks a language other than English in the home now constitute nearly one-third of all children between the ages of 0 and 8 (Park et al., 2018). Though resources and programs such as bilingual schools have grown, they do not have adequate reach to serve all students who need them (Lam and Richards, 2020). This includes EE programming, the majority of which is conducted in English (Arreguín-Anderson and Kennedy, 2013). Thus, linguistically diverse youth must frequently navigate the cultural dichotomy between their home environments and westernized, English-dominated classrooms and educational programs (Park et al., 2018). This dynamic is particularly acute in places like Texas, where 78% of parents are Spanish-speaking (Arreguín-Anderson and Kennedy, 2013; Park et al., 2018), New Mexico and Arizona, where 71% of parents are Spanish-speaking (Park et al., 2018), or in California, where 23% of students are linguistically diverse (Genesee et al., 2005). In a US context, Spanish is often the dominant minority language, but other major languages include Chinese and Arabic (Park et al., 2018). Understanding how linguistically diverse learners engage with EE programming is a first step to ensuring they are fully integrated into EE's mission of fostering environmentally literate individuals and communities.

Environmental education interventions that employ intergenerational learning (IGL) approaches could represent one strategy that may simultaneously support culturally and linguistically diverse students as well as encourage pro-environmental behaviors. As children from linguistically diverse households often assume the role of translator within their family, they may be particularly effective at engaging parents (Blanchet-Cohen and Reilly, 2017). Serving as a translator may provide practice for youth to transform complex, unfamiliar scientific information into a description that makes sense and has value to their family context – essentially, making the information culturally-relevant (Blanchet-Cohen and Reilly, 2017). Several studies have highlighted how EE approaches that empower youth – such as giving them decision-making authority in choosing environmental actions (Haynes and Tanner, 2015), or encouraging them to talk with their parents or other adults (Williams and Chawla, 2016; Valdez et al., 2018) – have resulted in increased environmental behaviors among both youth and the adults with whom they communicate (Lawson et al., 2019; Hartley et al., 2021). In this way, IGL approaches may support EE outcomes such as self-efficacy, youth empowerment, or environmental engagement and behavior (Bernal, 2001; Haynes and Tanner, 2015; Williams and Chawla, 2016), as well as leverage unique strengths of linguistically diverse learners as potential EE ambassadors at home. As has been found in other studies examining EE impacts on diverse identities (Blanchet-Cohen and Reilly, 2017; Braun, 2019), IGL approaches may have unique benefits and challenges for linguistically diverse learners. For instance, some studies have shown that Asian and Latinx students have stronger family relational ties and greater familial expectations than peers from European backgrounds (Fuligni et al., 1999), and others have found that immigrant children served as environmental ambassadors in their families after engaging with a culturally-responsive environmental education program (Blanchet-Cohen and Reilly, 2017). Encouraging IGL may provide an opportunity for learners to draw on these strong family ties to foster a sense of empowerment and validation, although family structures that emphasize parental authority may diminish this opportunity. Research examining cultural and language diversity specifically within IGL-based EE programs is extremely limited, with only two studies that we are aware of at the time of this writing (Chineka and Yasukawa, 2020; Parth et al., 2020). Results of the two studies were mixed and suggested that culture may prove to be a barrier to positive IGL impacts in countries outside of the United States. As such, more research is needed across both US and non-US contexts to understand the degree to which linguistically diverse learners are challenged by, or are particularly adept at, learning in EE contexts, particularly those that are designed in ways that may draw on their unique assets.

Here we begin addressing the need for further EE research focusing on linguistically diverse populations in a United States context with a pre-post treatment-control experimental evaluation of a marine debris curriculum designed to promote IGL and pro-environmental behaviors among 4th and 5th grade students in North Carolina, United States from 2018 to 2020. We chose the topic of marine debris as it remains a pressing environmental issue and provides an opportunity for students with varying proximities to waterways to learn about the inherent connectivity between ecosystems. Further, it is a tangible issue that is accessible to young learners (Torres et al., 2019). In this study, we examine differential impacts of the curriculum on pro-environmental behaviors exhibited by students from linguistically diverse households. Given the potential for linguistically diverse students to respond positively to IGL-based approaches as discussed above, we hypothesized that participation in the curriculum might drive increased pro-environmental marine debris behaviors among all students (hypothesis 1), but particularly those from linguistically diverse households (hypothesis 2).

2. Materials and methods

2.1. Ethics statement

Data collection procedures were approved by the North Carolina State University Institutional Review Board (IRB# 12847). We provided teachers with signed consent forms or opt out consent waivers per school district preference to distribute to parents/guardians, and students were provided age-appropriate assent information at the beginning of the surveys. Only assenting students with parent permissions were allowed to participate.

2.2. Curriculum

The Duke University Marine Lab (DUML) marine debris curriculum used in this study (DeMattia et al., 2020) was not designed specifically for linguistically diverse learners, but as most well-designed EE programs are, it contains asset-based elements that make it culturally responsive. As opposed to deficit-based approaches that attribute low achievement along narrowly defined criteria to a personal deficiency, asset-based approaches embrace cultural differences and acknowledge systemic and structural influences (Rios-Aguilar and Kiyama, 2012; Baquedano-López et al., 2013). EE programs often are characterized by their flexible style, less formal approach, and overall adaptability (Sandoval, 2014), which are congruous with many tenets of culturally responsive teaching (CRT; Pownall, 2022). For instance, the marine debris curriculum provides some structure for educators with a few in-school activities that can be easily adapted to most schoolyards or backyards (e.g., understanding drag and how it affects marine animals by playing a running game with umbrellas). The curriculum then transitions to student-led investigations, which draw on specific perspectives, experiences, and priorities of students to investigate challenges related to marine debris in their community (DeMattia et al., 2020). This community, place-based, and student-driven focus in the marine debris curriculum could

help to affirm participants' various identities and encourage participants' unique cultural contributions, which has been shown to improve the benefits to learners of diverse racial, ethic, socioeconomic, or linguistic backgrounds (Munez, 2019; Matthews and López, 2020; Pownall, 2022). Building on work by Pownall (2022), who scaffolded her findings from Geneva Gay (2018) seminal book, *Culturally Responsive Teaching: Theory, Research, and Practice*, we provide context for how activities from the marine debris curriculum map to both culturally responsive teaching and EE best practices (Table 1).

2.3. Sampling

For the purposes of this study, we chose to focus on 4th and 5th grade elementary school students, who were roughly 7–11 years old, from North Carolina, United States. Research demonstrates that young children have open minds about environmental topics and are able to engage in systems-level thinking on environmental topics (Forrester, 2009; Craig and Allen, 2015). Accordingly, we wanted to explore impacts of the curriculum and associated IGL activities among this age group. We used hierarchical sampling (Ericson and Gonzalez, 2003) in that we first recruited teachers; and through teachers, recruited students who were enrolled in the teachers' classes. To recruit both treatment and control teachers, we advertised the study through a North Carolina Department of Public Instruction listserv, which reached all elementary public school science teachers across North Carolina. Interested teachers then self-selected to participate. Those who expressed interest were invited to participate in an on-site, coastal teacher professional development workshop at the Duke University Marine Lab in Beaufort, North Carolina, highlighting activities within the DUML marine debris curriculum (DeMattia et al., 2020). We simultaneously invited teachers to participate as control teachers using a delayed treatment design, where teachers on the waiting list for the first workshop were invited to become control teachers during the first year in exchange for acceptance into another summer workshop at a later date. Consent for minors to participate was granted by the participating students' parent/legal guardian, and assent for non-minors to participate was self-granted.

We followed this procedure during both the 2018–2019 and 2019–2020 school years, which resulted in 36 teachers from 31 different schools across 18 counties participating in the study. Of those 18 counties, 8 (44%) were coastal plains counties, 2 (11%) were from mountain-region counties, and 8 (44%) were from the Piedmont (inland) area of North Carolina; 12 (67%) schools were in counties classified as rural. We surveyed 2,201 children associated with the participating teachers in pre-surveys. After data cleaning and pairing the pre-survey responses with the post-survey responses, we had 644 paired student responses ($n = 204$ control; $n = 440$ treatment). Slightly more children identified as girls (53.1%) than boys (45.3%), with 1.5% identifying as a gender not represented by these categories. Most respondents (44.7%) identified as White or Caucasian, with fewer identifying as Black or African American (11.2%), Hispanic or Latinx (8.1%), Asian or Pacific Islander (3.1%), Native American (4.7%), multiracial (16.0%) or as an identity not listed (12.2%). About 10% of the sample ($n = 49$ treatment, 18 control) students reported speaking another language than English at home.

2.4. Instrument development

We developed our survey instruments by drawing on previously published tools focused on levels of environmental literacy and climate literacy among children. To measure marine debris behaviors of children, we drew on questions used in behavior scales in Lawson et al. (2019) and Stevenson and Peterson (2015). The marine debris-focused question asked, "*How often do you do the following activities*?" (e.g., "*Use a reusable water bottle,*" "*Refuse to use plastic straws at home or in restaurants,*" and "*Pick up trash when I see it,*" among others), and children responded to the eight items on a five-point frequency scale ranging from "*Never*" to "*Every chance I get*," which were designed to measure self-reported behavior frequency. We also asked students to self-report race, age, language spoken at home, and if that language spoken at home was not English, what the language was. Pilot testing of the child instrument was conducted in Summer 2018 with three, 4th grade, North Carolina classes ($n = 56$). A member of the research team visited the pilot classrooms in person during the pilot sessions, and we administered the survey online using a Qualtrics survey link. While taking the survey, children were given the opportunity to directly provide comments on anything that they found difficult to understand or comprehend. They also provided direct feedback to the researcher afterwards; 3–5 students from each class also participated in follow-up cognitive interviews to help refine items and the overall survey clarity (Desimone and Le Floch, 2004). In the pilot data, we found the marine debris behavioral scale to have acceptable internal consistency (Cronbach, 1951; $\alpha = 0.79$) and to be a single factor scale, per confirmatory factor analysis (Comrey and Lee, 2009). See supplemental information for item wording, including the full behavior scale as well as additional reliability and validity statistics.

2.5. Data collection

Teachers facilitated data collection for this study at the beginning and end of the 2018–2019 and 2019–2020 school years. Although the first study year was conducted during normal school operations, the second study collection year was impacted by the global COVID-19 pandemic, as schools rapidly shut down in March 2020 and post-surveys were given online as opposed to in classrooms as at previous data collection points. A total of 36 teachers participated in data collection, with some participating in both years, either as repeat treatment teachers or as control and then treatment teachers ($n = 4$),

TABLE 1 Elements of Duke University Marine Lab (DUML) Marine Debris Curriculum that match culturally responsive teaching tenets and environmental education (EE) elements as drawn from Pownall, 2022. The DUML Marine Debris Curriculum is freely available online: https://sites.duke.edu/communityscience/files/2020/06/DUML-Marine-Debris-Curriculum2020.pdf

Culturally responsive teaching (CRT) tenet	Applications to environmental education (EE) strategies	Activity in Duke University Marine Lab (DUML) Marine Debris Curriculum	Citation
Develop a knowledge base about cultural diversity	Partner with cultural organizations to collaborate on relevant, existing initiatives	2.1 Waterway Cleanup: Collect & Quantify Marine Debris	Vaquero (2015)
	Develop connections between personal, social, and ecological well-being	1.1 Waste & Plastics: Waste Audit	Fien (2003); Schindel and Tolbert (2017)
		1.1 Waste & Plastics: *A Plastic Ocean*	
		1.2 STEM: Marine Debris Entanglement	
		2.1 Waterway Cleanup: Collect & Quantify Marine Debris	
		3.1 Community Art: Circle of Viewpoints	
Include ethnic and cultural diversity content in the curriculum	Link EE content to relevant, cultural student experience (*funds of knowledge*)	3.2 Civic Engagement & Communication: Public Presentation of Art & Civic Action	Agyeman (2002); Del Campo et al. (2016); Stern et al. (2010)
	Co-create programs with communities or cultural groups	2.1 Waterway Cleanup: Collect & Quantify Marine Debris	Pease (2015); Simon (2016)
		3.2 Civic Engagement & Communication: Public Presentation of Art & Civic Action	
Demonstrate cultural caring and build learning communities	Design lessons around cooperative learning	1.1 Waste & Plastics: How Long 'til it's Gone?	Sleeter (2012)
		1.2 STEM: Physics of Marine Debris Movement	
		2.1 Waterway Cleanup: Collect & Quantify Marine Debris	
		2.1 Waterway Cleanup: Data Analysis & Quantification	
		3.1 Community Art: Marine Debris Mosaic	
		3.1 Community Art: Journey of X Mural	
		3.1 Community Art: PSAs	
		3.2 Civic Engagement & Communication: Public Presentation of Art & Civic Action	
	Demonstrate care for people, place, and community social and economic well-being (*environmental carework*)	1.1 Waste & Plastics: *A Plastic Ocean*	Fien (2003); Schindel and Tolbert (2017)
		1.2 STEM: Marine Debris Entanglement	
		2.1 Waterway Cleanup: Collect & Quantify Marine Debris	
		3.1 Community Art: Circle of Viewpoints	
		3.2 Civic Engagement & Communication: Public Presentation of Art & Civic Action	
Cross-cultural communication	Use storytelling to convey information	3.1 Community Art: Circle of Viewpoints	Gay (2002); Jenkins (2020); Sowerwine et al. (2019)
		3.1 Community Art: Journey of X Mural	
		3.1 Community Art: PSAs	
		3.2 Civic Engagement and Communication: Public Presentation of Art & Civic Action	
	Convey cultural traditions using hands-on activities	1.1 Waste & Plastics: Waste Audit	Sowerwine et al. (2019)

(Continued)

TABLE 1 (Continued)

Culturally responsive teaching (CRT) tenet	Applications to environmental education (EE) strategies	Activity in Duke University Marine Lab (DUML) Marine Debris Curriculum	Citation
		1.1 Waste & Plastics: How Long 'til it's Gone?	
		1.2 STEM: Physics of Marine Debris Movement	
		1.2 STEM: Marine Debris Entanglement	
		2.1 Waterway Clean-up: Collect & Quantify Marine Debris	
		2.1 Waterway Clean-up: Data Analysis & Quantification	
		3.1 Community Art: Marine Debris Mosaic	
		3.1 Community Art: PSAs	
		3.2 Civic Engagement & Communication: Public Presentation of Art & Civic Action	
	Use art to build cultural understanding and share community stories	3.1 Community Art: Marine Debris Mosaic	Del Campo et al. (2016); Sowerwine et al. (2019)
		3.1 Community Art: Marine Debris Poetry	
		3.1 Community Art: Circle of Viewpoints	
		3.1 Community Art: Journey of X Mural	
		3.1 Community Art: PSAs	
Cultural congruity in delivery of information	Storytelling teaching style		Gay (2002); Jenkins (2020)
	Communicative learning		D'Amato and Krasny (2011)

and some working in teacher-pairs, of which 5 total classrooms were represented (control: $n = 0$; treatment: $n = 41$; Table 2). Most teachers were associated with a single class of elementary children (average class size = 18–20), but 4 participating teachers taught entire grade levels as science or other specialists, some teaching as many as 256 children per year. We provided teachers with survey links and an administration protocol, which they followed during class time. Treatment teachers administered surveys prior to (pre-tests) and after (post-tests) implementing the marine debris curriculum. Control teachers administered surveys on a similar timeline.

3. Analysis

To generate composite scores for behavior, we added each item-level score. The marine debris frequency behavior questions for children ranged from *Never* (1) to *Every chance I get* (5) with a range of composite scores from 5 to 40, where a score of 5 would indicate that the child never completed any marine debris behaviors and a score of 40 would indicate that they completed all eight of the marine debris behaviors every chance they got. To test our hypotheses, we used sequential multiple linear regression to model changes in student marine debris behavior as a function of the pre-test behavior scores (to control for ceiling effect: Theobald and Freeman, 2014), membership in the treatment group, and linguistic diversity in model 1 (hypothesis 1) and added an interaction between linguistic diversity and membership in the treatment group in model 2 (hypothesis 2). To account for the possibility that students from the same classroom may have responded similarly to the treatment intervention, we allowed the intercepts for the respective student-groups to vary, i.e., we included a "random intercept" term in the respective models. The possibility that teachers participating in multiple years of the study may have provided a different level of intervention to students was controlled for by a fixed-effect variable for the year of course delivery. That variable noting the year of data collection was important in the context of the emergence of COVID-19, which may have influenced student survey responses on many levels. All data analyses were conducted using STATA 14.2.

Although the initial study design was a multi-level clustered data analysis using ordinary least squares (OLS), we also opted to address concerns of unbalanced clusters using a Bayesian ANCOVA (Dettweiler et al., 2017; Rouder et al., 2017) using JASP, an open-source statistical software specializing in Bayesian statistics (JASP Team, 2022). As results from the Bayesian ANCOVA were consistent with findings from the regression, we chose to report the regression findings; Bayesian results can be found in the Supplemental information.

4. Results

Student behavior scores ranged from 8 to 38 (out of possible 5–40) on the pre-test and 8–40 on the post-test. Mean pre-test

TABLE 2 Number of students associated with teachers across years and treatment groups (total teachers=35; total students=644; total control students=204; total treatment students=440). Several teachers participated for multiple years, with some switching from control to treatment groups in year two.

	Year 1		Year 2	
Teacher code	Control	Treatment	Control	Treatment
1	2			
2	9			
3	12			2
4	15			11
5	18			
6	22			
7	27			1
8			1	
9			1	
10			7	
11			9	
12			12	
13			17	
14			43	
15		11		
16		12		7
17		15		
18		15		
19		17		1
20		21		
21		24		7
22		32		
23		37		
24		41		1
25				1
26				1
27				3
28				4
29				5
30				6
31				9
32				13
33				18
34				27
35				62
Total	105	225	90	179

scores were 23.49 (SD = 5.66) and mean post-test scores were 24.92 (SD = 5.79). The pre-test mean was 23.2 (SD = 5.48) among students whose primary language was English and 21.89 (SD = 4.24) among linguistically diverse students in the control group, and 23.8 (5.77) and 23.0 (5.94) in the treatment group, respectively. On the post-test, students whose primary language was English scored an average of 24.3 (SD = 5.96), while linguistically diverse students scored 22.4 (SD = 5.96) in the control group, and 25.2 (SD = 5.61) and 26.4 (SD = 5.41) in the treatment group, respectively (Figures 1, 2).

Table 3 displays regression results, which controlled for the timing of the COVID-19 pandemic as well as the nested sampling

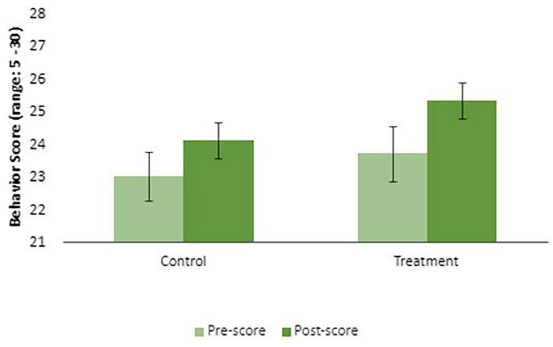

FIGURE 1
Pre versus post-test behaviour scores for student in the control (*n*=201) and treatment (*n*=422) groups. Error bars represent a 95% confidence interval.

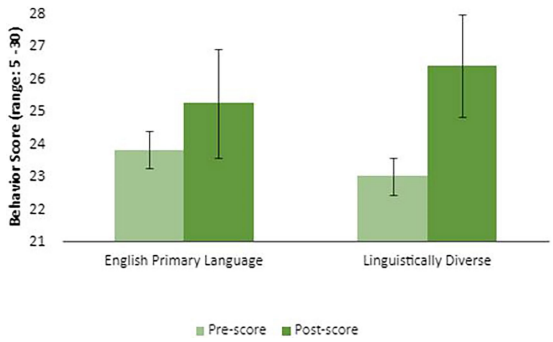

FIGURE 2
Pre versus post-test behaviour scores for student in the treatment group who responded that English was their primary language (*n*=366) and linguistically diverse students (*n*=46). Error bars represent a 95% confidence interval.

design, supported both hypotheses. In model 1, membership in the treatment group, compared to the control group, significantly predicted changes in behavior scores ($B = 0.943$, $p = 0.030$). In model 2, which included an interaction term between treatment group membership and linguistically diverse students, the main effect of the treatment group was not significantly related to changes in behavior, but the interaction term was ($B = 3.05$, $p = 0.036$;). Neither random effects nor treatment year were significant in either model. Given the considerable attrition between the pre- and post-surveys, we examined differences between the sample used in this paper ($n = 644$) and the full dataset of pre-test surveys ($n = 2{,}201$). We found no differences in pre-test behavior scores (full dataset mean = 23.1, SD = 6.0; sample for this paper mean = 23.49, SD = 5.67; $t = 1.507$, $p = 0.132$) or linguistic diversity (full dataset mean = 0.13, SD = 0.34; sample for this paper mean = 0.11, SD = 0.31; $t = 0.0437$ $p = 0.973$). As surveys were given during class time, attrition was likely attributed to teacher attributes (e.g., the onset of the COVID-19 pandemic in year 1, a lack of instructional time to complete the curriculum, etc.), rather than those of students.

5. Discussion

Our results indicate that the marine debris curriculum effectively encouraged pro-environmental behaviors for all students on average, but particularly among linguistically diverse students, adding to growing examples of the equigenic effects of environmental and nature-based education (Kuo et al., 2019; Faber Taylor et al., 2022). For example, nature-based or EE experiences often particularly benefit youth that can fall behind in mainstream educational context – such as among students with ADD (Taylor et al., 2001); students with other emotional, cognitive, or behavioral disabilities (Szczytko et al., 2018); uninterested students (Dettweiler et al., 2015); low-achieving students (Camasso and Jagannathan, 2018); or girls in science (Stevenson et al., 2021). In this study, the marine debris program designed to support student-led investigations of marine debris and associated action (DeMattia et al., 2020) supported development of marine debris behaviors, as has been found similarly in dozens of other studies in which EE promotes behavior change (Heimlich and Ardoin, 2008; Stern et al., 2008; Monroe et al., 2013). Further, the marine debris curriculum seemed to resonate particularly with linguistically diverse students such that most of the treatment impacts were accounted for by students from linguistically diverse households, a population that has been shown to fall behind their peers whose first language is English (Kanno and Kangas, 2014). These findings not only support our hypotheses but add to the growing evidence that EE may benefit all students in aggregate, but may provide particular support to specific groups of students who are typically underserved by mainstream educational structures and strategies (Camasso and Jagannathan, 2018; McCree et al., 2018; Sivarajah et al., 2018; Szczytko et al., 2018).

The culturally-responsive pedagogical strategies in the marine debris curriculum may explain why participation impacted linguistically diverse students more than their peers. To a large degree, professional guidelines for EE programming align with culturally responsive teaching methodologies (Burgess, 2019; Pownall, 2022). For instance, both emphasize student-centered approaches and learning within the context of culture (Burgess, 2019). In addition, IGL approaches emphasized in this curriculum may particularly align with culturally responsive approaches, as conversations with parents may promote agency (Blanchet-Cohen and Reilly, 2017) and may facilitate learning within the context of culture, shaping the curriculum to cultural contexts of families, and including the perspectives of parents (Pascal and Bertram, 2021). Because linguistically diverse learners including those in the Latinx community often have strong family structures (Fuligni et al., 1999), this IGL approach may be an example of how an asset-oriented perspective, wherein approaches intentionally draw on the diverse forms of experiences and expertise of learners (Lee, 2021), produces benefits for learners. Research on asset-oriented perspectives purports that within any given community, there exist individuals with diverse forms of expertise that are rooted in their unique social positions. That line of research supports explanations for our findings that perhaps the contributions of the linguistically diverse students' own expertise combined with their

TABLE 3 Changes in marine debris behavior as predicted by behavior pre-test scores, treatment group membership, linguistic diversity, and year of participation. Model 1 displays treatment effects for the entire sample, and model 2 includes an interaction term to detect differential treatment effects among linguistically diverse students.

Variable	Changes in marine debris behaviors											
	Model 1						Model 2					
	B	*β*	SE	*p*	*95% CI*		*B*	*β*	SE	*p*	*95% CI*	
Pre-curriculum behavior levels	−0.491***	−0.484	0.036	<0.001	−0.562	−0.420	−0.491***	<0.001	0.036	<0.001	−0.562	−0.420
Treatment	0.943*	0.077	0.433	0.030	0.094	1.792	0.645	0.156	0.455	0.156	−0.247	1.536
Linguistically diverse students	0.903	0.048	0.659	0.171	−0.389	2.195	−1.273	0.300	1.228	0.300	−3.681	1.134
Year	−0.632	−0.055	0.409	0.122	−1.434	0.169	−0.64	0.116	0.408	0.116	−1.440	0.159
Linguistically diverse * treatment	n/a			n/a	n/a	n/a	3.046*	0.036	1.452	0.036	0.120	5.892
Intercept	13.236***						13.446***					
N	607						607					
R^2	0.253						0.259					
Sigma	4.902						4.896					

Coding for all variables was as follows: Treatment students: 1 = Treatment; 0 = Control; Linguistically diverse students: 0 = non-linguistically diverse students, 1 = linguistically diverse students; Year: 0 = 2018–2019, 1 = 2019–2020. B = unstandardized; β = standardized. ***$p < 0.001$; **$p < 0.01$; *$p < 0.05$.

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unique social positions both in their classrooms and at home could have contributed to their increase in behavior change in the context of complex social-ecological problems. Though future research should investigate whether this asset-based explanation is consistent with the perspectives and experiences of students, our results suggest that IGL approaches may hold promise for ensuring EE programs are adaptable to a diversity of cultures.

Discovering consistent treatment effects between year one and two was somewhat surprising, given the COVID-19 pandemic emerged between the years. Though not part of our study hypotheses, we might have expected lower treatment effects in year two (during the pandemic) than year one on average, but particularly among linguistically diverse students. The COVID-19 impacts, including job loss, mental health, and physical health outcomes, as well as lower academic achievement among students, were more acutely felt in minoritized populations, including Latinx communities (Noe-Bustamante et al., 2021). Research suggests that people have finite pools of worry, or a limited capacity for worrying about issues (Weber, 2006; Shome and Marx, 2009), and that underrepresented groups were burdened more so by worries and struggles during COVID-19 than majority groups (Noe-Bustamante et al., 2021). As our sample included 10.5% of students speaking a language other than English at home, including 7% of students speaking Spanish at home, we might have expected lower levels of student engagement in year two. However, our results found that young people from linguistically diverse households saw the capacity for more behavior change over both years. These results call for additional investigations into the social emotional resilience of youth from these groups and their capacity for empowerment to engage in action despite, or in response to, hardships. This possibility is certainly consistent with environmental activism among minoritized groups, including the founders of environmental justice movements, who have argued for environmental change as a way to move toward the liberation of all people (Thomas, 2022).

Our study adds to others demonstrating that EE can contribute to behavior change among young learners by highlighting how linguistically diverse learners may benefit as participants in EE. Though the outcomes of interest within EE are diverse (e.g., connection to nature, social capital, environmental knowledge: Krasny, 2020), many frameworks understand these outcomes as precursors to individual (Hollweg et al., 2011) or collective (Ardoin et al., 2022) behavior change. This is not the first evaluative EE study to find that EE contributes to behavior change (Camp and Fraser, 2012; Ardoin and Heimlich, 2021), so our results are maybe not surprising, but are encouraging in terms of achieving the goals of EE. Perhaps more significantly, our results suggest that linguistically diverse learners may be a particularly receptive audience to EE programming. In this way, linguistically diverse learners are a key audience that deserve more attention in EE programming and EE research not only because of the changing demographics of the world and EE's commitment to serving and benefiting all learners (Stapleton, 2020), but also because linguistically diverse learners may be an audience that can help accelerate the goal of environmentally literate individuals and communities. As other studies have shown in similar contexts with young people (Lawson et al., 2019; Hartley et al., 2021), this possibility has the potential to be even more significant when considering EE can be more effective when multiple generations participate in EE programming together.

6. Limitations

Generalizability of this research study's reported findings should be approached with caution due primarily to the small clusters and unbalanced sample sizes within this study. Educational research studies that report outcomes associated with an educational intervention frequently contain contextual variability among different classes, teachers, and classroom settings, which cannot be perfectly controlled, and therefore not perfectly replicable in future studies (Dettweiler et al., 2017). We tried to address this critique on educational research design studies by controlling for teacher clusters within the analysis and introducing a random intercept term in respective models.

7. Conclusion

Our study represents one of a small handful of EE studies that focus specifically on linguistically diverse students (Tangen and Fielding-Barnsley, 2007), and the first United States-specific study of which we are aware. Results in this study found that students who engaged in the marine debris curriculum experienced significant changes in their pro-environmental behavior scores as compared with a control group. Moreover, these treatment effects were particularly pronounced, and mostly explained by, the linguistically diverse learners within the treatment sample. Though many EE studies have provided examples of how EE programming can promote pro-environmental behavior change, this is the first of which we are aware that is specific to linguistically diverse learners. In the context of current research looking to support culturally relevant practice, including emerging research on asset-based educational pedagogy, this study suggests that EE teachers, practitioners, researchers, and programming managers should consider how to more meaningfully engage linguistically diverse learners in their EE programs, and how those learners may benefit from their engagement in those programs. Future research should continue to include this group for several reasons. First, as the globe becomes more connected, linguistic diversity will become more important for accomplishing culturally responsive EE programming. Secondly, linguistically diverse learners may have unique assets culturally and within their families that create contexts in which they are primed to both strongly benefit from engagement with environmental content and subsequently become engaged in environmental action. Third, there remain many more questions to be answered. For example, studies with larger sample sizes (i.e., more statistical power) may detect nuances among different populations of diverse learners, and qualitative studies may uncover the mechanisms driving equigenic effects on environmental

behaviors detected in this study. Similarly, though we measured behavior change among students, their responses were self-reported, and focused on individual-level behaviors. Future research could examine the persistence and duration of treatment effects, whether the efficacy of this type of programming may spillover into more collective behaviors, and whether observed behaviors operate similarly to self-reported behaviors. This study is a start on a key and growing area of research aimed at understanding not only how EE can better include diverse groups, but more importantly, how mainstream EE can learn from diverse communities to strengthen efforts towards building environmental literacy in support of people and the planet.

Author's note

The authors of this paper recognize that we are all highly educated, all trained in the Eurocentric, colonial norms present in the academy, and all work at large research institutions within the United States. As such, we want to call attention to the fact that findings presented in this paper may already be known among grassroots, community-driven, and informal circles that are many times not included in academic publications such as this one. Therefore, the authors ask the reader to keep in mind that although our publication may be one of the first of its kind within a United States-centric academic context, that it is possible and likely that findings such as the ones presented here may already be extant within other geographic locations, realms of knowing, and/or gray literature that do not automatically prioritize privileged and traditionally trained academic voices.

Data availability statement

The datasets presented in this article are not readily available because de-identified data supporting the conclusions of this article can only be made available by the authors when consistent with IRB regulations. Interested parties should contact the corresponding author. Requests to access the datasets should be directed to Jenna Hartley, jennamh@unc.edu.

Ethics statement

The studies involving human participants were reviewed and approved by the North Carolina State University Institutional Review Board (IRB# 12847). Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

KS, DL, and MP contributed to study design. JH was responsible for data collection, data preparation, and preliminary analysis with assistance from BM on data preparation. JH and SP were responsible for the initial drafting of the manuscript, with assistance from KS and MP. KS supported with the secondary analysis. DL, MP, and KS edited the manuscript. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/feduc.2022.1058864/abstract#supplementary-material

References

Aguilar, O. M., Liddicoat, K. R., and McCann, E. (2017). "Inclusive education" in *Urban Environmental Education Review*. eds. A. Russ and M. E. Krasny (Cornell University Press), 194–201.

Agyeman, J. (2002). Culturing Environmental Education: From First Nation to Frustration. *Canadian Journal of Environmental Education (CJEE)* 7, 5–12.

Ardoin, N. M., Bowers, A. W., and Gaillard, E. (2020). Environmental education outcomes for conservation: a systematic review. *Biol. Conserv.* 241:108224. doi: 10.1016/j.biocon.2019.108224

Ardoin, N. M., Bowers, A. W., and Wheaton, M. (2022). Leveraging collective action and environmental literacy to address complex sustainability challenges. *Ambio* 52, 30–44. doi: 10.1007/s13280-022-01764-6

Ardoin, N. M., and Heimlich, J. E. (2021). Environmental learning in everyday life: foundations of meaning and a context for change. *Environ. Educ. Res.* 27, 1681–1699. doi: 10.1080/13504622.2021.1992354

Arreguín-Anderson, M. G., and Kennedy, K. D. (2013). Deliberate language planning in environmental education: a CRT/LatCrit perspective. *J. Environ. Educ.* 44, 1–15. doi: 10.1080/00958964.2012.665098

Baquedano-López, P., Alexander, R. A., and Hernandez, S. J. (2013). Equity issues in parental and community involvement in schools: what teacher educators need to know. *Rev. Res. Educ.* 37, 149–182. doi: 10.3102/0091732X12459718

Bernal, D. D. (2001). Learning and living pedagogies of the home: the mestiza consciousness of Chicana students. *Int. J. Qual. Stud. Educ.* 14, 623–639. doi: 10.1080/09518390110059838

Binning, K. R., Kaufmann, N., McGreevy, E. M., Fotuhi, O., Chen, S., Marshman, E., et al. (2020). Changing social contexts to Foster equity in college science courses: an ecological-belonging intervention. *Psychol. Sci.* 31, 1059–1070. doi: 10.1177/0956797620929984

Blanchet-Cohen, N., and Reilly, R. C. (2017). Immigrant children promoting environmental care: enhancing learning, agency and integration through culturally-responsive environmental education. *Environ. Educ. Res.* 23, 553–572. doi: 10.1080/13504622.2016.1153046

Borman, G. D., Rozek, C. S., Pyne, J., and Hanselman, P. (2019). Reappraising academic and social adversity improves middle school students' academic achievement, behavior, and well-being. *Proc. Natl. Acad. Sci.* 116, 16286–16291. doi: 10.1073/pnas.1820317116

Braun, S. M. (2019). *Outdoor School for all: Diverse Programming and Outcomes in Oregon: 2018 Pilot Study Evaluation.* Grey Family Foundation.

Burgess, D. J. (2019). Culturally responsive teaching that bridges indoor and outdoor settings. *Second. Educ.* 10

Camasso, M. J., and Jagannathan, R. (2018). Nurture thru nature: creating natural science identities in populations of disadvantaged children through community education partnership. *J. Environ. Educ.* 49, 30–42. doi: 10.1080/00958964.2017.1357524

Camp, E., and Fraser, D. (2012). Influence of conservation education dive briefings as a management tool on the timing and nature of recreational SCUBA diving impacts on coral reefs. *Ocean Coastal Manag.* 61, 30–37. doi: 10.1016/j.ocecoaman.2012.02.002

Chandler, D. (2007). *Semiotics: The Basics. 2nd* Edn Routledge.

Chineka, R., and Yasukawa, K. (2020). Intergenerational learning in climate change adaptations; limitations and affordances. *Environ. Educ. Res.* 26, 577–593. doi: 10.1080/13504622.2020.1733494

Clark, K., Pender, D., Peterson, M. N., Stevenson, K. T., Lawson, D., and Szczytko, R. (2020). Reaching underserved populations through a fisheries education program. *Fisheries* 45, 131–137. doi: 10.1002/fsh.10390

Comrey, A. L., and Lee, H. B. (2009). "Confidence intervals for means and tests on correlations" in *Elementary Statistics: A Problem Solving Approach. 4th* ed (Morrisville, NC: Lulu), 103–112.

Craig, C. A., and Allen, M. W. (2015). The impact of curriculum-based learning on environmental literacy and energy consumption with implications for policy. *Util. Policy* 35, 41–49. doi: 10.1016/j.jup.2015.06.011

Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika* 16, 297–334. doi: 10.1007/BF02310555

D'Amato, L. G., and Krasny, M. E. (2011). Outdoor adventure education: Applying transformative learning theory to understanding instrumental learning and personal growth in environmental education. *J. Environ. Educ.* 42, 237–254. doi: 10.1080/00958964.2011.581313

Del Campo, M. L., Purcell, K. A., and Marcos-Iga, J. (2016). *Environmental education in Latino communities: Sharing experiences*. Available at: https://celebrateurbanbirds.org/wpcontent/uploads/2017/07/Environmental-Education-in-Latino-Communities_SharingExperiences.pdf

DeMattia, E. A., Quattrone, C., and Harshbarger, A. (2020). DUML Marine Debris Curriculum: Community Science for 4th/5th Grade. Available at: https://sites.duke.edu/communityscience/files/2020/06/DUML-Marine-Debris-Curriculum2020.pdf

Desimone, L. M., and Le Floch, K. C. (2004). Are we asking the right questions? Using cognitive interviews to improve surveys in education research. *Educ. Eval. Policy Anal.* 26, 1–22. doi: 10.3102/01623737026001001

Dettweiler, U., Lauterbach, G., Becker, C., and Simon, P. (2017). A Bayesian mixed-methods analysis of basic psychological needs satisfaction through outdoor learning and its influence on motivational behavior in science class. *Front. Psychol.* 8:2235. doi: 10.3389/fpsyg.2017.02235

Dettweiler, U., Ünlü, A., Lauterbach, G., Becker, C., and Gschrey, B. (2015). Investigating the motivational behavior of pupils during outdoor science teaching within self-determination theory. *Front. Psychol.* 6:125. doi: 10.3389/fpsyg.2015.00125

Ericson, J. E., and Gonzalez, E. J. (2003). Hierarchical Sampling of Multiple Strata: An Innovative Technique in Exposure Characterization.

Faber Taylor, A., Butts-Wilmsmeyer, C., and Jordan, C. (2022). Nature-based instruction for science learning – a good fit for all: a controlled comparison of classroom versus nature. *Environ. Educ. Res.* 28, 1527–1546. doi: 10.1080/13504622.2022.2076811

Fien, J. (2003). Learning to care: Education and compassion. *Australian J. Environ. Educ.* 19, 1–13.

Flores, D., and Kuhn, K. (2018). Latino outdoors: using storytelling and social media to increase diversity on public lands. *J. Park. Recreat. Adm.* 36, 47–62. doi: 10.18666/JPRA-2018-V36-I3-7868

Forrester, J. W. (2009). Some Basic Concepts in System Dynamics. Sloan School of Management, Massachusetts Institute of Technology.

Fuligni, A. J., Tseng, V., and Lam, M. (1999). Attitudes toward family obligations among American adolescents with Asian, Latin American, and European backgrounds. *Child Dev.* 70, 1030–1044. doi: 10.1111/1467-8624.00075

Gay, G. (2002). Preparing for culturally responsive teaching. *J. Teacher Educ.* 53, 106–116. doi: 10.1177/0022487102053002003

Gay, G. (2018). *Culturally Responsive Teaching: Theory, Research, and Practice. 2nd* Edn Teachers College.

Genesee, F., Lindholm-Leary, K., Saunders, W., and Christian, D. (2005). English language learners in U.S. schools: an overview of research findings. *J. Educ. Stud. Placed Risk* 10, 363–385. doi: 10.1207/s15327671espr1004_2

Gray, D. L., Harris-Thomas, B., Ali, J. N., Cummings, T. N., McElveen, T. L., and Jones, T. R. (2022). Urban middle Schoolers' opportunities to belong predict fluctuations in their engagement across the school day. *Urban Educ.* 00420859221117682:004208592211176. doi: 10.1177/00420859221117682

Green 2.0. (2020). 2020 NGO & Foundation Transparency Report Card. Green 2.0. Available at: https://live-green-2.pantheonsite.io/transparency-cards/2020-ngo-foundation-report/

Haluza-DeLay, R. (2013). "Educating for environmental justice" in *International Handbook on Environmental Education Research*. eds. M. Brody, J. Dillon, R. Stevenson and A. Wals (Routledge), 394–402.

Hartley, J. M., Stevenson, K. T., Peterson, M. N., DeMattia, E. A., Paliotti, S., and Fairbairn, T. J. (2021). Youth can promote marine debris concern and policy support among local voters and political officials. *Front. Polit. Sci.* 3. doi: 10.3389/fpos.2021.662886

Haynes, K., and Tanner, T. M. (2015). Empowering young people and strengthening resilience: youth-centred participatory video as a tool for climate change adaptation and disaster risk reduction. *Child. Geogr.* 13, 357–371. doi: 10.1080/14733285.2013.848599

Heimlich, J. E., and Ardoin, N. M. (2008). Understanding behavior to understand behavior change: a literature review. *Environ. Educ. Res.* 14, 215–237. doi: 10.1080/13504620802148881

Hollweg, K. S., Taylor, J. R., Bybee, R. W., Marcinkowski, T. J., McBeth, W. C., and Zoido, P. (2011). *Developing a Framework for Assessing Environmental Literacy.* North American Association of Environmental Education, 122.

JASP Team (2022). JASP (Version 0.16.3) [Computer Software].

Jenkins, Z. S. (2020) *Is Essential in the Fight for Social Justice. National Geographic Education Blog*. Available at: https://blog.education.nationalgeographic.org/2020/10/27/storytelling-is-essential-in-the-fight-for-social-justice/ (Accessed December 9, 2020).

Kanno, Y., and Kangas, S. E. N. (2014). "I'm not going to be, like, for the AP": English language learners' limited access to advanced college-preparatory courses in high school. *Am. Educ. Res. J.* 51, 848–878. doi: 10.3102/0002831214544716

Krasny, M. E. (2020). *Advancing Environmental Education Practice*. Ithaca, NY: Comstock Publishing Associates, an imprint of Cornell University Press.

Kuo, M., Barnes, M., and Jordan, C. (2019). Do experiences with nature promote learning? Converging evidence of a cause-and-effect relationship. *Front. Psychol.* 10:305. doi: 10.3389/fpsyg.2019.00305

Lam, K., and Richards, E. (2020). *More US Schools Teach in English and Spanish, But Not Enough to Help Latino Kids* USA Today.

Larson, L. R., Whiting, J. W., and Green, G. T. (2011). Exploring the influence of outdoor recreation participation on pro-environmental behaviour in a demographically diverse population. *Local Environ.* 16, 67–86. doi: 10.1080/13549839.2010.548373

Latino Outdoors. (2021). Latino Outdoors. Available at: https://latinooutdoors.org/

Lawson, D. F., Stevenson, K. T., Peterson, M. N., Carrier, S. J., Seekamp, E., and Strnad, R. (2019). Evaluating climate change behaviors and concern in the family context. *Environ. Educ. Res.* 25, 678–690. doi: 10.1080/13504622.2018.1564248

Lawson, D. F., Stevenson, K. T., Peterson, M. N., Carrier, S. J., Strnad, R. L., and Seekamp, E. (2019). Children can foster climate change concern among their parents. *Nat. Clim. Chang.* 9, 458–462. doi: 10.1038/s41558-019-0463-3

Lee, O. (2021). Asset-oriented framing of science and language learning with multilingual learners. *J. Res. Sci. Teach.* 58, 1073–1079. doi: 10.1002/tea.21694

LGBT Outdoors (2022). LGBT Outdoors. Available at: https://www.lgbtoutdoors.com

Matthews, J. S., and López, F. (2020). Race-reimaging educational psychology research: investigating constructs through the lens of race and culture. *Contemp. Educ. Psychol.* 61:101878. doi: 10.1016/j.cedpsych.2020.101878

McCree, M., Cutting, R., and Sherwin, D. (2018). The hare and the tortoise go to Forest School: taking the scenic route to academic attainment via emotional wellbeing outdoors. *Early Child Dev. Care* 188, 980–996. doi: 10.1080/03004430.2018.1446430

Monroe, M. C., Agrawal, S., Jakes, P. J., Kruger, L. E., Nelson, K. C., and Sturtevant, V. (2013). Identifying indicators of behavior change: insights from wildfire education programs. *J. Environ. Educ.* 44, 180–194. doi: 10.1080/00958964.2012.746277

Munez, J. (2019). *Culturally Responsive Teaching*. New America.

Murphy, M. C., Kroeper, K. M., and Ozier, E. M. (2018). Prejudiced places: how contexts shape inequality and how policy can change them. *Policy Insights Behav. Brain Sci.* 5, 66–74. doi: 10.1177/2372732217748671

Noe-Bustamante, L., Krogstad, J. M., and Lopez, M. H. (2021). *For U.S. Latinos, COVID-19 Has Taken a Personal and Financial Toll* Pew Research Center Race & Ethnicity.

Outdoor Afro (2022). *Outdoor Afro*. Available at: https://outdoorafro.org.

Park, J. S., Weismer, S. E., and Kaushanskaya, M. (2018). Changes in executive function over time in bilingual and monolingual school-aged children. *Dev. Psychol.* 54, 1842–1853. doi: 10.1037/dev0000562

Parth, S., Schickl, M., Keller, L., and Stoetter, J. (2020). Quality child–parent relationships and their impact on intergenerational learning and multiplier effects in climate change education. Are we bridging the knowledge–action gap? *Sustainability* 12:7030. doi: 10.3390/su12177030

Pascal, C., and Bertram, T. (2021). What do young children have to say? Recognising their voices, wisdom, agency and need for companionship during the COVID pandemic. *European Early Childhood Educ. Res. J.* 29, 21–34.

Pease, J. L. (2015). Parks and underserved audiences: An annotated literature review. *J. Interpretation Res.* 20, 11–56. doi: 10.1177/109258721502000103

Pownall, M. A. (2022). *Exploring Culturally Responsive Teaching and Environmental Education* Virginia Tech University.

Rios-Aguilar, C., and Kiyama, J. M. (2012). Funds of knowledge: an approach to studying Latina(o) students' transition to college. *J. Latinos Educ.* 11, 2–16. doi: 10.1080/15348431.2012.631430

Rodrigues, C., and Lowan-Trudeau, G. (2021). Global politics of the COVID-19 pandemic, and other current issues of environmental justice. *J. Environ. Educ.* 52, 293–302. doi: 10.1080/00958964.2021.1983504

Rouder, J. N., Morey, R. D., Verhagen, J., Swagman, A. R., and Wagenmakers, E. J. (2017). Bayesian analysis of factorial designs. *Psychol. Methods* 22, 304–321. doi: 10.1037/met0000057

Sandoval, W. (2014). Conjecture mapping: an approach to systematic educational design research. *J. Learn. Sci.* 23, 18–36. doi: 10.1080/10508406.2013.778204

Schindel, A., and Tolbert, S. (2017). Critical caring for people and place. *J. Environ. Educ.* 48, 26–34. doi: 10.1080/00958964.2016.1249326

Shannon, C. E., and Weaver, W. (1949). *The mathematical Theory of Communication* University of Illinois Press, vi, 117.

Shome, D., and Marx, S. M. (2009). *The Psychology of Climate Change Communication: A Guide for Scientists, Journalists, Educators, Political Aides, and the Interested Public*. Center for Research on Environmental Decisions.

Simon, N. (2016). The art of relevance. *Santa Cruz, CA: Museum* 2.0.

Sivarajah, S., Smith, S. M., and Thomas, S. C. (2018). Tree cover and species composition effects on academic performance of primary school students. *PLoS One* 13:e0193254. doi: 10.1371/journal.pone.0193254

Sleeter, C. (2012). Confronting the marginalization of culturally responsive pedagogy. *Urban Educ.* 47, 562–584. doi: 10.1177/0042085911431472

Sowerwine, J., Sarna-Wojcicki, D., Mucioki, M., Hillman, L., Lake, F. K., and Friedman, E. (2019). Enhancing Indigenous food sovereignty: A five-year collaborative tribaluniversity research and extension project in California and Oregon. *J. Agr. Food Syst. Community Develop.* 1-24. doi: 10.5304/jafscd.2019.09B.013

Stapleton, S. R. (2020). Toward critical environmental education: a standpoint analysis of race in the American environmental context. *Environ. Educ. Res.* 26, 155–170. doi: 10.1080/13504622.2019.1648768

Stern, M. J., Powell, R. B., and Ardoin, N. M. (2008). What difference does it make? Assessing outcomes from participation in a residential environmental education program. *J. Environ. Educ.* 39, 31–43. doi: 10.3200/JOEE.39.4.31-43

Stern, M. J., Powell, R. B., and Ardoin, N. M. (2010). Evaluating a constructivist and culturally responsive approach to environmental education for diverse audiences. *J. Environ. Educ.* 42, 109–122. doi: 10.1080/00958961003796849

Stevenson, K. T., and Peterson, N. (2015). Motivating action through fostering climate change Hope and concern and avoiding despair among adolescents. *Sustainability* 8:6. doi: 10.3390/su8010006

Stevenson, K. T., Peterson, M. N., Bondell, H. D., Mertig, A. G., and Moore, S. E. (2013). Environmental, institutional, and demographic predictors of environmental literacy among middle school children. *PLoS One* 8:e59519. doi: 10.1371/journal.pone.0059519

Stevenson, K. T., Szczytko, R. E., Carrier, S. J., and Peterson, M. N. (2021). How outdoor science education can help girls stay engaged with science. *Int. J. Sci. Educ.* 43, 1090–1111. doi: 10.1080/09500693.2021.1900948

Szczytko, R., Carrier, S. J., and Stevenson, K. T. (2018). Impacts of outdoor environmental education on teacher reports of attention, behavior, and learning outcomes for students with emotional, cognitive, and behavioral disabilities. *Front. Educ.* 3:46. doi: 10.3389/feduc.2018.00046

Szczytko, R., Stevenson, K. T., Peterson, M. N., and Bondell, H. (2020). How combinations of recreational activities predict connection to nature among youth. *J. Environ. Educ.* 51, 462–476. doi: 10.1080/00958964.2020.1787313

Tangen, D., and Fielding-Barnsley, R. (2007). Environmental education in a culturally diverse school. *Aust. J. Environ. Educ.* 23, 23–30. doi: 10.1017/S0814062600000689

Taylor, A. F., Kuo, F. E., and Sullivan, W. C. (2001). Coping with add: the surprising connection to Green play settings. *Environ. Behav.* 33, 54–77. doi: 10.1177/00139160121972864

Tbilisi Declaration. (1977). (Intergovernmental Conference on Environmental Education). UNESCO. Available at: https://www.gdrc.org/uem/ee/Tbilisi-Declaration.pdf

Theobald, R., and Freeman, S. (2014). Is it the intervention or the students? Using linear regression to control for student characteristics in undergraduate STEM education research. *CBE Life Sci. Educ.* 13, 41–48. doi: 10.1187/cbe-13-07-0136

Thomas, L. (2022). *The Intersectional Environmentalist How to Dismantle Systems of Oppression to Protect People + Planet*. New York: Voracious, Little, Brown, and Company.

Torres, H. R., Reynolds, C. J., Lewis, A., Muller-Karger, F., Alsharif, K., and Mastenbrook, K. (2019). Examining youth perceptions and social contexts of litter to improve marine debris environmental education. *Environ. Educ. Res.* 25, 1400–1415. doi: 10.1080/13504622.2019.1633274

Tuck, E., McKenzie, M., and McCoy, K. (2014). Land education: indigenous, post-colonial, and decolonizing perspectives on place and environmental education research. *Environ. Educ. Res.* 20, 1–23. doi: 10.1080/13504622.2013.877708

Vaquero, I. (2015). Latinos care about the environment. So why aren't green groups engaging them more? Ensia. https://ensia.com/articles/latinos-care-about-theenvironment-so-why-arent-green-groups-engaging-them-more/

Valdez, R. X., Peterson, M. N., and Stevenson, K. T. (2018). How communication with teachers, family and friends contributes to predicting climate change behaviour among adolescents. *Environ. Conserv.* 45, 183–191. doi: 10.1017/S0376892917000443

Walton, G. M., Logel, C., Peach, J. M., Spencer, S. J., and Zanna, M. P. (2015). Two brief interventions to mitigate a "chilly climate" transform women's experience, relationships, and achievement in engineering. *J. Educ. Psychol.* 107, 468–485. doi: 10.1037/a0037461

Weber, E. U. (2006). Experience-based and description-based perceptions of long-term risk: why global warming does not scare us (yet). *Clim. Chang.* 77, 103–120. doi: 10.1007/s10584-006-9060-3

Williams, C. C., and Chawla, L. (2016). Environmental identity formation in nonformal environmental education programs. *Environ. Educ. Res.* 22, 978–1001. doi: 10.1080/13504622.2015.1055553

Williams, C. L., Hirschi, Q., Sublett, K. V., Hulleman, C. S., and Wilson, T. D. (2020). A brief social belonging intervention improves academic outcomes for minoritized high school students. *Motiv. Sci.* 6, 423–437. doi: 10.1037/mot0000175

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Changes in social interaction, social relatedness, and friendships in Education Outside the Classroom: A social network analysis

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Introduction: Social interaction is associated with many effects on the psychological level of children such as mental health, self-esteem, and executive functions. Education Outside the Classroom (EOtC) describes regular curricular classes/lessons outside the school building, often in natural green and blue environments. Applied as a long-term school concept, EOtC has the potential to enable and promote social interaction. However, empirical studies on this topic have been somewhat scant.

Methods: One class in EOtC (N = 24) and one comparison class (N = 26) were examined in this study to explore those effects. *Statistical Actor-Oriented Models* and *Exponential Random Graph Models* were used to investigate whether there are differences between EOtC and comparison class regarding changes over time in social interaction parameters; whether a co-evolution between social interaction during lessons and breaks and attendant social relatedness and friendships exists; whether students of the same gender or place of residence interact particularly often (homophily).

Results: Besides inconsistent changes in social interaction parameters, no co-evolutional associations between social interaction and social relatedness and friendships could be determined, but grouping was evident in EOtC. Both classes showed pronounced gender homophily, which in the case of EOtC class contributes to a fragmentation of the network over time.

Discussion: The observed effects in EOtC could be due to previously observed tendencies of social exclusion as a result of a high degree of freedom of choices. It therefore seems essential that in future studies not only the quality of the study design and instruments should be included in the interpretation – rather, the underlying methodological-didactic concept should also be evaluated in detail. At least in Germany, it seems that there is still potential for developing holistic concepts with regards to EOtC in order to maximize the return on the primarily organizational investment of implementing EOtC in natural environments.

KEYWORDS

Education Outside the Classroom, social interaction, social relatedness, natural environments, social network analysis, children

1. Introduction

Social interaction and peer relations have been a central topic in social and developmental psychology for years (Hartup, 1999; Hay et al., 2018). From this perspective, the crucial role played by social factors in children's development should not be underestimated (Seppala et al., 2013). If the

social needs of children, such as having a sense of connection and building trust in relations with significant others, remain unsatisfied in the long term, this could lead to the development of mental disorders (Pachucki et al., 2015; McNamara et al., 2017). The importance of such skills is also emphasized with regard to 21st century skills (Chalkiadaki, 2018; Hirsh-Pasek et al., 2020; van Laar et al., 2020). Experiencing social situations that contain the potential to develop social skills in children's lives, is therefore of tremendous relevance (Hartup, 1989). School life can be seen as a social situation on both a macro (whole school community) and micro (situation in class) level (Sarason and Klaber, 1985; Ma, 2018). Social psychology pursues the task of looking at and analyzing the connections between social situations shaped by social interaction and individual characteristics, behavior or experiences (Baron et al., 2000). In this context, we understand social interactions to be an active process between individuals on an interpersonal level (Simmel, 2013). From this, according to Ryan and Deci (2017), the passive state of social relatedness (as one of the basic psychological needs assumed to be central for the individual), which alludes to a feeling of belonging, can result. Following this, social relatedness also expresses the perceived connection to other people and, thus, inclusion in a particular group. With that being largely based on a particular individual and non-standardized feeling, other aspects like the number of friends cover solely quantitative impressions of embeddedness in a certain group (Fullerton and Ursano, 1994). Both can be the result of previous social interaction as the core of a social situation, such as school life (Baron et al., 2000).

1.1. Research on social interaction in children

Social interaction is important to various aspects of children's life, such as well-being (Lee et al., 2020) and mental health (Li et al., 2020), self-esteem (Harris and Orth, 2020), learning outcomes (Hurst et al., 2013), and executive functions (Moriguchi, 2014). The school setting provides an extremely valuable platform for observing, analyzing, and affecting social interaction since it represents the most important place for social interaction among young people (McNamara et al., 2017; García-Carrión et al., 2019). Children and adolescents spend a great deal of time here. Additionally, the majority of children can be reached and have the opportunity to participate in certain programs regardless of their background. Furthermore, childhood seems to be particularly suitable for forming social bonds between peers (Gifford-Smith and Brownell, 2003). However, there continues to be a paucity of intervention studies that address all students equally, with the explicit goal of improving social interaction between the students with possible effects on social relatedness and friendships.

In childhood, one's own gender and the gender of peers in particular prove to be significant for socialization and friendships (Maccoby, 1988; Block and Grund, 2014). Confrontation with members of the same gender fulfills various important functions in the development of one's own (gender) identity [as does later confrontation with the other biological gender (depending on sexual orientation); Ridgeway and Smith-Lovin, 1999; Powlishta, 2004; Perry et al., 2019]. During late childhood and early adolescence, a strong tendency for girls to interact more with girls and for boys to interact more with boys is evident (Maccoby, 1988; Shrum et al., 1988). Apart from these tendencies, which are typical in the course of development, the school setting also provides additional opportunities to influence social interaction between students. This could include the creation of special meeting and social spaces in school, or the implementation of specific social activities. Also, entire teaching concepts could be used in order to influence social interaction. One of those is "Education Outside the Classroom" (EOtC).

1.2. Social interaction in Education Outside the Classroom

EOtC is a teaching concept that is – in line with the curriculum – regularly carried out in a natural or cultural environment. EOtC is often practiced for a duration of several consecutive months and up to whole years or more. In most studies, explicitly investigating EOtC, this concept has to be applied at least bi-weekly for four or more lessons. If EOtC is sustainably established at a school, it can enrich the daily school routine as an applicable long-term concept with manageable extra costs (Bentsen et al., 2009, 2021). EOtC lessons are said to be experimental, student-centered, and there is an increased use of group and partner work (Bentsen et al., 2021; Ellinger et al., 2022b). They lead to higher levels of physical activity (Schneller et al., 2017), especially if they are conducted in natural environments (Bølling et al., 2021), which is in part associated with a healthy pattern of cortisol secretion that indicates less stress over the course of the day (Becker et al., 2019). In addition, it can be assumed, that EOtC promotes intrinsic school motivation (Bølling et al., 2018; Ellinger et al., 2022a) and well-being of the students (Jørring et al., 2019).

Moreover, EOtC offers numerous ways of affecting students' social interaction. Even with regard to natural spaces in themselves, it is worthwhile to consider facets of social interaction from different perspectives (Waite et al., 2016; Torkos, 2017; Roberts et al., 2020). Independently of school lessons, it has occasionally been demonstrated that children's intensive engagement in and with nature in groups (e.g., free outdoor play, adventure therapy, seated relaxation, and orienteering) can improve several social aspects such as mutual trust, social cohesion, social functioning, relationship to peers, and cooperation (Doucette, 2004; Roe and Aspinall, 2011; McArdle et al., 2013; Mygind et al., 2019). The availability of natural spaces in the immediate living environment also seems to be able to influence social factors and consequently health (Faber Taylor et al., 1998; Sugiyama et al., 2008). These different and partly specific outcomes limit the comparability, but in sum, there is a clear tendency that both adults, but also children can benefit from group activities in and with nature with regard to their social skills (Mygind et al., 2019; Fyfe-Johnson et al., 2021). As EOtC often takes place in natural environments, these possible benefits of natural environments are combined with a special teaching situation, enabling substantial restructuring, simplification, and promoting cooperative group work, because rigid structures of traditional school teaching such as a fixed seating and desk arrangement are eliminated. Therefore, EOtC offers specific conditions that may help to improve social relations (e.g., play, interaction, student-centered tasks, and cooperation; Hartmeyer and Mygind, 2016; Glackin, 2018). This produces the result that the lessons often differ significantly from traditional indoor school lessons. Regarding social aspects, previous research has shown that EOtC could lead to more positive peer relations than traditional teaching concepts (Mygind, 2009) and to the development of new positive peer affiliations (Bølling et al., 2019), which could be explained by the character of EOtC (Fägerstam, 2014): In the indoor setting of the classroom, social contacts are often limited to the students sitting near to each other. Since the usual spatial forms of organization are largely absent in EOtC, it can be assumed that other ways of teaching and new social constellations are facilitated, as already shown in surveys regarding social forms in EOtC (Ellinger et al., 2022b), as well as opportunities for informal interaction are

created (Jørring et al., 2019). This could lead to intensified movement in space and its appropriation by the students, especially in group constellations – while teaching the same subject matter as during traditional indoor teaching (Mall et al., 2021). Additionally, it has been shown that curriculum-compliant teaching in natural settings can lead to comparatively increased (facets of) social relatedness (Dettweiler et al., 2017), which could be a result of those new or intensified opportunities for social interaction. Undoubtedly, however, there is still a great demand for further studies on this promising topic (Becker et al., 2017).

The central assumption of this study is that EOtC, due to its integration into natural environments, as well as the utterly changed teaching situation, enables not only the implementation of new forms of social interaction, but also more social interaction. This could be captured by the numerical number of classmates with whom a particular child interacts in the context of school or class. Change in social interaction in turn could have an impact on the experience of social relatedness and friendships. In the present study, we therefore aim to map social relatedness and the structure of friendships in addition to assessing social interaction in the class, which represents a novelty in EOtC. We pursue the approach of viewing these social constructs not as factors or mediators for other behaviors but as the main outcomes, which in this context is still rare. In summary, we hypothesize that the introduction of EOtC in natural environments could lead to intensification and restructuring of the network of social interaction in a school class, which is the main focus in this article. With that, also changes over time in social relatedness, as well as friendships seem reasonable. Furthermore, it seems possible that, due to the preference of same-gender interactions in children and adolescents (Maccoby, 1988; Shrum et al., 1988), gender can also influence their social interaction. This, in turn, is of scientific interest given the relevance of engagement with other genders for child development (Ridgeway and Smith-Lovin, 1999; Perry et al., 2019). Additionally, place of residence could also be relevant. This assumption is partly due to the special situation regarding many secondary schools in Germany: When children move from primary to secondary school, this often involves a change of location, as secondary schools are often located only in (larger) cities, so that children from rural areas have to be transported here. This means that children from different cities and villages come together in secondary school. We assume that children who, for example, move from the same village to the same secondary school at the same time have a closer connection because they share their way to school or they may have already been to elementary school together.

This study aims to investigate the following central hypothesis: (a) The students within a EOtC class show increases in social interaction over time, which go beyond those changes in a comparison class without EOtC. Additionally, this study explores the interrelations of those changes with other social factors. Therefore, two sub-hypotheses are set up: (b) There is a co-evolution of the changes of social interaction and social relatedness and friendships over time in both classes; (c) Gender and place of residence partly explain the positions of actors in the network in both classes.

2. Materials and methods

2.1. Intervention

In this study, a class with EOtC is compared to a class without EOtC. In the following, it is described how EOtC was implemented at the cooperating school and how the environment the EOtC took place at can be characterized. Please see also Table 1 for a detailed schedule of an exemplary EOtC-day.

Although the forest used for the EOtC is accessible from the city and the school within approximately 15–20 min walking distance, it can clearly be classified as a natural space or natural environment following consolidated definitions within the field of outdoor play, learn, and teach (Lee et al., 2022). On the fixed EOtC day during our study, the students and two teachers first met in the school building. There, attendance was checked and, if necessary, important instructions for the day were given. Then, the class set off on foot into the forest. Often the students talked among themselves or with the teachers or played little games on the way there. However, there were no organized activities along the way. After a few meters in the residential area, the path the class used was characterized by agricultural land and open meadows. Once in the forest, the class was divided to be taught initially for two school hours (90 min) in one subject and, after a change of groups, in a second subject (90 min) by the two accompanying teachers. In the case of this investigation, the subjects were German and Biology. The learning site visited in the case of this study is a forest with old trees and unstructured vegetation that, apart from the usual forest management, is left in its natural state. The lessons did not take place in a clearly defined outdoor classroom. Accordingly, there were no benches or a blackboard. The

TABLE 1 Schedule of an exemplary EOtC-day.

Schedule	Content	Environment
7.55–8.15 am	EOtC class and two teachers meet at school; check for attendance; important announcements	School building or grounds
8.15–8.30 am	Walking from school to the natural environments nearby the city	Residential area, agri-cultural land and meadows
8.30–8.35 am	Arrival at forest; class splitting up (half of the class with one teacher each); arrangement of a meeting point	Natural environments like forest, clearings and meadows
8.35–8.45 am	Groups walking to the specific places of teaching; preparation of the teaching materials	
8.45–10.15 am	Teaching in the subject of German or Biology; shorter breaks	
10.15–10.45 am	Walking back to the meeting point; longer break	
10.45–10.55 am	Walking to the specific places of teaching; preparation of the teaching materials	
10.55 am–12.25 pm	Teaching in the subject of German or Biology; shorter breaks	
12.25–12.35 pm	Walking back to the meeting point; check for attendance	Natural environments like forest, clearings and meadows
12.35–12.50 pm	Walking back to school together (whole class with both teachers)	Residential area, agri-cultural land and meadows
Approx. 12.55 pm	Official closing of the school day	School grounds

lessons were realized in different places where the children sat or stood on tree trunks or on the ground and it was the responsibility of the respective teacher how he or she organizes the lesson – e.g., whether movement breaks were specifically built in or special social forms were used. After those two different lessons, the group walked back to the school building together, where the school day ends.

2.2. Participants and procedure

Two fifth-grade classes of a German public school participated in this study ($N = 50$). The school cooperating in this study has one fifth-grade class that received at least 4 h of curriculum-compliant schooling in the nearby forest [EOtC class; $n = 24$ (female = 45.8%)] for the whole school year at one fixed day of the week (first year of conducting EOtC at that school). The comparison class [$n = 26$ (female = 46.2%)] received only indoor teaching. Students of the EOtC class came from five different places of residence in and around the city where the school is located. In the comparison class, there were six different places of residence. Since the class assignment depends on the registration of the parents of their children in the respective class, no randomization could be carried out. We conducted our surveys at this school at two time points during the 2019/2020 school year: One month after the beginning of the school year (to wait for a certain period of acclimatization in the new class at the beginning) (T1) and after 5 months (T2). Due to the pandemic-related school closures, the planned third time point at the end of the school year could not take place. This article is part of a larger research project.[1] First results concerning school motivation, health-related quality of life, and the satisfaction of basic psychological needs are published elsewhere (Ellinger et al., 2022a). The differences in the sample size of the two studies result from different methods applied in both studies. The partial secondary analysis of basic psychological needs (social relatedness) is based on the different research questions of the articles.

2.3. Instrumentation

2.3.1. Social interaction

We developed our own questionnaire to collect data on social networks, following common practices (Borgatti et al., 2018). The questionnaire contained two different initial questions and a class list for each question. The students were asked to tick all the students on the lists to whom the initial questions applied. The questions asked were: *(a) With whom do you regularly learn and work during the lessons? (b) With whom do you regularly play during the school breaks?* For the EOtC class, the questions were phrased to refer explicitly to EOtC, the comparison class answered the questions in terms of normal indoor lessons. We understand these questions to represent social interaction and act as the basis for our network data (network questions).

2.3.2. Social relatedness

We used a German translation of the *Basic Psychological Needs Scale* (*BPNS*; La Guardia et al., 2000; Hanfstingl et al., 2010) to assess social relatedness using a 5-point Likert scale (e.g., *I have a good relationship with my classmates*). Social relatedness (Cronbach's $\alpha = 0.77$) is one of the subscales of the *BPNS*; the results of the other subscales were not of interest for the present analysis and were therefore not included in the analysis. The factorial validity of the *BPNS* and its subscales has been frequently addressed in the past and is in general well-supported both theoretically and statistically [CFI (comparative fit index), TLI (Tucker-Lewis index) > 0.95; Deci and Ryan, 2000; Wang et al., 2019]. Following the recommendations by the authors of the statistical method used (*cf.* the following chapter *Statistical data analysis*), the raw values of social relatedness were divided into seven even categories (Nynke et al., 2019).

2.3.3. Friendships

We also asked the students which of their classmates they would describe as a friend. With this information, we calculated the total number of friends (friendships) and the proportion of mutually declared friendships (mutual friendships). We divided those into three categories (1 = one is nominated as a friend by more than 20% more classmates than the other way around [meaning, the corresponding person is perceived as a friend by more classmates, as he or she would refer to as a friend], 2 = one is nominated as a friend by about as many [+/− 20%] classmates as the other way around, 3 = one is nominated as a friend by more than 20% less classmates as the other way around). With that, we managed to receive three groups about the same size. This categorization is not intended to indicate a qualitative classification but to facilitate the interpretation of the results.

We consider, that social relatedness and (mutual) friendships complement each other to capture an overall impression of perceived embeddedness in the social structure of the class: One representing more the feeling of inclusion, independent of the number of personal contacts (social relatedness) and one the quantitative measurement of the number of a certain type of social reference persons (friendships). In addition, we assessed the age, gender, and place of residence of the participants in a demographic questionnaire.

2.4. Statistical data analysis

In our analysis, the relationship structures generated from the answers to the network questions represent the networks themselves. This means that if person A has indicated that he or she works together with person B during lessons, there is a connection (edge) between person A and B (nodes) in the logic of a network. Thus, a network for the whole class results from the totality of the answers of all students. We treat social relatedness and (mutual) friendships as dynamic attributive variables of the students while defining gender and place of residence as static attributes and covariates. We set up four models, two models each for the EOtC and comparison class representing the two network questions regarding interaction during lessons and breaks.

There are currently two different main approaches for the purpose of statistical network analysis. "Random Exponential Graph Models" (ERGMs) are well-suited to test for the randomness of realized connections in a cross-sectional network analysis (Shumate and Palazzolo, 2010). This means that ERGMs check whether connections in the overall network occur particularly frequently between persons who have the same characteristic of interest (e.g., gender). "Stochastic Actor-Oriented Models" (SAOMs) are feasible for longitudinal network data combined with additional dynamic variables (Ripley et al., 2012). SAOMs therefore combine ERGMs with a temporal component that can also determine randomness (or over-randomness) of connections over

1 https://osf.io/6unbf

a certain period of time. Compared to ERGMs with temporal extension, SAOMs have certain advantages and disadvantages, the relevance of which depends on the type of data collected (Block et al., 2019).

For our analysis of hypotheses (a) and (b), we used the R-package *RSiena* for constructing SAOMs. As key-figures in order to address hypothesis (a), we calculated density, diameter, clustering coefficients, and similarity index. Those are central metrics for gaining an impression of the overall constitution of a network. Since the two classes are almost identical in size and also largely homogeneous in terms of age and gender composition, these parameters can subsequently also be used to compare the results of the EOtC class with the comparison class. We assume that the inclusion of different parameters allows a deeper understanding of the network structures in comparison if only a single metric would be included. To address hypothesis (b), co-evolutional associations (degree and dense triads) were tested. We checked whether the number of the realized edges of a person (degree) correlates with the calculated value of social relatedness and the number of friendships over time. Please see Table 2 or respective basic literature (e.g., Luke, 2015) to clarify these key terms in interpreting social networks. In network analysis, hypotheses like hypothesis (c) are referred to as "homophily" hypotheses, as they test whether nodes that share the same characteristics in relevant aspects (in our case: characteristics of gender and/or place of residence) tend to interact more closely or more often. To address hypothesis (c), we constructed ERGMs using the R-package *ergm* (Hunter et al., 2008). We conducted separate analyses for T1 and T2.

3. Results

In terms of density, a strong decrease in social interaction during lessons from T1 (0.26) to T2 (0.22) can be observed in the EOtC class (*cf.* Table 3), which runs contrary to hypothesis (a) and the trends in the comparison class (T1: 0.2; T2: 0.22). However, a strong increase in density is observed concerning social interaction during breaks from T1 (0.3) to T2 (0.36) in the EOtC class, whose relevance is also underlined by statistical significant results of the SAOM analysis regarding associations over time [*cf.* Table 4 ($\beta = -1.02$; $SE = 0.53$; $p < 0.05$)]. The values in the comparison class regarding social interaction during breaks drop slightly (T1: 0.33; T2: 0.31). Measured by the Jaccard similarity index (Snijders et al., 2010), both groups show moderate stability over time in the respective forms of interaction. There is an apparent network fragmentation in social interaction both during lessons and during breaks, which complicates the interpretation of the diameter and the clustering coefficients (Luke, 2015). Please see the up-coming section regarding gender homophily for more information on those fragmentations.

In calculating the models concerning hypothesis (b), excellent t-ratios as an indicator for convergence of the models were found in 72.2% of the calculated effects, 27.8% have to be described as reasonable based on established recommendations with no specific pattern occurring (Ripley et al., 2012). In our analysis, we found initial evidence that in EOtC, measured by transitivity, there is a structural tendency to form groups concerning social interaction during lessons ($\beta = 0.27$; $SE = 0.13$; $p < 0.05$) and breaks ($\beta = 0.54$; $SE = 0.23$; $p < 0.05$) over time, as

TABLE 2 Central terms in the interpretation of a social network and their meaning.

Term	Meaning
Degree	The degree indicates how many connections a node/actor in total has to others in the network. In most networks, a higher degree is considered better because it increases integration in the network. This has to be assessed differently if the recorded interaction is classified as negative (e.g., bullying). Whether, in our case, higher degree is also associated with higher social relatedness (and thus would be considered clearly positive) is to be tested in our study.
Density	The density of a network indicates the proportion of how many of the maximum possible connections are realized between the nodes/actors. As a result, possible values range from 0 to 1. These are not standardized values, so a difference of 0.2 should be interpreted differently in a particularly dense network (e.g., insults between siblings) than in less dense networks (e.g., insults between work colleagues). Similar to the degree, a higher density is desired in most cases and can, therefore, be classified as better. In our case, the classification as "good" for a higher density depends, analogously to degree, on its associations with further parameters.
Diameter	For a network, it is important how many intermediate steps (other nodes/actors) connect each node/actor to every other node/actor, whereby a small number is considered as better. In order to determine the diameter of a network, a two-step procedure is followed. For every actor, the minimal distances (*via* the existing edges) to reach each of the other actors are identified. The longest of these minimal distances then represents the diameter. Since this is about absolute and not relative numbers, a comparison only makes sense if the networks to be compared have (roughly) the same number of nodes/actors. In our case, for example, a lower diameter could imply that lesson-relevant information reaches all students more quickly.
Clustering coefficient, transitivity, and dense triad	The calculation of clustering coefficient, transitivity, and dense triads provides information (probability between 0 and 1) about whether the nodes/actors in a network tend to form groups (meaning: A being connected with B and C also implies a high probability of B being connected with C). High values indicate that there is increased clique or triad formation. Depending on the background of the network, this can be assessed as positive or negative. As the children in the EOtC are able to interact more freely with each other, it seems possible that this will either lead to the strengthening of existing groups or to a break-up of them. It is important to note that the calculation of the clustering coefficient (based on clustering for each node) on the one hand and transitivity and dense triads (proportion of triangles compared to total number of connected triples), despite their similarity, can show different values and even different tendencies.
Similarity index	Corresponding values provide information about how similar two networks are. The possible values range from 0 (no similarity) to 1 (identical networks). This could mean two networks of different groups or, like in our case, the same network at two different time points. In that case, one could also talk about a "stability index." While the density only allows a statement to be made about the proportion of realized connections, the similarity index also considers whether the same nodes/actors remain directly connected over time. Thus, it is possible to have an unchanged density and low similarity at the same time. Therefore, similarity index and density represent important complementary indicators.

also illustrated by the results in Table 4. Given the other results presented, our analysis cannot confirm the existence of co-evolutional associations between the two forms of social interaction on the one hand and social relatedness and (mutual) friendships on the other. Our results, as shown in Table 4, suggest that models 3 and 4 (comparison class) show higher standard errors than models 1 and 2 (EOtC class).

Looking at gender homophily regarding hypothesis (c), strong associations for social interaction during the lessons at T1 within students of the same gender are apparent for EOtC class ($\beta = 3.85$; $SE = 0.43$; $p < 0.001$). For comparison group, that is evident for both during-lesson and during-break social interaction and both time points (Lessons T1: $\beta = 2.82$; $SE = 0.32$; $p < 0.001$; Lessons T2: $\beta = 2.81$; $SE = 0.3$; $p < 0.001$; Breaks T1: $\beta = 3.50$; $SE = 0.28$; $p < 0.001$; Breaks T2: $\beta = 3.53$; $SE = 0.29$; $p < 0.001$). This is also illustrated in Figures 1 (social interaction during lessons), 2 (social interaction during breaks). Please also see Table 5 for the full results. The EOtC class shows several times that a calculation of gender homophily is not possible. This is because the corresponding networks fragment, and none of these fragments show more than one characteristic – in this case, gender (*cf.* Figures 1, 2). This means that the formerly connected network of the whole class has become two separate networks – one consisting only of boys, one only of girls. In substance, this is to be evaluated as evidencing even stronger homophily than could be expressed by statistical significance. This also applies to the results regarding hypothesis (a) presented above.

TABLE 3 Network parameters.

Education Outside the Classroom					Comparison				
	Density	DM	CC	JSI		Density	DM	CC	JSI
Model 1 (Lessons)					Model 3 (Lessons)				
T1	0.26	6	0.67			0.20	5	0.47	
T2	0.22	X/3*	0.56			0.22	5	0.41	
				0.467					0.448
Model 2 (Breaks)					Model 4 (Breaks)				
T1	0.30	X/3*	0.74			0.33	4	0.64	
T2	0.36	X/3*	0.84			0.31	4	0.68	
				0.655					0.522

Density (Density), diameter (DM), clustering coefficient (CC) and Jaccard similarity index (JSI) for both groups (Education Outside the Classroom, Comparison) at different time points (T1, T2); Models 1 and 3 concern the interaction during the lesson, models 2 and 4 the interaction during the breaks in the corresponding group.*In the case of fragmentation of the corresponding network (X), the diameter of the largest fragment was calculated instead.

TABLE 4 Results of testing for structural effects and co-evolutional associations over time.

Education Outside the Classroom					Comparison				
		β	SE	p			β	SE	p
Model 1 (Lessons)					Model 3 (Lessons)				
	Transitivity	0.27	0.13	*		Transitivity	0.34	0.26	–
	Density	−1.02	0.53	–		Density	1.06	0.62	–
SR	Degree	0.34	0.70	–	SR	Degree	−0.33	1.19	–
	Dense Triads	−0.12	0.18	–		Dense Triads	0.19	0.80	–
Friends	Degree	0.02	0.21	–	Friends	Degree	0.01	0.44	–
	Dense Triads	0.01	0.05	–		Dense Triads	−0.01	0.21	–
MFC	Degree	−0.11	0.40	–	MFC	Degree	−0.35	3.76	–
	Dense Triads	0.06	0.20	–		Dense Triads	0.49	2.78	–
Model 2 (Breaks)					Model 4 (Breaks)				
	Transitivity	0.54	0.23	*		Transitivity	0.38	0.58	–
	Density	1.88	0.43	*		Density	−1.68	1.59	–
SR	Degree	0.53	0.51	–	SR	Degree	0.50	4.05	–
	Dense Triads	−0.11	0.08	–		Dense Triads	−0.14	0.89	–
Friends	Degree	0.53	1.13	–	Friends	Degree	0.04	0.74	–
	Dense Triads	−0.09	0.23	–		Dense Triads	−0.01	0.33	–
MFC	Degree	0.61	3.96	–	MFC	Degree	0.74	5.33	–
	Dense Triads	−0.16	0.91	–		Dense Triads	−0.06	1.95	–

SR, social relatedness; Friends, friendships; MFC, mutual friends category for both groups (Education Outside the Classroom, Comparison); β = Estimates; SE = Standard error; p = Significance at the corresponding level (* < 0.05); Models 1 and 3 concern the interaction during the lesson, models 2 and 4 the interaction during the breaks in the corresponding group.

In the case of residence, significant associations emerge only in the comparison class concerning social interaction during lessons at T2 ($\beta = 0.68$; $SE = 0.25$; $p < 0.01$).

4. Discussion

Without a doubt, EOtC must be seen as an investment and not a matter of course in the context of traditional public schools in Germany. This concerns only secondarily financial aspects, but primarily an organizational investment. In sum, the school and the teachers involved have to invest time (e.g., adapting the lessons to the new learning location and travel times) and teaching load (often two teachers for one class) in order to implement the concept. The possible outcomes - or return-on-investments – are, in the best case, positive changes in students and/or teachers. These could relate to learning, health, environmental behavior and much more (Becker et al., 2017). Whether the return on organizational investment is sufficient to justify the concept is at the discretion of the school and the actual effort involved in implementing it. As classroom processes as well as social interaction were only rarely focused on in research on EOtC, we contribute to a deeper understanding of those with the results of our social network analysis. We will discuss those results and how to increase the return-on-investments in EOtC, as well as point out future research implications based on learnings from this study.

4.1. Changes in social interaction

Since we observed a decrease in density regarding social interaction during lessons over time in EOtC, but an increase in social interaction during breaks and exactly the opposite tendencies in the comparison class, no clear pattern in favor of the EOtC class can be derived from the present models. The observed trends in the EOtC lessons are surprising considering the existing literature on the influence of natural environments in general and EOtC in particular on social facets (Bølling et al., 2019; Putra et al., 2020). The observed increase in density in social interaction during the breaks in EOtC initially underlines opinions that are based on the assumption that free play in natural spaces positively influences children's cooperation (Tremblay et al., 2015). Based on the values of the clustering coefficients (*cf.* Table 3) and longitudinal transitivity results (*cf.* Table 4), there appears to be a substantial degree of grouping in the EOtC class. This is in line with previous impressions of social exclusion in EOtC in qualitative studies (Jørring et al., 2019). Previous studies also indicated that existing or missing didactical concepts or guidelines should be taken into account when interpreting results with regard to EOtC in any case (Mygind, 2009; Hartmeyer and Mygind, 2016). Following this, in this case, processes could even occur that favor segregation: EOtC is at least in Germany a relatively new concept, and often initiated as an "educational experiment." This often leaves teachers with some uncertainties (Barfod, 2018), which could also apply to this case as the studied school year was the first-ever with EOtC being implemented at our cooperation school. Accordingly, the focus is often on the successful delivery of the lesson and less on the targeted mixing of the class. This in turn could lead to teachers leaving the children to organize themselves into groups, which could result in certain group structures being strengthened and established even more, rather than promoting the formation of new interactions. In this respect, a comparison can certainly be drawn with the situation of young teachers in the transition from the "Referendariat" (final practical part of teacher training in Germany) to actual teaching work in the school. Here, too, it can be observed that disruptions (which do occur frequently in reality) of the ideal-typical lesson lead to a focus on the superordinate organization of the school lesson and that desirable didactic requirements (e.g., the promotion of social exchange) are pushed into the background. Consequently, the implementation of these would only be sought again when a certain level of self-confidence in teaching is perceived by the teacher (Miethling, 1986). Teachers may face a similarly new situation when they take the step of implementing EOtC for the first time. Therefore, it remains to be noted that even in a teaching concept that, like EOtC, makes it increasingly easy to use cooperative forms of learning, the integration of possible outsiders does not happen naturally. This conclusion is also in line with other empirical findings and theoretical considerations regarding integration and inclusion in schools (Koster et al., 2009).

In summary, it can be stated that despite the (partly) high organizational investments and the favorable framework conditions in a natural environment, it is not given that expected effects will actually occur. With regard to increases in social interaction, we consider nature-based learning to be a great opportunity, but we also point out the necessity that concepts such as EOtC are not "self-propelling," but also require concrete didactic-pedagogical principles and guidelines.

4.2. Interrelations with other social factors

In this study, we considered the relationships between social interaction and two social facets that have manifold relevance at the psychosocial level but differ in their substantive meaning: Social relatedness as a highly individual and non-standardized feeling of inclusion in the class on the one hand and the number of (mutual) friendships as a purely quantitative representation of social contacts (of outstanding importance) on the other hand. Contrary to hypothesis (b), there are no indications based on our analysis for a substantial co-evolution between the network parameters of social interaction and social relatedness and (mutual) friendships. Thus, the analysis of our sample does not immediately imply that there is a direct association between social interaction and, for example, perceived social relatedness on an individual level over time. Those results apply for both groups. The first network question particularly targeted classroom interaction during the lessons, which can be understood as social interaction. However, social interaction during lessons may be much more related to learning or academic effects than to psychosocial effects such as social relatedness. Suppose one were to understand this question more as an inquiry into cooperative learning in the classroom. In that case, a variety of possible effects on facets of school motivation, cognitive activation, and academic comprehension in students could be identified from empirical research (Gillies and Ashman, 2000; Hänze and Berger, 2007; Fernandez-Rio et al., 2017), but only very rarely on social facets such as bullying (Van Ryzin and Roseth, 2018). Nevertheless, based on previous research we assumed that those cooperative forms of learning might affect social factors (Roseth et al., 2008). In the future, it should be carefully considered which processes the asked questions explicitly address and with which other parameters an association seems possible. However, this explanatory approach does not apply to the social interaction during breaks, as we suspected playing with peers to be fundamentally relevant to social relatedness - a field of research that still offers great potential for future studies. Unfortunately, we do not have any information on how the breaks were organized in the EOtC and the comparison class, which makes

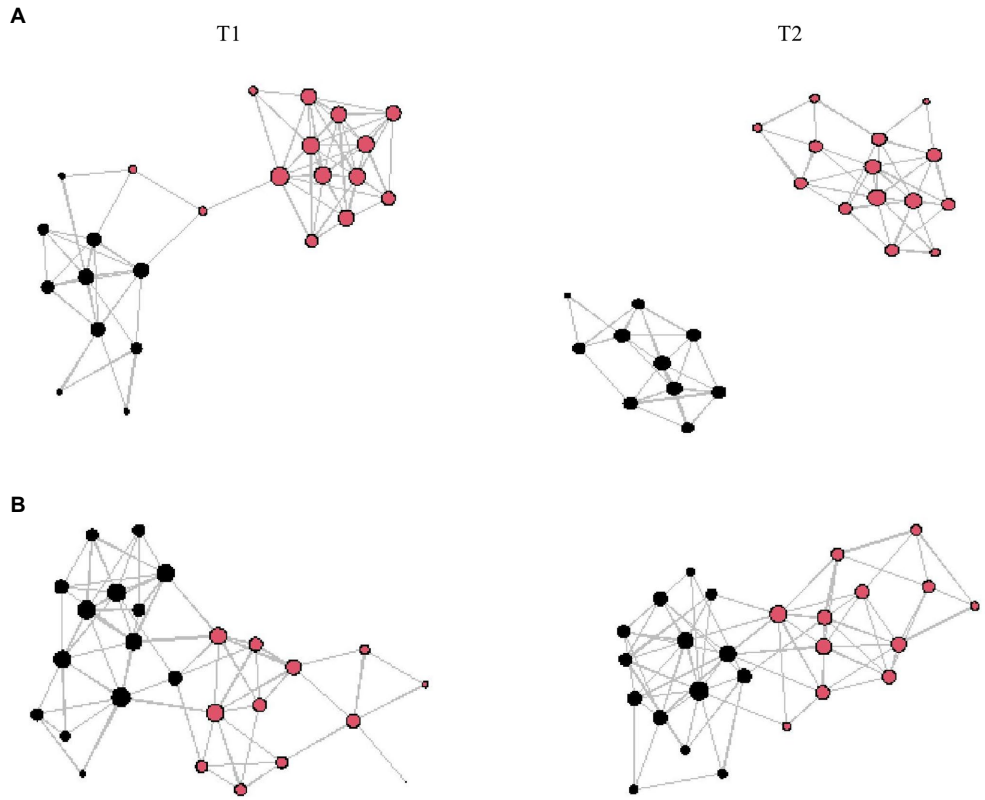

FIGURE 1
Visualized networks taking gender into account (red represents female students, black represents male students); the size of the dots reflects the degree of connections; the length of the lines does not communicative substantive information; **(A)** Interaction during lessons in EOtC class, **(B)** Interaction during lessons in comparison class; T1=first time point; T2=second time point.

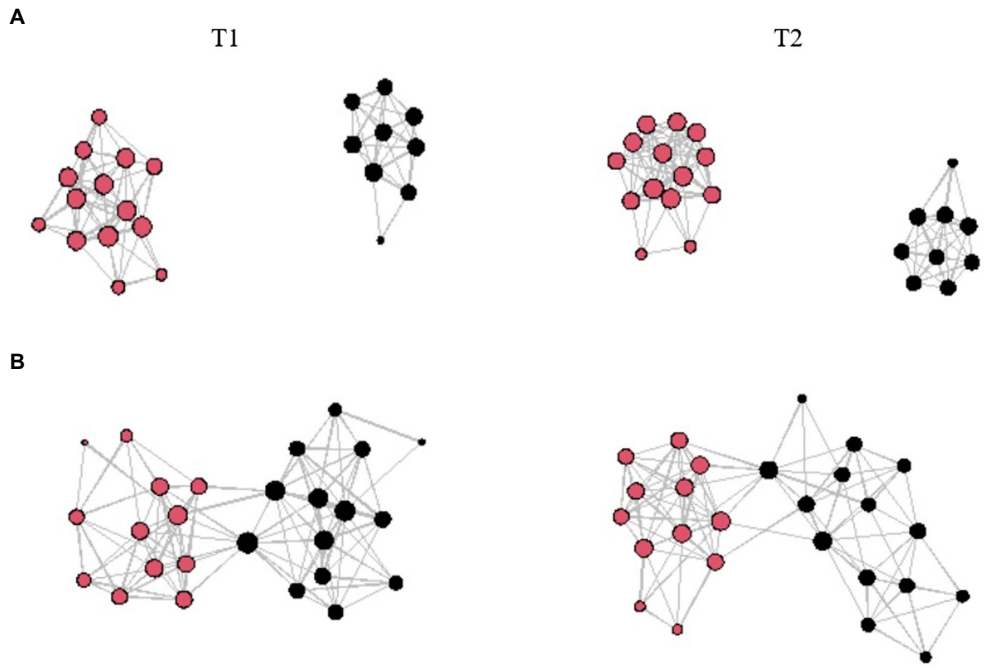

FIGURE 2
Visualized networks taking gender into account (red represents female students, black represents male students); the size of the dots reflects the degree of connections; the length of the lines does not communicative substantive information; **(A)** Interaction during breaks in EOtC class, **(B)** Interaction during breaks in comparison class; T1=first time point; T2=second time point.

TABLE 5 Results of testing for homophily effects.

Education Outside the Classroom					Comparison				
		β	SE	*p*			*β*	SE	*p*
Model 1 (Lessons)					Model 3 (Lessons)				
T1	Gender	3.85	0.43	***		Gender	2.82	0.32	***
	Residence	0.26	0.25	–		Residence	0.27	0.28	–
T2	Gender	X	X	X		Gender	2.81	0.3	***
	Residence	−55.8	−2.77	–		Residence	0.68	0.25	**
Model 2 (Breaks)					Model 4 (Breaks)				
T1	Gender	X	X	X		Gender	3.50	0.28	***
	Residence	0.12	0.24	–		Residence	−0.32	0.26	–
T2	Gender	X	X	X		Gender	3.53	0.29	***
	Residence	−0.15	0.24	–		Residence	−0.09	0.26	–

Gender and place of residence (Residence) for both groups (Education Outside the Classroom, Comparison) at different time points (T1, T2); β, estimates; SE, standard error; p = Significance at the corresponding levels (Codes: *** < 0.001; ** < 0.01; * < 0.05); Models 1 and 3 concern the interaction during the lesson, models 2 and 4 the interaction during the breaks in the corresponding group; X = Not possible to calculate a value for the class as a whole because of fragmentation of the corresponding network.

further explanations very difficult. Such a classification and description of the social situation should be enabled and considered in future studies.

Concerning hypothesis (c), the results indicate strong gender homophily in both groups for both forms of social interaction, which in the case of the EOtC class even seems to be causal for a fragmentation of the network (*cf.* Figures 1, 2). In general, these results are in line with earlier findings suggesting the importance of having the same gender for the initiation of friendship relationships in childhood and adolescence (Shrum et al., 1988; Block and Grund, 2014). Similar results of the comparison class point to distinctive homophily concerning gender in both forms of social interaction. However, in contrast to the EOtC class, this does not lead to network fragmentation. On the contrary: An increase in the density of social interaction in the comparison class can be observed during lessons, even if corresponding intensifications could not be proven for social interaction during the break. One possible reason for this could be the character of the comparison class. It is for this class to get 45 more minutes of physical education (PE) per week than the other classes, as this class is part of a special school program (PE-profile). This additional lesson of PE was conducted co-educationally, meaning mixed between genders, in contrast to the regular PE lessons. Earlier, the mixing of genders in PE was discussed as being worthwhile (Hills and Croston, 2012), even though a solid scientific basis on the influence of a co-educational approach on social interaction is still lacking. However, it is also explicitly anchored in the curriculum and pedagogical paradigm in the region of our cooperation school that co-educational PE should be utilized to promote gender interaction (Ministerium für Kultus, Jugend und Sport Baden-Württemberg [Ministry of Education, Youth and Sports Baden-Württemberg], 2016). The observed tendency for the genders to be more closely intertwined in the comparison class may be due to this pedagogical paradigm. An equivalent claim of gender interaction does not yet exist for EOtC. Instead, a similar mechanism could come into play here as it has been cited for the changes in social interaction before. The teachers' focus at our cooperation school might have been primarily on the successful delivery of the lessons. This may have led to students organizing themselves in the context of group work, for example. This, in turn, may have consolidated already existing groups, as reflected in the results of this study as well as a study by Jørring et al. (2019).

It also seems conceivable that the observed effects of homophily with respect to place of residence in the comparison class are due to their affinity for sports: Often, students in PE-profile classes have a relevant sports biography – e.g., many years of membership in sports clubs – as they or their parents actively opt for that school profile. Given the described considerations regarding a closer relationship of the students who come from the same village and possibly already interacted with each other in sports clubs there, these effects could be due to this and apply more to the students within the comparison class.

4.3. Limitations and future research implications

We examined EOtC in natural environments as a feasible long-term concept in terms of different facets of social interaction as outcomes. With that, new insights could be gained for research in this area. Subsequent investigations should be aware of and address the limitations and learnings derived from this study. In this study we compared the results of the EOtC class with those of a comparison group that has special characteristics (PE-profile), which offers additional approaches for the interpretation of the results. In the future nevertheless, it would be worthwhile to proceed in a similar way with a real non-treatment group. Second, the sample size must be considered small, which could be the reason for the variance in the level of standard error when comparing the models. However, in this context (examination of complete and closed school classes), it can also only be expanded to a limited extent. It should therefore be examined which strategies exist to enlarge the sample or which statistical approaches could be considered in the future to compensate for this weakness [e.g., Bayesian estimations (Farine and Strandburg-Peshkin, 2015)]. In addition, there are the previously described concerns about the validity of the network questions. Pilot testing could help remedy this in the future. Finally, consideration should also be given to whether certain network data (e.g., social interaction during lessons) could be collected more objectively, for example, through observations by an external person or by electronic sensors. This would help to avoid possible bias due to social desirability. A comparison of this data with qualitative interview data would offer the chance of great insights – e.g., whether the observed developments from the perspective of the teachers are due to the strong influence of individuals or tendencies of the entire

group. In particular, observations would also include the opportunity to test the assumptions about the organization of the school hours (e.g., for example, the use of certain social forms in the EOtC). In a larger follow-up study, consideration should also be given to grading the networks' interactions in terms of intensity, frequency, and reciprocity.

5. Conclusion

There is no doubt that both natural environments and the characteristics of EOtC concepts itself make it possible to realize new and intensified forms of social interaction. However, based on our results, but also those of previous research, it also appears that this realization and intensification of social interaction because of EOtC should not be mistakenly assumed as an automatism. On the contrary, under certain circumstances, the frequently observed and praised freedom of choice for students in EOtC or other nature-based educational and learning concepts might lead to a solidification of existing contacts and groups, as well as the social exclusion of individuals. From our perspective, in addition to the need for methodologically well-constructed research, there is also a high demand for the development and evolution of specific didactic frameworks for EOtC and other nature-based forms of teaching and learning. In countries in which EOtC historically and currently plays a larger role (especially in Scandinavia), corresponding concepts have already been adopted in ministerial recommendations. In other countries such as Germany, where the concept is still rarely used, there is a lack of such. Last but not least, the example of the PE-profile shows that objectives that go beyond academic learning–e.g., in terms of social factors–can be effectively anchored in official recommendations. Only under these conditions there seems to be a possibility that EOtC as a social situation in natural environments can unfold its full potential in terms of social interaction and thus hold a return on investment that justifies a consequent dissemination of the concept.

Data availability statement

The original contributions presented in the study are included in the article, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving human participants were reviewed and approved by Technical University of Munich (Institute of Medicine). Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

The study was designed by FM and CM. Data collection was performed by JE and CM. Statistical analysis was performed by JE with the assistance of JB and CM. JE prepared the draft of the manuscript. JA, FM, JB, and CM made essential comments and substantial revisions to it. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

References

Barfod, K. S. (2018). Maintaining mastery but feeling professionally isolated: experienced teachers' perceptions of teaching outside the classroom. *J. Adv. Educ. Outdoor Learn.* 18, 201–213. doi: 10.1080/14729679.2017.1409643

Baron, R., Byrne, D., and Suls, J. (2000). *Exploring Social Psychology*. Boston: Allyn and Bacon.

Becker, C., Lauterbach, G., Spengler, S., Dettweiler, U., and Mess, F. (2017). Effects of regular classes in outdoor education settings: a systematic review on students' learning, social and health dimensions. *Int. J. Environ. Res. Public Health* 14:485. doi: 10.3390/ijerph14050485

Becker, C., Schmidt, S., Neuberger, E., Kirsch, P., Simon, P., and Dettweiler, U. (2019). Children's cortisol and cell-free DNA trajectories in relation to sedentary behavior and physical activity in school: a pilot study. *Front. Public Health* 7:26. doi: 10.3389/fpubh.2019.00026

Bentsen, P., Mygind, L., Elsborg, B., Nielsen, G., and Mygind, E. (2021). Education outside the classroom as upstream school health promotion: 'adding-in' physical activity into children's everyday life and settings. *Scand. J. Public Health* 50, 303–311. doi: 10.1177/1403494821993715

Bentsen, P., Mygind, E., and Randrup, T. B. (2009). Towards an understanding of udeskole: education outside the classroom in a Danish context. *Education* 37, 29–44. doi: 10.1080/03004270802291780

Block, P., and Grund, T. (2014). Multidimensional homophily in friendship networks. *Netw. Sci.* 2, 189–212. doi: 10.1017/nws.2014.17

Block, P., Stadtfeld, C., and Snijders, T. A. B. (2019). Forms of dependence: comparing SAOMs and ERGMs from basic principles. *Sociol. Methods Res.* 48, 202–239. doi: 10.1177/0049124116672680

Bølling, M., Mygind, E., Mygind, L., Bentsen, P., and Elsborg, P. (2021). The association between education outside the classroom and physical activity: differences attributable to the type of space? *Children* 8:486. doi: 10.3390/children8060486

Bølling, M., Otte, C. R., Elsborg, P., Nielsen, G., and Bentsen, P. (2018). The association between education outside the classroom and students' school motivation: results from a one-school-year quasi-experiment. *Int. J. Educ. Res.* 89, 22–35. doi: 10.1016/j.ijer.2018.03.004

Bølling, M., Pfister, G. U., Mygind, E., and Nielsen, G. (2019). Education outside the classroom and pupils' social relations? A one-year quasi-experiment. *Int. J. Educ. Res.* 94, 29–41. doi: 10.1016/j.ijer.2019.02.014

Borgatti, S. P., Everett, M. G., and Johnson, J. C. (2018). *Analyzing Social Networks*. Thousand Oaks: Sage Publications.

Chalkiadaki, A. (2018). A systematic literature review of 21st century skills and competencies in primary education. *Int. J. Instr.* 11, 1–16. doi: 10.12973/iji.2018.1131a

Deci, E., and Ryan, R. (2000). The "what" and "why" of goal pursuits: human needs and the self-determination of behavior. *Psychol. Inq.* 11, 227–268. doi: 10.1207/S15327965PLI1104_01

Dettweiler, U., Lauterbach, G., Becker, C., and Simon, P. (2017). A Bayesian mixed-methods analysis of basic psychological needs satisfaction through outdoor learning and its influence on motivational behavior in science class. *Front. Psychol.* 8:2235. doi: 10.3389/fpsyg.2017.02235

Doucette, P. A. (2004). Walk and talk: an intervention for behaviorally challenged youths. *Adolescence* 39, 373–388.

Ellinger, J., Mess, F., Blaschke, S., and Mall, C. (2022a). Health-related quality of life, motivational regulation and basic psychological need satisfaction in education outside the classroom: an explorative longitudinal pilot study. *BMC Public Health* 22:49. doi: 10.1186/s12889-021-12450-9

Ellinger, J., von Au, J., Bernhardt, L., Singer, M., Tangerding, S., and Mall, C. (2022b). Eine Frage der Perspektive: die Unterrichtssituation im Draußenunterricht [A matter of perspective: the classroom situation in outdoor education]. In: AuJ. von and R. Jucker (eds). *Draussenlernen Neue Forschungsergebnisse und Praxiseinblicke für eine Bildung für nachhaltige Entwicklung [Outdoor Learning New Research Findings and Practical Insights for Education for Sustainable Development]*. Bern: hep. 387–406.

Faber Taylor, A., Wiley, A., Kuo, F., and Sullivan, W. (1998). Growing up in the inner city. Green spaces as places to grow. *Environ. Behav.* 30, 3–27. doi: 10.1177/0013916598301001

Fägerstam, E. (2014). High school teachers' experience of the educational potential of outdoor teaching and learning. *J. Adv. Educ. Outdoor Learn.* 14, 56–81. doi: 10.1080/14729679.2013.769887

Farine, D., and Strandburg-Peshkin, A. (2015). Estimating uncertainty and reliability of social network data using Bayesian inference. *R. Soc. Open Sci.* 2:150367. doi: 10.1098/rsos.150367

Fernandez-Rio, J., Sanz, N., Fernandez-Cando, J., and Santos, L. (2017). Impact of a sustained cooperative learning intervention on student motivation. *Phys. Educ. Sport Pedagog.* 22, 89–105. doi: 10.1080/17408989.2015.1123238

Fullerton, C. S., and Ursano, R. J. (1994). Preadolescent peer friendships: a critical contribution to adult social relatedness? *J. Youth Adolesc.* 23, 43–63. doi: 10.1007/BF01537141

Fyfe-Johnson, A., Hazlehurst, M., Perrins, S., Bratman, G., Thomas, R., Garrett, K., et al. (2021). Nature and children's health: a systematic review. *Pediatrics* 148:e2020049155. doi: 10.1542/peds.2020-049155

García-Carrión, R., Villarejo-Carballido, B., and Villardón-Gallego, L. (2019). Children and adolescents mental health: a systematic review of interaction-based interventions in schools and communities. *Front. Psychol.* 10:918. doi: 10.3389/fpsyg.2019.00918

Gifford-Smith, M. E., and Brownell, C. A. (2003). Childhood peer relationships: social acceptance, friendships, and peer networks. *J. Sch. Psychol.* 41, 235–284. doi: 10.1016/S0022-4405(03)00048-7

Gillies, R. M., and Ashman, A. F. (2000). The effects of cooperative learning on students with learning difficulties in the lower elementary school. *J. Spec. Educ.* 34, 19–27. doi: 10.1177/002246690003400102

Glackin, M. (2018). 'Control must be maintained': exploring teachers' pedagogical practice outside the classroom. *Br. J. Sociol. Educ.* 39, 61–76. doi: 10.1080/01425692.2017.1304204

Hanfstingl, B., Andreitz, I., Müller, F. H., and Thomas, A. (2010). Are self-regulation and self-control mediators between psychological basic needs and intrinsic teacher motivation? *J. Educ. Res. Online* 2, 55–71. doi: 10.25656/01:4575

Hänze, M., and Berger, R. (2007). Cooperative learning, motivational effects, and student characteristics: an experimental study comparing cooperative learning and direct instruction in 12th grade physics classes. *Learn. Instr.* 17, 29–41. doi: 10.1016/j.learninstruc.2006.11.004

Harris, M. A., and Orth, U. (2020). The link between self-esteem and social relationships: a meta-analysis of longitudinal studies. *J. Pers. Soc. Psychol.* 119, 1459–1477. doi: 10.1037/pspp0000265

Hartmeyer, R., and Mygind, E. (2016). A retrospective study of social relations in a Danish primary school class taught in 'u deskole'. *J. Adv. Educ. Outdoor Learn.* 16, 78–89. doi: 10.1080/14729679.2015.1086659

Hartup, W. W. (1989). Social relationships and their developmental significance. *Am. Psychol.* 44, 120–126. doi: 10.1037/0003-066X.44.2.120

Hartup, W. W. (1999). "Peer experience and its developmental significance," in *Developmental Psychology: Achievements and Prospects*. ed. M. Bennett (Hove: Psychology Press), 106–125.

Hay, D. F., Caplan, M., and Nash, A. (2018). "The beginnings of peer relations," in *Handbook of Peer Interactions, Relationships, and Groups*. eds. W. Bukowski, B. Laursen and K. Rubin (New York City: The Guilford Press), 200–221.

Hills, L. A., and Croston, A. (2012). 'It should be better all together': exploring strategies for 'undoing'gender in co-educational physical education. *Sport Educ. Soc.* 17, 591–605. doi: 10.1080/13573322.2011.553215

Hirsh-Pasek, K., Hadani, H. S., Blinkoff, E., and Golinkoff, R. M. (2020). A new path to education form: playful learning promotes 21st century skills in school and beyond. *Policy Brookings 2020*. Available at: https://www.brookings.edu/wp-content/uploads/2020/10/Big-Ideas_Hirsh-Pasek_PlayfulLearning.pdf (Accessed August 29, 2022).

Hunter, D. R., Handcock, M. S., Butts, C. T., Goodreau, S. M., and Morris, M. (2008). Ergm. A package to fit, simulate and diagnose exponential-family models for networks. *J. Stat. Softw.* 24:nihpa54860. doi: 10.18637/jss.v024.i03

Hurst, B., Wallace, R. R., and Nixon, S. B. (2013). The impact of social interaction on student learning. *Reading Horiz.* 52, 375–398.

Jørring, A. H., Bølling, M., Nielsen, G., Stevenson, M. P., and Bentsen, P. (2019). Swings and roundabouts? Pupils' experiences of social and academic well-being in education outside the classroom. *Education* 48, 413–428. doi: 10.1080/03004279.2019.1614643

Koster, M., Nakken, H., Pijl, S. J., and Van Houten, E. (2009). Being part of the peer group: a literature study focusing on the social dimension of inclusion in education. *Int. J. Incl. Educ.* 13, 117–140. doi: 10.1080/13603110701284680

La Guardia, J., Ryan, R., Couchman, C., and Deci, E. (2000). Basic psychological needs scales. *J. Pers. Soc. Psychol.* 79, 367–384. PMID: 10981840

Lee, E. Y., de Lannoy, L., Li, L., de Barros, M., Bentsen, P., Brussoni, M., et al. (2022). Play, learn, and teach outdoors–network (PLaTO-net): terminology, taxonomy, and ontology. *Int. J. Behav. Nutr. Phys. Act.* 19. doi: 10.1186/s12966-022-01294-0

Lee, R. L. T., Lane, S., Brown, G., Leung, C., Kwok, S. W. H., and Chan, S. W. C. (2020). Systematic review of the impact of unstructured play interventions to improve young children's physical, social, and emotional well-being. *Nurs. Health Sci.* 22, 184–196. doi: 10.1111/nhs.12732

Li, J., Li, J., Jia, R., Wang, Y., Qian, S., and Xu, Y. (2020). Mental health problems and associated school interpersonal relationships among adolescents in China: a cross-sectional study. *Child Adolesc. Psychiatry Ment. Health* 14, 12–10. doi: 10.1186/s13034-020-00318-6

Luke, D. A. (2015). *A User's Guide to Network Analysis in R*. Berlin: Springer.

Ma, J. (2018). Qualitative change in social situation of development as the starting point of children's role adjustment during the transition to school. *Early Child Dev. Care*. 190, 750–765. doi: 10.1080/03004430.2018.1490895

Maccoby, E. E. (1988). Gender as a social category. *Dev. Psychol.* 24, 755–765. doi: 10.1037/0012-1649.24.6.755

Mall, C., von Au, J., and Dettweiler, U. (2021). "Students' appropriation of space in education outside the classroom. Some aspects on physical activity and health from a pilot study with 5th-graders in Germany," in *Nature and Health*. eds. E. Brymer, M. Rogerson and J. Barton (London: Routledge), 223–232.

McArdle, K., Harrison, T., and Harrison, D. (2013). Does a nurturing approach that uses an outdoor play environment build resilience in children from a challenging background? *J. Adv. Educ. Outdoor Learn.* 13, 238–254. doi: 10.1080/14729679.2013.776862

McNamara, L., Colley, P., and Franklin, N. (2017). School recess, social connectedness and health: a Canadian perspective. *Health Promot. Int.* 32, dav102–dav402. doi: 10.1093/heapro/dav102

Miethling, W.-D. (1986). *Belastungssituationen im Selbstverständnis junger Sportlehrer. Ein Beitrag zur Praxisforschung im Sportunterricht [Stressful Situations in the Self-concept of Young Physical Education Teachers. A Contribution to Practice Research in Physical Education]*. Schorndorf: Verlag Karl Hofmann.

Ministerium für Kultus, Jugend und Sport Baden-Württemberg [Ministry of Education, Youth and Sports Baden-Württemberg] (2016). Bildungsplan des Gymnasiums. Sport [Educational plan of the high school. Sports]. Available at: https://www.bildungsplaene-bw.de/site/bildungsplan/get/documents/lsbw/export-pdf/depot-pdf/ALLG/BP2016BW_ALLG_GYM_SPO.pdf (Accessed August 29, 2022).

Moriguchi, Y. (2014). The early development of executive function and its relation to social interaction: a brief review. *Front. Psychol.* 5:388. doi: 10.3389/fpsyg.2014.00388

Mygind, E. (2009). A comparison of childrens' statements about social relations and teaching in the classroom and in the outdoor environment. *J. Adv. Educ. Outdoor Learn.* 9, 151–169. doi: 10.1080/14729670902860809

Mygind, L., Kjeldsted, E., Hartmeyer, R., Mygind, E., Bølling, M., and Bentsen, P. (2019). Mental, physical and social health benefits of immersive nature-experience for children and adolescents: a systematic review and quality assessment of the evidence. *Health Place* 58:102136. doi: 10.1016/j.healthplace.2019.05.014

Nynke, M. D., Niezink, T., Snijders, M., and van Duijn, M. (2019). No longer discrete: modeling the dynamics of social networks and continuous behavior. *Sociol. Methodol.* 49, 295–340. doi: 10.1177/0081175019842263

Pachucki, M. C., Ozer, E. J., Barrat, A., and Cattuto, C. (2015). Mental health and social networks in early adolescence: a dynamic study of objectively-measured social interaction behaviors. *Soc. Sci. Med.* 125, 40–50. doi: 10.1016/j.socscimed.2014.04.015

Perry, D. G., Pauletti, R. E., and Cooper, P. J. (2019). Gender identity in childhood: a review of the literature. *Int. J. Behav. Dev.* 43, 289–304. doi: 10.1177/0165025418811129

Powlishta, K. K. (2004). "Gender as a social category: intergroup processes and gender-role development," in *The Development of the Social Self*. eds. M. Bennett and F. Sani (London: Psychology Press), 103–133.

Putra, I., Astell-Burt, T., Cliff, D. P., Vella, S. A., John, E. E., and Feng, X. (2020). The relationship between green space and prosocial behaviour among children and adolescents: a systematic review. *Front. Psychol.* 11:859. doi: 10.3389/fpsyg.2020.00859

Ridgeway, C., and Smith-Lovin, L. (1999). The gender system and interaction. *Annu. Rev. Sociol.* 25, 191–216. doi: 10.1146/annurev.soc.25.1.191

Ripley, R. M., Snijders, T. A. B., Boda, Z., Vörös, A., and Preciado, P. (2012). Manual for Siena version 4.0. Available at: https://www.stats.ox.ac.uk/~snijders/siena/s_man401.pdf (Accessed August 29, 2022).

Roberts, A., Hinds, J., and Camic, P. M. (2020). Nature activities and well-being in children and young people: a systematic literature review. *J. Adv. Educ. Outdoor Learn.* 20, 298–318. doi: 10.1080/14729679.2019.1660195

Roe, J., and Aspinall, P. (2011). The emotional affordances of forest settings: an investigation in boys with extreme behavioural problems. *Landsc. Res.* 36, 535–552. doi: 10.1080/01426397.2010.543670

Roseth, C. J., Johnson, D. W., and Johnson, R. T. (2008). Promoting early adolescents' achievement and peer relationships: the effects of cooperative, competitive, and individualistic goal structures. *Psychol. Bull.* 134, 223–246. doi: 10.1037/0033-2909.134.2.223

Ryan, R. M., and Deci, E. L. (2017). *Self-Determination Theory: Basic Psychological Needs in Motivation, Development, and Wellness*. New York: Guilford Publications.

Sarason, S. B., and Klaber, M. (1985). The school as a social situation. *Annu. Rev. Psychol.* 36, 115–140. doi: 10.1146/annurev.ps.36.020185.000555

Schneller, M. B., Duncan, S., Schipperijn, J., Nielsen, G., Mygind, E., and Bentsen, P. (2017). Are children participating in a quasi-experimental education outside the classroom intervention more physically active? *BMC Public Health* 17:523. doi: 10.1186/s12889-017-4430-5

Seppala, E., Rossomando, T., and Doty, J. R. (2013). Social connection and compassion: important predictors of health and well-being. *Soc. Res.* 80, 411–430. doi: 10.1353/sor.2013.0027

Shrum, W., Cheek, N. H. M. D. Jr., and Hunter, S. (1988). Friendship in school: gender and racial homophily. *Sociol. Educ.* 61, 227–239. doi: 10.2307/2112441

Shumate, M., and Palazzolo, E. T. (2010). Exponential random graph (p*) models as a method for social network analysis in communication research. *Commun. Methods Meas.* 4, 341–371. doi: 10.1080/19312458.2010.527869

Simmel, G. (2013). "Soziologie: Untersuchungen über die Formen der Vergesellschaftung [Sociology: studies on the forms of socialisation]," in *Hauptwerke der Emotionssoziologie [Major Works in the Sociology of Emotion]*. eds. K. Senge and R. Schützeichel (Wiesbaden: Springer), 311–332.

Snijders, T., van de Bunt, G., and Steglich, C. (2010). Introduction to stochastic actor-based models for network dynamics. *Soc. Networks* 32, 44–60. doi: 10.1016/j.socnet.2009.02.004

Sugiyama, T., Leslie, E., Giles-Corti, B., and Owen, N. (2008). Associations of neighbourhood greenness with physical and mental health: do walking, social coherence and local social interaction explain the relationships? *J. Epidemiol. Community Health* 62:e9. doi: 10.1136/jech.2007.064287

Torkos, H. (2017). Social and psychological aspects of outdoor education. *Agora Psycho Pragmat.* 11, 215–223.

Tremblay, M. S., Gray, C., Babcock, S., Barnes, J., Bradstreet, C. C., Carr, D., et al. (2015). Position statement on active outdoor play. *Int. J. Environ. Res. Public Health* 12, 6475–6505. doi: 10.3390/ijerph120606475

van Laar, E., van Deursen, A. J., van Dijk, J. A., and de Haan, J. (2020). Determinants of 21st-century skills and 21st-century digital skills for workers: a systematic literature review. *SAGE Open* 10:215824401990017. doi: 10.1177/2158244019900176

Van Ryzin, M. J., and Roseth, C. J. (2018). Cooperative learning in middle school: a means to improve peer relations and reduce victimization, bullying, and related outcomes. *J. Educ. Psychol.* 110, 1192–1201. doi: 10.1037/edu0000265

Waite, S., Bølling, M., and Bentsen, P. (2016). Comparing apples and pears?: a conceptual framework for understanding forms of outdoor learning through comparison of English Forest schools and Danish udeskole. *Environ. Educ. Res.* 22, 868–892. doi: 10.1080/13504622.2015.1075193

Wang, Y., Tian, L., and Huebner, S. (2019). Basic psychological needs satisfaction at school, behavioral school engagement, and academic achievement: longitudinal reciprocal relations among elementary school students. *Contemp. Educ. Psychol.* 56, 130–139. doi: 10.1016/j.cedpsych.2019.01.003

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Does growth in the outdoors stay in the outdoors? The impact of an extended residential and outdoor learning experience on student motivation, engagement and 21st century capabilities

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Introduction: Student motivation and engagement underpin educational success, and recent research has found they are lowest in middle high school, especially for boys. At the same time, education systems are recognizing that academic performance is necessary but not sufficient to prepare young people for the adult world, and so-called "21st Century skills" (communication, collaboration, critical thinking, and creativity) have been suggested as critical capabilities across all employment sectors in the future. The Glengarry program is a 6-month residential and outdoor learning experience for Year 9 (14–15 years old) boys at an Australian independent school, The Scots College (TSC) Glengarry. Intentionally located during the lowest point of engagement in their adolescent student journey, the Residential and Outdoor Education experience was hypothesized to boost their motivation and engagement and develop 21st Century skills.

Methods: The Glengarry program involves students living in a boarding-style community for 20 weeks away from their families, participating in classes across all regular school subjects at a bush campus, and undertaking increasingly challenging outdoor education trips each week. The study aimed to measure how these factors transferred into students' traditional school environment after their Glengarry experience. Year 9 was split into two cohorts who both participated in the study: one of which completed the Glengarry program in the first half of 2019, and the other during the second half of the year.

Results: Self-reported quantitative and qualitative data supported the hypothesis that the Glengarry program did indeed, boost student motivation and 21st Century skills. While gains in 21st Century skills endured over the next 8–10 months, motivation and some engagement factors decreased upon return to the traditional school environment. Students described key factors in the Glengarry program which facilitated their development, including: an intense residential environment necessitating social growth, a closer connection with teachers in both school and community life, and an appreciation of learning in the natural environment. Recommendations are made for future research to strengthen these findings, and for how these mediating factors could be incorporated into the regular school environment.

KEYWORDS

student engagement, student motivation, 21st Century skills, outdoor learning, outdoor education

Introduction

While academic grades are the most easily measured metric of educational success, there are important antecedent factors which contribute to students' achievement, and a range of outcomes which describe their holistic development. One such factor is students' sense of engagement, or connection to their learning and the school community. Engagement recognizes that the student is not just an intellectual vessel waiting to be filled, but also needs a positive emotional climate and supportive web of peer and teacher relationships in order for effective and lasting learning to occur. Although educational learning outcomes were previously defined through the narrow lens of academic achievement, there is increasing recognition that young people require a broad set of capabilities to thrive in contemporary society. These proficiencies have been variously defined as "21st Century skills," in an attempt to categorize the human-centric proficiencies thought to be applicable to every profession and industry. The current study seeks to explore the potential of an extended residential and outdoor school program for enhancing student engagement and building 21st Century capabilities, and how these factors endure on return to the traditional school environment.

Student engagement

Student engagement has been described as a multifaceted construct with a myriad of definitions in the literature (e.g., Appleton et al., 2008). At its simplest, engagement is about a significant connection, such as when a couple marks a new level of commitment in their relationship by becoming "engaged" (Yazzie-Mintz, 2006). Students' engagement with their learning has often been defined with behavioral, affective and cognitive dimensions (Fredricks et al., 2004). Behavioral engagement relates to participation in schooling activities; affective engagement describes emotional ties to school created by reactions to peers, teachers and school authorities, and; cognitive engagement relates to a student's willingness to exert effort in order to understand ideas and master skills. An alternate but similar framework includes social (including sense of belonging, participation in voluntary school activities, and positive friendships), academic (attendance and absence frequency) and intellectual (emotional and cognitive investment using higher order thinking skills) dimensions of student engagement (Willms et al., 2009).

The terms "motivation" and "engagement" are both attached to distinct sets of literature, and there is also an intersection between the two sets. Maehr and Meyer (1997) noted that motivational theories had begun to inform educational practice, and Self Determination Theory (Ryan and Deci, 2000) is an example of a prominent psychological conceptualization of motivation which has been applied extensively in educational research (e.g., White et al., 2021). Appleton et al. (2008) argued that motivation is essential to understanding engagement, however engagement is a construct in its own right. In Australian research, Martin (2005) initially described motivation as "students' energy and drive to engage, learn, work effectively, and achieve to their potential at school" and engagement as "the behaviours that follow from this energy and drive" (p. 180), but then used both terms as one phrase in later writing (Martin, 2008a,b, 2009; Martin et al., 2016). A model which synthesizes these theories proposes that student motivation answers the question about the reasons *why* students do what they do at school, as suggested by Appleton et al. (2008). Engagement is concerned with *how* students "do" school (Martin, 2005)—how they cognitively apply learning strategies, how they emotionally feel about being in their school community, and how they behaviorally participate in various school activities (Fredricks et al., 2004). Educational outcomes are *what* results from this cognitive, affective and behavioral engagement with school.

Engagement with the social and learning environment at school has been proposed as an essential condition for effective student development (Abbott-Chapman et al., 2014; Gallup, 2014; Griffiths and Webber, 2017; Mann, 2018), and has been correlated with various educational outcomes. Early research studies conducted in the late 20th Century suggested that students reporting higher engagement tend to earn higher grades, perform better on tests, and drop out at lower rates, and also that lower levels of engagement place students at risk for negative outcomes such as lack of attendance, disruptive classroom behavior, and leaving school early (Klem and Connell, 2004). Appleton et al. (2008) similarly reviewed a range of research studies which established evidence for the connection between engagement, achievement, and school behavior across levels of economic and social advantage and disadvantage. In a study of 11,800 French-Canadian high school students, a global measure of engagement reliably predicted early high school dropout, and behavioral engagement (attendance, completion of classwork and homework, participation in school activities) contributed to this accuracy while affective and cognitive engagement dimensions did not (Archambault et al., 2009). A study of over 78,000 United States students in 160 schools across eight states showed that a 1% increase in emotional engagement (defined as enthusiasm for school) was associated with a 6% increase in reading and an 8% increase in mathematics achievement, while controlled for socio-economic status (Gallup, 2014). A student-voice survey of 272,000 Canadian middle and high school students found that the 40% of students who considered they had high skills and were similarly challenged in their learning (i.e., were intellectually engaged) were less likely to report experiencing anxiety and depression (Tramonte and Willms, 2012). Public school students in NSW who reported higher behavioral engagement (i.e., attentiveness in class and abiding by school rules) in Year 7 were 7 months ahead in reading performance in Year 9 (McCarthy and McCourt, 2017). Analysis of nationally representative data on Australian 12–13 year old students showed that cognitive and affective engagement was a mediating factor of socio-economic status on academic achievement (Tomaszewski et al., 2020). An Australian longitudinal study of 6,600 students aged between 9 and 15 years old found that each unit on a six point affective engagement scale (i.e., enjoyment of school) was associated with a 10% higher chance of completing a post-school qualification, as well as higher status occupations 20 years later (Abbott-Chapman et al., 2014). A recent study in the United States found that cognitive and behavioral engagement levels of senior high school students predicted both college enrolment and persistence (Fraysier et al., 2020). Recognizing its multidimensional nature, student engagement has been shown to significantly contribute to in-school and post-school outcomes.

Although research has shown the importance of student engagement, recent indicators suggest that many Australian students are disengaged, particularly in mid-high school and especially boys

(Goss et al., 2017; Griffiths and Webber, 2017). A Western Australian longitudinal study by Angus et al. (2009) found that 40% of primary and lower secondary students showed consistent unproductive behaviors in class, and that these disengaged students were one to 2 years behind their peers in academic performance. Furthermore, only a quarter of these unproductive students were actively disruptive, while over half were described as compliant but disengaged. A review for the Western Australian government similarly indicated that 25% of 15 year-old Australian students thought that school had not prepared them for adult life, and 22% felt that they did not belong at school (Hancock and Zubrick, 2015). In a measurement of Australian student engagement over the academic lifespan including 23,000 participants, Martin (2009) found that elementary students had the highest level of engagement, followed by university students and that high school students were least engaged. Fifteen year-old students' sense of belonging in school was analyzed across the 38 countries which participated in the 2003 and 2012 rounds of the Program for International Student Assessment (PISA) testing, and Australia had the fifth highest decrease in affective engagement during this period (Organisation for Economic Cooperation Development, 2013). Within Australia, a survey of 79,000 New South Wales students across Year 7–12 showed that sense of belonging, positive relations with teachers and perceptions of teacher expectations were at their lowest in middle high school, which has been coined "the Year 9 dip" (Willms, 2015). This age-related low point in school belonging and aspirations to finish Year 12 was also seen in the same survey 2 years later, and an analysis of gender effects revealed that boys were less likely to aspire to finish high school, aim to go to university, exhibit positive behavior at school, and have positive relationships with their teachers (Griffiths and Webber, 2017). International data similarly shows that boys tend to be less engaged with school in most developed countries (Organisation for Economic Cooperation Development, 2015), and a review of research on gender and engagement reported that boys generally show lower levels of engagement, and behavioral engagement particularly (Lietaert et al., 2014). When considering gender differences in student engagement, it should be acknowledged that these trends do not describe all boys and all girls as homogenous groups (Martino, 2008), and that boys and girls may exhibit engagement or disengagement differently (Griffiths and Webber, 2017).

Willms (2015) argued that "student voice" is one of the best ways to measure engagement, as it directly accesses the social and affective aspects of engagement. Student surveys are an effective method to capture student voice, as they can access a large number of students quickly and cost-effectively. On the other hand biased responses and accuracy of self-perception are drawbacks to student surveys, however these disadvantages can be mediated by triangulating data from student qualitative data and other sources in the school community, such as teachers or parents (McCourt and Griffiths, 2016).

21st Century skills

As we progress through the 21st Century, there is a growing recognition by researchers and governments that school outcomes need to be broader than just academic grades, and should also include meta-cognitive and socio-emotional skills (Lamb et al., 2017; OECD, 2019). These capabilities have always been important, of course, but recent challenges like automation of lower order tasks, globalization of the workforce, rising mental health issues, climate change and mass migration make them particularly relevant to this century (Lambert, 2017). The emerging economic, educational and social ripples of the COVID-19 pandemic can be added to this list of 21st Century challenges (Pendergast, 2022; Mann et al., 2022a; Adams and Gray, 2023). Anderson and Jefferson (2018) suggested that "the skills which equip young people to engage with the world of work are the same skills that will help them live life to the full as 21st Century citizens" (p. 14).

Similar to student engagement research, there are many models of 21st Century skills with varying lists of capabilities (Trilling, 2009; Fullan and Langworthy, 2013; World Economic Forum, 2015; Fadel, 2016; Anderson and Jefferson, 2018; OECD, 2019). Four factors are common to most frameworks: the cognitive skills of creative and critical thinking, and the social skills of communication and collaboration. Creativity refers to divergent thinking which sees problems from new perspectives and encourages playing with possibilities; critical thinking challenges assumptions, asks key questions, and adapts knowledge to new applications; communication includes identification of verbal and non-verbal messaging, conveying meaning and purpose, and enabling agency, and; collaboration incorporates the offering of ideas, shaping of these ideas in an emotionally safe context, and co-constructing new solutions (Anderson and Jefferson, 2018).

Fadel (2016) suggested these higher order skills are essential for students to deeply engage with academic content, and for demonstrating their understanding of disciplinary knowledge. 21st Century skills can be seen in the recent development of a national Australian Curriculum as the General Capabilities of critical and creative thinking, and personal and social capabilities (Australian Curriculum Assessment and Reporting Authority, 2018), as well as featuring in various Australian state curricula (Lambert, 2017). While many educational systems across the world recognize the importance of 21st Century capabilities, there are few examples of how these should be operationalized in terms of specific teaching, learning and assessment strategies (Lamb et al., 2017). In the Australian context, the Australian Council for Educational Research has recently developed a pilot resource for assessing creative thinking, collaboration and critical thinking in a project-based learning context (Scoular et al., 2020).

Research into 21st Century capabilities is only just emerging, and Lamb et al. (2017) described a dense web of overlapping theories in this area. Although some theorists seem to describe 21st Century skills as the panacea for modern education, in fact research is yet to determine whether the skills are specific to a disciplinary domain (e.g., mathematical critical thinking) and the extent to which they may be transferable between domains (Lamb et al., 2017). The connection between 21st Century skills and traditional academic performance is also yet to be rigorously explored, however 21st Century capabilities can stand as useful educational outcomes in their own right rather than simply being valued as mediators of academic progress.

Learning outdoors

The outdoor "*in situ*" environment has been the setting for learning across most of human history (Nicol and Waite, 2020), and the indoor classroom only became the "normal" place of learning with

the advent of mass schooling in the 19th Century (Mann et al., 2021). Contemporary outdoor learning has been classified into two forms (Mann et al., 2022a): outdoor adventure education (OAE), which utilizes challenge and perceived risk to create cognitive dissonance (Priest and Gass, 2005), and curricular-based learning outside the classroom (LOTC) which incorporates student-led experiential learning principles (Beames et al., 2012). Outdoor learning contexts include: school gardens, school playgrounds, local parks and forests, field trips, residential camps and wilderness trips (Mann et al., 2022b). An ample body of research has demonstrated the benefits of both OAE (Gray, 1997; Hattie et al., 1997; McLeod and Allen-Craig, 2007) and LOTC (Becker et al., 2017; Mygind et al., 2019; Miller et al., 2021) across a range of socio-emotional and wellbeing outcomes such as: self-concept, interpersonal skills, mental and emotional health, environmental knowledge and attitudes, learning dispositions and academic progress (Mann et al., 2022b).

School attendance has been considered as a metric of behavioral engagement, and two small studies in the United Kingdom showed improved attendance in vulnerable primary (McCree et al., 2018) and junior secondary (Price, 2015) student groups who undertook student-led and adventurous activities in natural settings. School motivation was directly measured in a larger Danish study of 28 primary classes from 18 schools, which found that regular subject-based LOTC across 1 year improved students' self-reported motivation (Bølling et al., 2018), however there has been little other research into the potential for outdoor learning to boost student motivation and engagement. There is good evidence for OAE and LOTC developing the 21st Century skills of communication and collaboration, and for nature exposure generally to benefit critical and creative thinking, however there is a paucity of research into the potential for outdoor learning experiences to develop these cognitive 21st Century skills (Mann et al., 2022a).

Summary

Student motivation and engagement are essential pre-requisites for school learning, and 21st Century skills are becoming widely regarded as important educational outcomes along with academic knowledge. Learning in natural outdoor environments could be a prime context for both engaging students in learning and growing 21st Century capabilities (Figure 1), however there has been little research to date connecting these areas.

Assuming outdoor learning experiences could enhance student engagement and 21st Century skills, students also need to translate these gains back into their normal school context for enduring growth. Although the last stage of the established framework for experiential learning is active experimentation in a new environment (Kolb, 1984), transfer of learning on OAE programs back into the school environment has typically been a challenge (Sibthorp et al., 2011) and there has been little research into the mechanisms of this learning transfer (Bobilya et al., 2015).

While the research described above has shown strong evidence for OAE developing various self-identity factors, the Glengarry program provides an opportunity to examine the effect of OAE and LOTC on the educationally-focused constructs of student engagement and 21st Century skills. The current study aims firstly to ascertain whether the Glengarry residential outdoor learning program influences students' sense of engagement and 21st Century capabilities, and secondly whether any gains are transferred into their traditional school environment following completion of the program. The following research questions are proposed:

1. Does an extended residential and outdoor program increase student engagement and 21st Century skills?
2. Are changes in student engagement and 21st Century skills enduring once the students return to their normal school environment?
3. What do students perceive are the contributing factors to hypothesized changes in these areas, and their variation over time?

Methods

Background

The Scots College is an independent K-12 boys' school in Sydney, Australia. Students come from affluent socio-economic backgrounds, and most live in highly developed suburban environments. Enrolment is not based on academic performance; however, a small number of students receive academic scholarships. The Glengarry campus of the school is located in a bush environment about 3 h' drive away from the main school, and facilities are comprised of simple dormitory accommodation blocks, classrooms, a dining hall and recreational spaces.

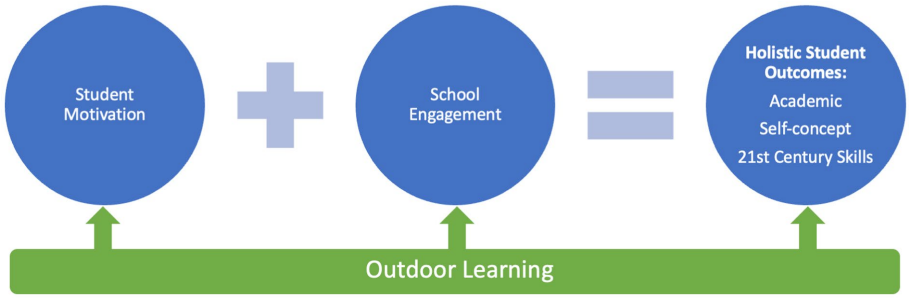

FIGURE 1
Hypothesized boosting effect of outdoor learning on student motivation, school engagement, and holistic student outcomes.

TABLE 1 Quantitative survey administration time points and respondent numbers.

Time point	Intake 1	Respondents	Intake 2	Respondents
1	February 2019 (1 month into Glengarry)	104	February 2019 (5 months before Glengarry)	78
2	August 2019 (2 months after Glengarry)	49	June 2019 (1 month before Glengarry)	75
3	February 2020 (8 months after Glengarry)	82	February 2020 (2 months after Glengarry)	74
4			October 2020 (10 months after Glengarry)	40

The Glengarry program has been running continuously since 1989, and is compulsory for all students in Year 9 (ages 14–15). There are approximately 200 students in each year, and they are assigned to a first or second semester intake to the Glengarry program. Students spend two school terms (about 20 weeks) away from their families at the Glengarry campus, living in dormitories of about 20 boys, participating in regular school classes for 5 days of the week, undertaking regular running and mountain biking activities before and after school, and going on outdoor adventure trips over the remaining 2 days of the week. Peak outdoor adventures occur at the end of the first term (e.g., 4-day hike, 6-h rogaine orienteering competition) and at the culmination of the program (e.g., 3-day solo, 24-h rogaine competition, 6-day "Long Journey Home" hike and bike trip back to the main school). The Glengarry program thus incorporates the outdoor learning forms of OAE through the formal outdoor adventure trips, and LOTC to the extent that teachers choose to take their classes outdoors. The residential nature of the program is also an important element of the program, facilitating development of relationships with peers and teachers.

Study design

The 2019 cohort of Year 9 Glengarry students were followed before, during and after their two-term outdoor learning program, and the experience of Intake 1 students was compared with a waitlist group (Intake 2) who undertook the Glengarry program 6 months later. Engagement and 21st Century skills surveys were administered to students at key time points, with respondent number for each survey detailed in Table 1. Practical constraints prevented survey 2 being administered to both intakes simultaneously, with Intake 1 unavailable in June 2019 while away on peak adventure trips.

A focus group was conducted with six students from each intake in the month after they completed their final quantitative survey. Purposive sampling was used to randomly select three students from those with high quantitative engagement scores and three from those with low scores from each intake. The focus groups followed a semi-structured design utilizing pre-determined questions around the key themes of engagement and 21st Century skills, and also with capacity to follow matters raised by the students.

This mixed method design enabled a quantitative exploration of student-rated student engagement and 21st Century skills over time, as well as a qualitative student reflection on the contributing factors behind these changes. Creswell (2015) defined this approach as an explanatory sequential design, where quantitative measures are first used to identify the breadth of an effect and then qualitative methods help to explain these results in more depth.

Participants

The first semester Glengarry intake of 2019 was comprised of 108 boys, who participated in the program between February and June with a 2-week school holiday break in April. The second semester intake of 102 boys undertook regular classes at the main school during the first half of 2019, and could be regarded as a "waitlist" group before participating in the Glengarry program between July and December (with a 2-week school holiday break in October). Rather than the school allocating students to either intake using any single factor (e.g., academic ability, effort grades, or sport team), consideration was given to achieving a broad mix of students in each intake. A small number of students were allocated to a particular intake to fit in with elite sporting commitments. The average student age in February 2019 was 14 years and 6 months for Intake 1, and 14 years and 5 months for Intake 2.

Because the Glengarry program is compulsory for all Year 9 students, participation in the research study did not involve any additional intervention except completing surveys at four time points across 2 years. Students and their parents were informed in writing about the study requirements and given opportunity to opt out before the study began, and students were given this same opportunity to opt out at the start of every survey. Time was allocated during pastoral lessons to complete each survey. No students were excluded from participation in the study. Survey data was de-identified by usage of an identification number to link student data across surveys. Purposive sampling was used to identify candidates for a focus group of six students from each intake, representing high and low levels of engagement. Participation in a focus group was voluntary, and some students declined and were replaced from the high or low engagement list. Ethics approval for the study was obtained from the University of Western Sydney (H13009).

Instruments

Motivation and engagement scale

The Motivation and Engagement Scale (MES) is an Australian instrument originally developed by Martin (2007) and validated across a range of student contexts and age groups. In psychometric testing with over 12,000 students across 38 Australian high schools, the MES instrument has shown within and between network validity, internal consistency (Cronbach alpha coefficients over 0.7), and invariance across gender and school year levels (Martin, 2007). The MES has since been utilized in university, workplace, music and sport settings (Martin, 2008b), and across the academic lifespan (Martin, 2009). The MES contains 44 items representing 11 self-reported dimensions, including six motivation factors (learning focus, valuing, self-belief, anxiety, failure avoidance, uncertain control) and five engagement factors (planning and monitoring, task management, persistence, disengagement, self-sabotage).

21st Century skills scale

In the absence of a psychometrically validated instrument in the academic literature which measures self-reported 21st Century skills, a 16 item 21st Century Skills Scale (21CSS) was developed based on the four core capabilities (communication, collaboration, creativity, critical thinking) proposed by Fadel (2016) and present in most 21st Century skills frameworks (refer to Introduction). Four statements were written for each skill area, synthesized from the Center for Curriculum Redesign (2019) subcategories, with seven point Likert-style response options for consistency with the MES. The prototype 21CSS instrument was piloted with 71 participants in the case study school, and the wording of one item was adjusted based on their feedback of understanding the questions. Table 2 shows that correlations between items within each skill area were in the moderate range (0.3–0.59) for the prototype instrument, according to Cohen (1988). In terms of reliability, the 21CSS instrument had an overall Cronbach Alpha value of 0.88, and individual skills were above 0.6 (see Table 2). Pallant (2010) recommended that Cronbach alpha coefficients should ideally be above 0.7, however noted that the statistic is sensitive to the number of items in a scale and that coefficients can be lower in shorter scales. The baseline administration of the final 21CSS survey revealed similar moderate inter-item correlations for each intake group respectively: creativity (0.25, 0.35), critical thinking (0.38, 0.37), communication (0.40, 0.45) and collaboration (0.39, 0.29). Based on these correlations, the 21CSS was considered to have sufficient validity as a self-report measure of the four identified 21st Century skills.

TABLE 2 21st Century Skills Scale correlations and reliability.

21st century skill	Mean inter-item correlation (Pearson's co-efficient)	Reliability (Cronbach's alpha)
Creativity	0.34	0.67
Critical thinking	0.37	0.71
Communication	0.38	0.71
Collaboration	0.32	0.64

Results

The findings of this study are arranged into quantitative sections which respond to the first two research questions, and a qualitative section which addresses research question three.

Quantitative findings

IBM SPSS Statistics (Version 27) was used for statistical analysis of quantitative data. Survey data points were arranged into a row for each student, which allowed analysis of within-subject comparison over time. Survey response rates were fairly consistent across time points, apart from a dip in Intake 1 responses at time point 2 and Intake 2 responses at time point 4 (Table 1). A simple *t*-test strategy for statistical analysis was used to compare the same group over two time points (within subjects) or the two intake groups across the same time point (between subjects). Statistics for each t-test are based on the cases with no missing or out-of-range data for any variable in the analysis. Prior to t-tests being undertaken, a histogram was produced for each variable at each time point to check for normal distribution.

Quantitative data from intake 1

The first two research questions concerned the quantitative changes in self-reported student motivation and engagement and 21st Century capabilities during and after the Glengarry extended residential and outdoor program. In summary, most 21st Century skills increased after the Glengarry program, and then remained static over the following 6 months back at school (refer to Figure 2).

In contrast, Figure 3 shows that positive motivation decreased and negative motivation and engagement factors increased once students

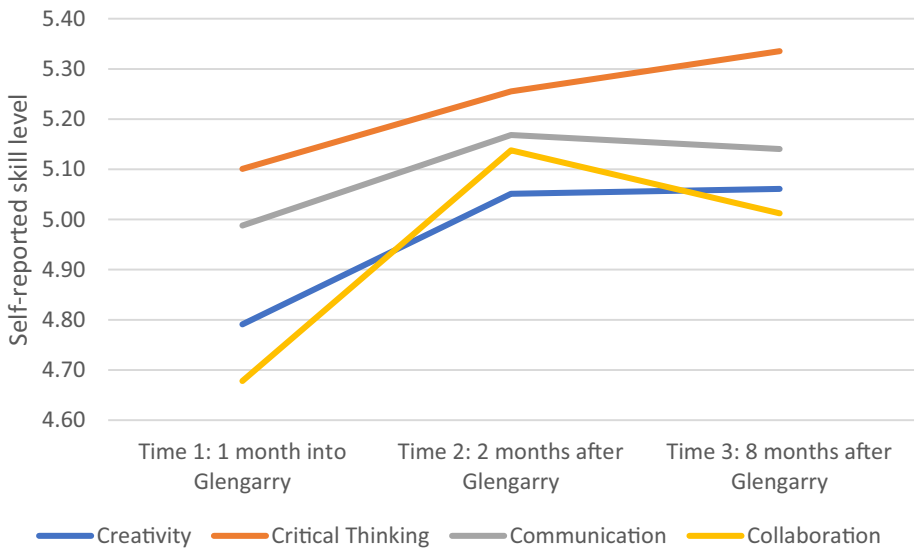

FIGURE 2
Intake 1 self-reported 21st Century skills at various time points.

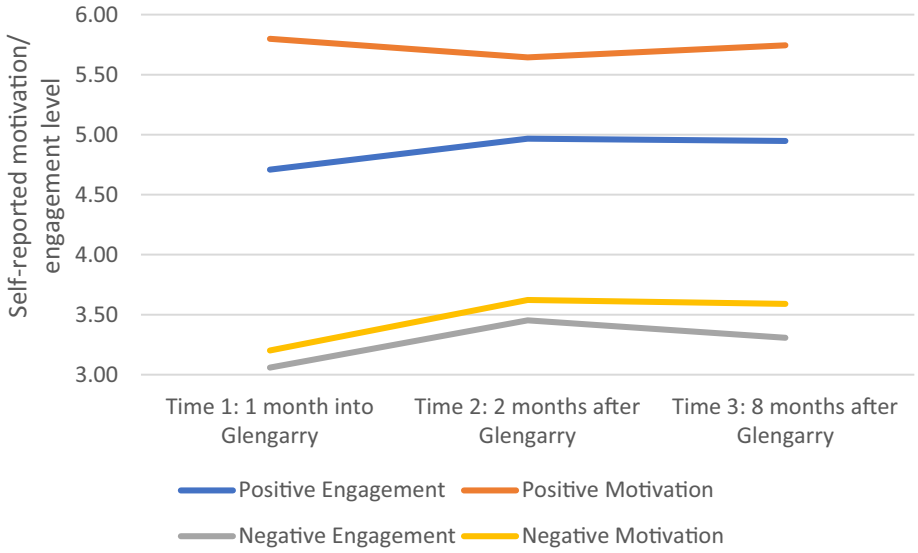

FIGURE 3
Intake 1 self-reported engagement and motivation at various time points.

returned to school, and similarly were unchanged over the next 6 months (except for positive motivation which recovered to its previous level).

Table 3 shows these changes in more detail with statistically significant differences at the $p < 0.05$ level indicated in bold. Between the start of the Glengarry program and 1 month afterwards (Time 1–2), Intake 1 students significantly increased in self-rated creativity, communication and collaboration, although perceived levels of critical thinking were unchanged. In contrast, once students had been back at school for 2 months, they felt significantly less positive motivation, including focus on learning ($p = 0.027$), and more negative motivation specifically focused on avoiding failure ($p = 0.026$). Positive engagement skills were unchanged after the Glengarry program, however students reported significantly more negative engagement strategies including disengagement ($p = 0.021$) and self-sabotage ($p = 0.001$).

Between 1 and 8 months in their normal school routine after Glengarry (Time 2–3), the levels in self-rated 21st Century skills of Intake 1 students had plateaued, and there was no significant change in any of the four skill areas. In terms of positive motivation, students felt significantly more motivated about their interest in learning ($p = 0.008$) and ability to do well at school ($p = 0.002$), however their level of negative motivation (anxiety and control over their performance), their positive engagement skills (e.g., persistence, planning and time management), and the level of self-sabotage and disengagement remained unchanged.

Finally, when looking from the start of their Glengarry experience to 8 months afterwards (Time 1–3), Intake 1 students reported a significant increase in all 21st Century skill areas apart from communication. In other words, their improvement in creativity and collaboration after Glengarry endured, and while critical thinking did not significantly change over the first two time periods (Time 1–2 and Time 2–3) there was an overall significant increase from the start of Glengarry to 8 months afterward (Time 1–3). The initial significant increase in communication skills during Glengarry (Time 1–2) then underwent a slight (but not significant) decrease in the post-Glengarry (Time 2–3) period, resulting in a non-significant increase over the whole study (Time 1–3). There was an overall significant rise in negative engagement and negative motivation factors upon the students return to school, and these stayed similarly depressed over the next 7 months (Time 2–3) resulting in an overall decrease across the study (Time 1–3).

Positive motivation was unchanged over the duration of the whole study (Time 1–3), after an initial drop (Time 1–2) and subsequent rise (Time 2–3). Positive engagement (especially planning skills; $p = 0.019$) significantly increased over the whole measurement period (Time 1–3) even though there were no significant changes in the first two-time intervals (Time 1–2 and Time 2–3).

Supporting quantitative data from intake 2

During the same 6-month period that Intake 1 students went through the Glengarry program, Table 4 shows that Intake 2 students (of very similar age and maturation) experiencing regular schooling did not record any significant changes in 21st Century skills or (positive or negative) engagement and motivation factors (Time 1–2).

Similarly to Intake 1, the positive motivation of Intake 2 students was significantly lower after Glengarry than 6 months beforehand [and specifically the subscales of learning focus ($p = 0.032$) and self-belief ($p = 0.036$)] and there was no change in positive engagement skills (Time 1–3). Intake 2 did not show the same statistically significant increases in negative motivation or engagement after their return to school as did Intake 1 (Time 1–3), however there was an increase in these means (0.25 and 0.15 respectively) indicating a similar trend of lower motivation and engagement. Intake 2 students did not report any significant change in 21st Century skills from 5 months before Glengarry to 2 months afterward (Time 1–3). Between 2 and 10 months of being back at school, Intake 2 students followed a similar pattern to Intake 1 of no significant differences in outcome variables (Time 3–4).

TABLE 3 Intake 1 quantitative changes over time (significant changes at p <0.05 level in bold).

	Creativity	Critical thinking	Communication	Collaboration	Positive engagement	Positive motivation	Negative engagement	Negative motivation
Time 1–2	**Increase $p = 0.000$**	No change $p = 0.416$	**Increase $p = 0.046$**	**Increase $p = 0.007$**	No change $p = 0.118$	**Decrease $p = 0.018$**	**Increase $p = 0.005$**	**Increase $p = 0.018$**
Time 2–3	No change $p = 0.869$	No change $p = 0.333$	No change $p = 0.679$	No change $p = 0.640$	No change $p = 0.595$	**Increase $p = 0.023$**	No change $p = 0.724$	No change $p = 0.595$
Time 1–3	**Increase $p = 0.023$**	**Increase $p = 0.028$**	No change $p = 0.224$	**Increase $p = 0.003$**	**Increase $p = 0.049$**	No $p = 0.494$	**Increase $p = 0.030$**	**Increase $p = 0.002$**

TABLE 4 Intake 2 quantitative changes over time (significant changes at p <0.05 level in bold).

	Creativity	Critical thinking	Communication	Collaboration	Positive engagement	Positive motivation	Negative engagement	Negative motivation
Time 1–2	No change $p = 0.739$	No change $p = 0.266$	No change $p = 0.282$	No change $p = 0.295$	No change $p = 0.102$	No change $p = 0.501$	No change $p = 0.541$	No change $p = 0.928$
Time 1–3	No change $p = 0.525$	No change $p = 0.312$	No change $p = 0.613$	No change $p = 0.746$	No change $p = 0.079$	**Decrease** $p = 0.024$	No change $p = 0.637$	No change $p = 0.189$
Time 3–4	No change $p = 0.385$	No change $p = 0.730$	No change $p = 0.956$	No change $p = 0.736$	No change $p = 0.885$	No change $p = 0.812$	No change $p = 0.500$	No change $p = 0.344$

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TABLE 5 Differences between Intakes at similar durations before and after Glengarry (significant changes at $p < 0.05$ level in bold).

	Creativity	Critical thinking	Communication	Collaboration	Positive engagement	Positive motivation	Negative engagement	Negative motivation
1 month before/ into Glengarry	**Yes $p = 0.025$**	**Yes $p = 0.013$**	**Yes $p = 0.005$**	**Yes $p < 0.001$**	**Yes $p = 0.015$**	No $p = 0.970$	No $p = 0.713$	No $p = 0.707$
2 months after Glengarry	No $p = 0.401$	No $p = 0.922$	No $p = 0.733$	No $p = 0.881$	No $p = 0.096$	No $p = 0.689$	No $p = 0.254$	No $p = 0.676$
8–10 months after Glengarry	No $p = 0.944$	No $p = 0.406$	No $p = 0.242$	No $p = 0.320$	No $p = 0.082$	No $p = 0.890$	No $p = 0.380$	No $p = 0.333$

In summary, while Intake 2 students did not report significant gains in 21st Century skills from 5 months before Glengarry to 2 months afterward, small decreases in motivation and no change in positive engagement after Glengarry were similar to Intake 1. The levels of 21st Century skills, motivation and engagement reported by Intake 2 students did not change in the subsequent 8 months of school, matching Intake 1 results for the same post-program period.

T-tests comparing the two student groups at the same time relative to their Glengarry experience (Table 5) showed that Intake 2 students reported significantly higher 21st Century skills and positive engagement before the program, whereas there was no difference between intake groups in three of the four motivation and engagement factors. Even though Intake 2 had higher reported baseline levels of 21st Century skills, there were no significant differences between intakes both 2 months and 8–10 months after their Glengarry experience.

Summary of quantitative results

The first research question in this study concerned whether the Glengarry residential and outdoor program had an effect on the target variables of motivation, engagement and 21st Century skills. The quantitative data from Intake 1 clearly supported the hypothesis that 21st Century skills increased during the program, and the lack of significant changes for Intake 2 across the same time period confirmed that this change was not simply due to maturational development. Intake 2 students did not report significant gains in 21st Century skills across the program period, however their pre-program levels were high compared to those of Intake 1.

The second research question enquired whether these increases at Glengarry were enduring after return to the normal school environment, and the quantitative data suggested a more complicated pattern of change. Three of the four 21st Century capabilities increased during the Glengarry program for Intake 1 students and remained at these elevated levels for the next 8–10 months in the standard school setting, and while the increase of the fourth skill area (communication) did not achieve statistical significance across the Glengarry program it was significantly higher 8 months afterwards. In contrast, while positive engagement was unchanged for both intakes after 2 months back at school, there were significant decreases in positive motivation (both intakes) and increased negative engagement and motivation (Intake 1). In the following 6–8 months at school, the dip in positive motivation reported by Intake 1 students returned to its original level, however there were no changes to other 21st Century skills and engagement and motivation factors for both intake groups.

Qualitative insights

Research question three sought to explore the contributing factors to the quantitative changes recorded above, by means of semi-structured focus groups with students from each Glengarry intake. The two focus groups were conducted with a representative sample of students with low and high engagement, and provide deeper understanding of the quantitative results through hearing student voice. Two collaborators (the first author and an independent education researcher) were provided with a list of the *a-priori* factors of motivation, engagement and 21st Century skills, and separately coded the focus group transcripts. The two first round code lists were then consolidated into a master code list, and the same collaborators

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TABLE 6 Qualitative codes and themes, with Kappa coefficient of inter-rater agreement.

Theme	Code	Kappa coefficient
Social capacities	Communication	0.85
	Collaboration	0.71
Cognitive capacities	Creative thinking	0.91
	Critical thinking	0.89
Engagement	Agency in learning	0.68
	Connection with natural environment	0.89
	Connection with peers	0.91
	Connection with teachers	0.88
	Enjoyment of learning	0.94
	Pressure in learning	0.95
Personal change	Personal development	0.90
	Transfer of learning	0.93

again coded the transcripts independently using this master list. Discrepancies in second round coding decisions were discussed, and coding adjusted in some cases, resulting in an overall Kappa coefficient of 0.87. Table 6 shows an excellent (>0.75) level of agreement for all codes except collaboration and agency in learning, which were both in the higher end of the good (0.40–0.75) agreement range. The 12 codes were arranged into four themes, described below.

Theme 1: Social capacities

Students frequently mentioned the social capacities of communication (39 references) and collaboration (39 references). The experience of living closely together was positive for most students, but importantly they thought it necessitated the development of social capabilities. One student described *"you had to learn, um, like, how to interact with people that you do not choose to be around."* This included dealing with conflict, as it was not possible to get away from peers at the end of the day like at school—*"with your dorm mates, instead of just, um, like, conflicting with someone, you could actually, like, talk it out maybe. And just, um, understand where everyone is coming from, because everyone is coming from different places in life."* Outdoor activities also provided opportunities to develop social aptitudes, *"for example rock climbing, you have got two people down the bottom ensuring that you are not falling from a bloody wall, and so obviously you need to communicate between them how to be responsible."* Collaboration and communication were regarded by students to be less important in normal school life, as classroom learning was perceived to have more of an individual focus. One student described: *"Once you go back to school, um you do not get as many opportunities to work together, and especially, like, going from Glengarry with 100 people back to a school with 1,000 people—um, it's a lot more individual based, not community based, because it's so much larger."*

Theme 2: Cognitive capacities

Cognitive capacities were referenced slightly less frequently (20 references for creative thinking and 25 for critical thinking) but were still a major theme for students. There were mixed opinions as to the extent that their Glengarry experience developed creativity, however students agreed that hikes and solo camping facilitated creative thinking, at least in part because there was time to reflect: *"on hikes, there's just a lot of time by yourself, just thinking, and then you get to really be creative about how you spend that time. For example, like, thinking about some possible, a novel or something. And there's, just, like, a lot of time to think about that compared with at school."* Students suggested that adventure activities with open-ended challenges promoted critical thinking skills, including hikes, rogaine, solo, and even putting up tents. *"The environment they put you in is quite natural – it's not really something you can just be given a textbook to read about. They just, like, put you in situations, and, well I guess you think and adapt to what happens."* Students perceived that there is opportunity to be creative at school across most school subjects, and particularly the humanities. Critical thinking was said to be useful in everyday life, and could be applied to strategies for academic study habits.

Theme 3: Engagement

The most prominent factors which made Glengarry engaging to students were the close connections with peers (48 references) and teachers (36 references). Although the social environment was intense, it built a rich sense of community which most students greatly valued: *"just being with those same people, like, in the same dorm,* [meeting] *at the flagpole, on hikes and through all of that, um, like, it was thick with real community, that you just cannot get back here."* Students reported that this resulted in growth of social skills, conflict management strategies, self-confidence and increased ability to make new friends. Connection with teachers at Glengarry was no less significant, as one student described: *"I feel like I felt a lot more connected because again like, you are a lot more, like, emotionally connected with the teachers, and you are kind of like friends with them, and it is just so much easier to have a conversation with them."* Seeing the teachers across different parts of Glengarry life contributed to this deeper sense of connection—*"what happened outside the classroom, like, made the relationship stronger between teachers and students"*—and the inverse was true back at school: *"Up here in Bellevue Hill* [main school campus], *it's a bit harder because we just see the teachers in the classroom and then we might see them around school but that's about it."* There was also a perception that teachers were less directive at Glengarry, which allowed greater student agency in learning: *"they did not really focus too much on teaching – they just answered your questions."*

Connection with the natural environment was an unexpected finding, with 30 references across the two focus groups even though the topic was not raised by the interviewer. Students appreciated the opportunity to live in a natural environment and felt more connected to nature, as one student described—*"I think I just loved the whole outdoor experience, like, it's pretty surreal."* When it came to their academic work, boys enjoyed hands-on learning in the outdoors and preferred this even to using screens inside the classroom. Some students expressed that outdoor learning was not only a fun experience but also more effective for learning—*"my science teacher, often he'd take us outside to learn, and actually I enjoyed it a lot more, because I felt like I was getting more out of it. And it was just better, nicer, being out, like, with nature."* One student summarized: *"to round up everything we said, I reckon we should do more outdoor activities and more, kind of, nature-based things. Like, not sitting in classrooms on laptops and stuff."*

According to students, the learning culture at Glengarry was more relaxed and less stressful (27 references). One commented that *"at*

Glengarry it's more laid back, and you have a lot of time" and another replied *"Yeah, school at Glengarry was like a lot less formal."* A third student was quick to point out that this relaxed environment wasn't because little schoolwork was undertaken: *"I would not say that it is easier. It's a lot different, like there is different components of it that, like, I have never done…we studied 4 texts in one term you know."* Students described that the informal culture was influenced by: no homework, self-driven learning, more time, less formal classroom norms, no uniform requirement, closer relationship with teachers, and less rules. They categorically saw subsequent school life as more pressured, however were fatalistic about school becoming more stressful in senior years—*"going from Year 8, and then Year 9 and 10, and then into Year 11 and 12, it's kind of like a really big ramp up in, like, the stress, and how much you have got to learn, and so I think in Year 9 going to Glengarry gives you like a break before, like the calm before the storm."*

Theme 4: Personal change

The last identified theme was personal change, with personal development and transfer of learning codes both referenced frequently in the focus groups (33 and 34 references respectively). Students described understanding themselves and others better at Glengarry, and appreciating opportunities beyond school life. One student reflected: *"I learnt a lot about different people. And so, understood what, how people thought, how they acted, a lot more, and throughout Glengarry that I, like, shifted how I treated them, kind of, like, how they acted as well, and I kind just understood them a bit more, I guess."* Students talked about growing in maturity, and specifically: self-management skills, self-confidence, good habits, and healthy diet. For example: *"I do not know if it was just 'cause I got older, but I feel, down at Glengarry, I became more mature, and like, I feel like with maturity you get a better understanding of what's important – what you find important."* The school holidays provided a break after the intensity of Glengarry, and some students made personal changes during this time. Others described that it took them some time to get used to the routines of school: *"over the summer holidays I think we just tried to put our minds to rest. And then when we came back here, we were pretty slow."*

In terms of transferring their learning from Glengarry to subsequent school life, students mentioned maintaining a greater confidence in learning, the ability to make new friends, and a healthier diet. One clearly articulated the connection between learning from a navigational adventure activity and the application of this learning in an academic context: *"with the rogaine, we have to plan out the best possible path. And like up here with studying you probably also have to plan the best possible way of studying."* Not all gains made at Glengarry were transferred back into normal school life, as some students considered that the 21st Century skills they had learned at Glengarry were not needed as much at school. While a number of students felt that they could approach teachers for help more confidently, others thought that they were not able to ask questions as easily to teachers back at school. *"Like up here, it would be a lot harder to say like, oh sir, could you help me, and maybe after school down there they would help you out with something as well, but here you cannot really do that."* In general, however, students considered that the skills they developed at Glengarry were useful for their subsequent school life: *"I think Glengarry helps create those skills, and then, coming back to Bellevue Hill, that's just ensuring those skills are there. And so, you know, I think it's important that we take these things from Glengarry, but ensure that they are all relevant to how we spend our last years at Bellevue Hill."*

Summary of qualitative findings

Research question 3 aimed to explore students' insights about the factors behind changes in 21st Century skills, motivation and engagement levels. Adventurous activities and an intense social environment were seen to drive the social capacities of communication and collaboration, whereas normal schooling was regarded to be more individually focused. The presence of open-ended situations in OAE was regarded to develop critical thinking skills, and space to think (for example while hiking) helped to build creativity.

The close connection with both peers and teachers at Glengarry was the strongest contributing factor to student motivation and engagement, including opportunities to interact with teachers in different contexts outside the classroom environment. Students found the more informal classroom culture engaging, and contrasted this with an expected ramp up in stress during their senior high school years. A closer connection with the natural environment was an unexpected driver of student engagement, and was even preferred to learning with digital devices which are typically enticing for boys.

Students considered that they had grown in maturity over the Glengarry program, and described development in self-awareness and understanding of others. Students generally felt that they could transfer skills learnt at Glengarry into their subsequent school life as needed, however were less confident about transferring their relational skills to teachers whom they only saw for shorter periods in the normal classroom context.

Discussion

Both quantitative and qualitative data support the hypothesis that the Glengarry program boosted 21st Century skills and student motivation, however while students' estimations of their personal skills remained high their motivation decreased on return to school. The immediate post-program levels of 21st Century skills, motivation and engagement generally endured over the next 8–10 months at school, both for Intake 1 students as they completed Year 9 (while Intake 2 was at Glengarry), and for both intakes back at school together in Year 10. These results are discussed in terms of the outcome variables, limitations of the study and recommendations for future research.

21st Century skills

Both in Australia (Lambert, 2017) and internationally (Organisation for Economic Cooperation Development, 2012), 21st Century skills have been recognized as important educational outcomes. However, there has been little policy advice or research evidence on how to effectively grow these capabilities (Lamb et al., 2017). This study demonstrates that challenging and open-ended OAE experiences in a rich social context builds the 21st Century skills of communication, collaboration, creativity and critical thinking, and that these gains can be maintained over time on return to the traditional school environment. It is acknowledged that the quantitative data across the program period did not show the same significant increase in 21st Century skills for Intake 2 students (Table 4) as for Intake 1 (Table 2), however comparison of the two groups prior to the program revealed that Intake 2 already had high

self-reported levels of these capabilities (Table 5). Moreover, after Intake 1 gains across the Glengarry program, the two groups then had no statistical difference in their 21st Century skill levels 2 and 8–10 months later (Table 5). Even though there was no statistically significant increase in Intake 2 levels of 21st Century skills, students from this intake qualitatively described situations at Glengarry which had facilitated growth of all four 21st Century skills.

The only 21st Century competency which did not show a quantitatively significant improvement for Intake 1 after the Glengarry program was critical thinking, and yet students described in focus groups how various open-ended challenges and risk decisions at Glengarry required this 21st Century skill. Interestingly, students in the focus groups were less effusive about the development of creativity than critical thinking skills during Glengarry, whereas the quantitative data showed a significant increase in the former 1 month after the program but not the latter. There is only minimal evidence in the research literature for OAE improving critical and creative thinking, however this is due to a paucity of research with these outcome variables rather than findings of no change (Mann et al., 2022a). While a change in critical thinking may not have been sufficiently large to achieve statistical significance straight after Glengarry, there was a significant increase in perceived critical thinking between the start of Glengarry and 8 months afterward. As one student put it: *"I think critical thinking continually develops – it does not just, like, go up at Glengarry and just, I do not know, flatline. It's something you, like, keep on building, like, through experience throughout your life."* Perceived communication skills were significantly higher after Glengarry (Table 3) but then dipped slightly in the following 8 months at school, causing a non-significant change between Time 1–3. These quantitative changes match the students' qualitative perception that communication skills were vital at Glengarry but not as important to individually-focused achievement at school.

Motivation and engagement

Student motivation and engagement followed a different pattern over time to 21st Century skills, in that these factors generally decreased once students returned to school. Students' sense of their positive engagement skills (planning, task management, and persistence) was largely unchanged; however, they were prone to feel less positively motivated and more detached from school while investing minimal effort in their school work (negative motivation). Intake 2 students did not record the same statistically significant deterioration in most motivation and engagement factors, however means trended in the same direction as Intake 1 showing an initial decrease after return to the normal school environment. Focus group comments indicated that students were able to internalize personal skills developed by Glengarry-specific experiences and could apply them to other environments, which is line with previous OAE research (e.g., Bobilya et al., 2015; Beames et al., 2020). In contrast, students' sense of connection to school and learning seemed to be linked to the context they were in, and therefore changed once they returned to the main school environment. While there has been some research exploring the effect of regular short outdoor learning experiences on student motivation and engagement (e.g., Ruiz-Gallardo et al., 2013; Bølling et al., 2018), Richmond et al. (2018) noted that there is surprisingly little research on the effect of OAE experiences for student learning outcomes. Their study in an all-girls independent school in the United States found that annual multi-day OAE programs developed emotional engagement with school seen through increased rapport between students and with teachers. Additional research is required to explore whether the high level of engagement and motivation on OAE programs can be transferred back to the traditional school environment, and under what conditions.

Intake 1 students returned to traditional school learning for the second half of Year 9 while Intake 2 completed the Glengarry program, then the whole year group was back at school for the start of Year 10. It is possible that Intake 1 students showed no change in motivation, engagement and 21st Century skills over the first half year at school (between Time 2–3) because they were in limbo while they waited for the rest of the students to begin Year 10 together, but then may have experienced an uptick in the target variables once Year 10 was underway. The last measurement of Intake 2 students provides some clarification of this hypothesis, as it would show change between February and October of Year 10 (Time 3–4), however there was no significant change in 21st Century skills, engagement nor motivation across this period. These findings support the Intake 1 data which shows a lasting improvement in 21st Century skills, and a rise in motivation and engagement during Glengarry followed by a dip on return to the normal school environment.

Motivation and engagement were conceptualized by Martin (2007) as two inter-related constructs, yet students in the current study rated them differently after their Glengarry experience. In Martin's model, positive engagement is linked to student skills (e.g., planning, task management, persistence) and these did not change after Glengarry. Negative engagement, on the other hand, describes how disengaged a student feels toward school, which was more prominent on return to the normal school environment. Positive motivation describes how a student sees themselves as a learner (e.g., self-belief, value placed on learning), and this recovered after an initial drop. Negative motivation rose after Glengarry and stayed elevated over the next 8 months, indicating that students were more anxious and felt less control in their normal school environment even though they had experienced a higher locus of control at Glengarry. In summary, students perceived that they developed learner capacities during their Glengarry experience, but upon return to the normal school context they felt less motivated about why they were at school and its relevance to them. One student described how he felt about school almost a year after Glengarry: *"My connection to school is just, I do not know, like, I come in and, like, go to school, like, learn some stuff, like, have fun with friends, and just go back home."*

Some teachers at the case study school have anecdotally expressed that the Glengarry experience is unhelpful for students because a number come back less motivated than beforehand, which is line with the quantitative findings of this study. However, it is argued the spotlight should be on factors in the school environment that are demotivating for students, rather than removing the outdoor learning experience which raised their motivation. Students described that the significant motivational factors at Glengarry included their close relationship with peers and teachers, an increased connection to the natural environment, and a less formal classroom environment. Future research should explore how these factors can be incorporated

into the normal school context, in line with literature on the importance of social facilitators of engagement (e.g., Furlong and Christenson, 2008; Lietaert et al., 2014) and international evidence on the benefits of outdoor learning (Mann et al., 2022b). Additionally, further research could investigate intentional strategies to maximize transfer of learning from OAE environments to the normal school context (Bolick et al., 2022).

Limitations

A noteworthy strength of this study design was the benefit of intervention and waitlist groups which were matched in age, sex, and socio-economic status, in contrast to the OAE literature which sometimes lacks rigor in research design (Mann et al., 2022b). For example, Intake 1 showed gains over the outdoor program period (Table 3, Time 1–2) while Intake 2 did not show any significant changes over the same time period at school (Table 4, Time 1–2). Having said this, responses were much lower at two points which raises concerns over the validity of quantitative results at these time points (Table 1). Although the Intake 1 response rate was lower immediately after Glengarry, there were no significant differences in any target variables between the two intakes on their return to school (Table 5) and almost all Intake 1 significant changes from the Glengarry program endured across the next 8 months to time point 3 (Table 3) which had a higher response rate, indicating that time point 2 results were representative despite the lower number of responses. Intake 2 showed a similar drop in responses at time point 4 (10 months after Glengarry), and the validity of this data can be similarly be supported by the lack of any significant differences within Intake 2 between time points 3–4 and between the intakes 8–10 months after their Glengarry experience (Table 4).

A potential confounding factor in this study design was the two intakes had different levels of 21st Century skills and/or motivation and engagement from the start, even though they were not intentionally selected on the basis of these factors. Table 5 shows that Intake 2 students did indeed perceive their 21st Century skills and positive engagement to be significantly higher than Intake 1 immediately before the Glengarry program, which offers an explanation for why they did not significantly increase across the program period. Although Intake 1 students started with lower self-reported 21st Century skill levels, these rose across the program period to match Intake 2 such that there were no significant differences between the student groups either 2 or 8–10 months afterwards. Moreover, Intake 2 quantitative data showed the same trend (although not reaching statistical significance) of a slump in motivation and engagement after their initial return to school. From these observations, it can be concluded that similar program effects were taking place for both student intakes even though their baseline characteristics varied.

The authors acknowledge the quantitative instrument used to measure 21st Century skills had not been fully psychometrically validated, and recommend that such a process be undertaken for future research. Both quantitative instruments relied on student self-perception of 21st Century skills and motivation/engagement, which has been recommended as an effective methodology (Willms, 2015) but also has some limitations. An observer (for example a teacher) may have noticed changes which were not apparent to the students themselves, or countered a student's perception that they were changing in a particular area. Also, students' benchmarks may have increased as they got older, meaning that their self-expectations may have been higher in later measurement time points. This could potentially account for the decrease in student motivation; however, it would not explain that the students' perceived engagement remained fairly static and 21st Century skills increased. Further research in this area could certainly benefit from a design which gathers and compares data from students, teachers and parents (McCourt and Griffiths, 2016). The construct validity of the MES has been demonstrated across various participant ages and contexts (Martin, 2008b, 2009). While the 21CSS is based on an established theoretical framework (Fadel, 2016), and the current study triangulated it with qualitative data sources, the 21CSS could undergo further construct validity testing as part of a comprehensive psychometric validation process (as suggested above).

Conclusion

This study sought to provide evidence to respond to three research questions. The first was around whether the 6-month Glengarry residential and outdoor program increased Year 9 boys' self-rated motivation, engagement and 21st Century skills, and both quantitative and qualitative data supported the benefit of the Glengarry program in all these factors. The second question asked whether these gains were maintained on the students' return to their normal school context and for the next year, and the data painted a more complex picture of these changes. The gains in 21st Century capabilities were evident in the first month back at school, and endured over the next 8–10 months. Positive engagement skills (planning, task management, and persistence) remained stable in the year after Glengarry, but students' motivation decreased on their initial return to school and then partially recovered after 8–10 months. These effects were not simply due to maturation, as they were not mirrored in the waitlist Intake 2 cohort who experienced a normal semester at school at the same time. Nor were they due to inherent differences between the two intakes, as Intake 1 started with lower levels but there were no significant differences between groups at both 2 and 8–10 months after Glengarry. The third question enquired about contributing factors to the gains in outcome variables, and qualitative data revealed that students perceived connections with peers, teachers and the natural environment were key environmental factors which boosted 21st Century skills and motivation at Glengarry.

The challenge arising out of this study is how these key factors can be incorporated into a standard high school experience for every student. Further research could explore how the connections with peers, teachers and the natural environment could be integrated into current models for schooling; which specific elements of OAE and LOTC effect student gains in engagement and 21st Century skills; how boosted engagement and motivation levels on outdoor learning programs can be transferred back to the traditional school context; and, whether these gains could be achieved on shorter outdoor learning programs.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by Western Sydney University (H13009). Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

JM, TG, and ST contributed to the study design. JM collected and analyzed data and wrote the first draft of the manuscript. TG and ST helped to reshape the manuscript and expand the literature review. All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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References

Abbott-Chapman, J., Martin, K., Ollington, N., Venn, A., Dwyer, T., and Gall, S. (2014). The longitudinal association of childhood school engagement with adult educational and occupational achievement: findings from an Australian national study. *Br. Educ. Res. J.* 40, 102–120. doi: 10.1002/berj.3031

Adams, D., and Gray, T. (2023). An exploration of how the disruption of mainstream schooling during the COVID-19 crisis provided opportunities that we can learn from so that we may improve our future relationship with the more-than-human world. *SN Soc. Sci.* 3:18. doi: 10.1007/s43545-022-00588-1

Anderson, M., and Jefferson, M. (2018). *Transforming organizations: Engaging the 4Cs for powerful organizational learning and Change*. Sydney: Bloomsbury.

Angus, M., McDonald, T., Ormond, C., Rybarcyk, R., Taylor, A., and Winterton, A. (2009). *The pipeline project: Trajectories of classroom behaviour and academic progress: A study of student engagement with learning*. Mount Lawley, Western Australia: Edith Cowan University.

Appleton, J. J., Christenson, S. L., and Furlong, M. J. (2008). Student engagement with school: critical conceptual and methodological issues of the construct. *Psychol. Sch.* 45, 369–386. doi: 10.1002/pits.20303

Archambault, I., Janosz, M., Fallu, J.-S., and Pagani, L. S. (2009). Student engagement and its relationship with early high school dropout. *J. Adolesc.* 32, 651–670. doi: 10.1016/j.adolescence.2008.06.007

Australian Curriculum Assessment and Reporting Authority. (2018). General capabilities in the Australian curriculum (Version 8.4). Available at: https://www.australiancurriculum.edu.au/f-10-curriculum/general-capabilities/

Beames, S., Higgins, P., and Nicol, R. (2012). *Learning outside the classroom: Theory and guidelines for practice*. New York, NY: Routledge.

Beames, S., Mackie, C., and Scrutton, R. (2020). Alumni perspectives on a boarding school outdoor education programme. *J. Advent. Educ. Outdoor Learn.* 20, 123–137. doi: 10.1080/14729679.2018.1557059

Becker, C., Lauterbach, G., Spengler, S., Dettweiler, U., and Mess, F. (2017). Effects of regular classes in outdoor education settings: a systematic review on students' learning, social and health dimensions. *Int. J. Environ. Res. Public Health* 14:485. doi: 10.3390/ijerph14050485

Bobilya, A. J., Kalisch, K., Daniel, B., and Coulson, E. R. (2015). An investigation of participants' intended and actual transfer of learning following an outward bound wilderness experience. *J. Outdoor Recreat. Educ. Leadersh.* 7, 93–111. doi: 10.18666/JOREL-2015-V7-I2-7006

Bolick, C. M., Glazier, J., and Stutts, C. (2022). Taking off the backpacks: the transference of outdoor experiential education to the classroom. *J. Outdoor Recreat. Educ. Leadersh.* 14, 54–71. doi: 10.18666/JOREL-2022-V14-I2-11137

Bølling, M., Otte, C. R., Elsborg, P., Nielsen, G., and Bentsen, P. (2018). The association between education outside the classroom and students' school motivation: results from a one-school-year quasi-experiment. *Int. J. Educ. Res.* 89, 22–35. doi: 10.1016/j.ijer.2018.03.004

Center for Curriculum Redesign. (2019). Competencies/subcompetencies framework. Available at: https://curriculumredesign.org/framework/

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (*2nd*) Edn. Hillsdale, N.J: L. Erlbaum Associates.

Creswell, J. W. (2015). *A concise introduction to mixed methods research*. Thousand Oaks, California: SAGE.

Fadel, C. (2016). Redesigning the curriculum for a 21st century education. Available at: https://curriculumredesign.org/wp-content/uploads/CCR-FoundationalPaper-Updated-Jan2016.pdf

Fraysier, K., Reschly, A., and Appleton, J. (2020). Predicting postsecondary enrollment with secondary student engagement data. *J. Psychoeduc. Assess.* 38, 882–899. doi: 10.1177/0734282920903168

Fredricks, J., Blumenfeld, P., and Paris, A. (2004). School engagement: potential of the concept, state of the evidence. *Rev. Educ. Res.* 74, 59–109. doi: 10.3102/00346543074001059

Fullan, M., and Langworthy, M. (2013). *Towards a new end: New pedagogies for deep learning*. Seattle, Washington. Available at: https://michaelfullan.ca/wp-content/uploads/2013/08/New-Pedagogies-for-Deep-Learning-An-Invitation-to-Partner-2013-6-201.pdf

Furlong, M. J., and Christenson, S. L. (2008). Engaging students at school and with learning: a relevant construct for all students. *Psychol. Sch.* 45, 365–368. doi: 10.1002/pits.20302

Gallup, A. (2014). *State of America's schools: The path to winning again in education*. Washington, DC: Gallup Inc.

Goss, P., Sonnemann, J., and Griffiths, K. (2017). *Engaging students: creating classrooms that improve learning* (2017-01). Grattan Institute. Available at: https://grattan.edu.au/report/engaging-students-creating-classrooms-that-improve-learning/

Gray, T. (1997). *The impact of an extended stay outdoor education school program upon adolescent participants*. Doctor of philosophy thesis. University of Wollongong. Available at: http://ro.uow.edu.au/theses/1799

Griffiths, K., and Webber, A. (2017). *Tell them from me: gender and engagement*. Centre for Education Statistics and Evaluation. Available at: https://www.cese.nsw.gov.au/images/stories/PDF/TTFM_gender_and_engagement_F17_AA.pdf

Hancock, K. J., and Zubrick, S. (2015). *Children and young people at risk of disengagement from school: Commissioner for children and young people*. Western Australia: Commissioner for Children and Young People.

Hattie, J., Marsh, H. W., Neill, J. T., and Richards, G. E. (1997). Adventure education and outward bound: out-of-class experiences that make a lasting difference. *Rev. Educ. Res.* 67, 43–87. doi: 10.2307/1170619

Klem, A. M., and Connell, J. P. (2004). Relationships matter: linking teacher support to student engagement and achievement. *J. Sch. Health* 74, 262–273. doi: 10.1111/j.1746-1561.2004.tb08283.x

Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development*. Englewood Cliffs, N.J.: Prentice-Hall.

Lamb, S., Maire, Q., and Doecke, E. (2017). *Key skills for the 21st century: An evidence-based review*. NSW Department of Education. Available at: https://education.nsw.gov.au/content/dam/main-education/teaching-and-learning/education-for-a-changing-world/media/documents/Key-Skills-for-the-21st-Century-Executive-Summary.pdf

Lambert, P. (2017). *Hard focus on "soft" skills*. Available at: https://education.nsw.gov.au/our-priorities/innovate-for-the-future/education-for-a-changing-world/media/documents/exar/Hard_focus_on_soft_skills_Dr_Phil_Lambert.pdf

Lietaert, S., Verschueren, K., De Fraine, B., and Laevers, F. (2014). Indicators and facilitators of student engagement in secondary education: reviewing the gender gap. In: *Paper presented at the international congress for school effectiveness and improvement (ICSEI) conference*, Yogyakarta, Indonesia.

Maehr, M. L., and Meyer, H. A. (1997). Understanding motivation and schooling: where We've been, where we are, and where we need to go. *Educ. Psychol. Rev.* 9, 371–409. doi: 10.1023/A:1024750807365

Mann, J. (2018). Is school working for teenage boys? Outdoor learning and real-life skills could be the keys to re-engagement. *Curric. Pers.* 38, 169–174. doi: 10.1007/s41297-018-0051-0

Mann, J., Gray, T., and Truong, S. (2022a). Rediscovering the potential of outdoor learning for developing 21st century capabilities. In R. Jucker and AuJ. von (Eds.), *High quality outdoor learning: Evidence-based education outside the classroom for children*. Teachers and Society: Springer Nature.

Mann, J., Gray, T., Truong, S., Brymer, E., Passy, R., Ho, S., et al. (2022b). Getting out of the classroom and into nature: a systematic review of nature-specific outdoor learning on school Children's learning and development. *Front. Public Health* 10:877058. doi: 10.3389/fpubh.2022.877058

Mann, J., Gray, T., Truong, S., Sahlberg, P., Bentsen, P., Passy, R., et al. (2021). A systematic review protocol to identify the key benefits and efficacy of nature-based learning in outdoor educational settings. *Int. J. Environ. Res. Public Health* 18:1199. doi: 10.3390/ijerph18031199

Martin, A. J. (2005). Exploring the effects of a youth enrichment program on academic motivation and engagement. *Soc. Psychol. Educ.* 8, 179–206. doi: 10.1007/s11218-004-6487-0

Martin, A. J. (2007). Examining a multidimensional model of student motivation and engagement using a construct validation approach. *Br. J. Educ. Psychol.* 77, 413–440. doi: 10.1348/000709906X118036

Martin, A. J. (2008a). Enhancing student motivation and engagement: the effects of a multidimensional intervention. *Contemp. Educ. Psychol.* 33, 239–269. doi: 10.1016/j.cedpsych.2006.11.003

Martin, A. J. (2008b). Motivation and engagement in diverse performance settings: testing their generality across school, university/college, work, sport, music, and daily life. *J. Res. Pers.* 42, 1607–1612. doi: 10.1016/j.jrp.2008.05.003

Martin, A. J. (2009). Motivation and engagement across the academic life span. *Educ. Psychol. Meas.* 69, 794–824. doi: 10.1177/0013164409332214

Martin, A. J., Martin, T. G., and Evans, P. (2016). Motivation and engagement in Jamaica: testing a multidimensional framework among students in an emerging regional context. *J. Psychoeduc. Assess.* 36:0734282916674424. doi: 10.1177/0734282916674424

Martino, W. (2008). *Boys' underachievement: Which boys are we talking about?* Ontario: Literacy and Numeracy Secretariat.

McCarthy, I., and McCourt, B. (2017). *Improving high school engagement, classroom practices and achievement*. Sydney: Centre for Education Statistics and Evaluation.

McCourt, B., and Griffiths, K. (2016). Capturing and measuring student voice. Centre for Education Statistics and Evaluation. Available at: https://www.cese.nsw.gov.au/publications-filter/learning-curve-15-capturing-and-measuring-student-voice

McCree, M., Cutting, R., and Sherwin, D. (2018). The hare and the tortoise go to Forest School: taking the scenic route to academic attainment via emotional wellbeing outdoors. *Early Child Dev. Care* 188, 980–996. doi: 10.1080/03004430.2018.1446430

McLeod, B., and Allen-Craig, S. (2007). What outcomes are we trying to achieve in our outdoor education programs? *Aust. J. Outdoor Educ.* 11, 41–49. doi: 10.1007/BF03400856

Miller, N. C., Kumar, S., Pearce, K. L., and Baldock, K. L. (2021). The outcomes of nature-based learning for primary school aged children: a systematic review of quantitative research. *Environ. Educ. Res.* 27, 1115–1140. doi: 10.1080/13504622.2021.1921117

Mygind, L., Kjeldsted, E., Hartmeyer, R., Mygind, E., Bølling, M., and Bentsen, P. (2019). Mental, physical and social health benefits of immersive nature-experience for children and adolescents: a systematic review and quality assessment of the evidence. *Health Place* 58:102136. doi: 10.1016/j.healthplace.2019.05.014

Nicol, R., and Waite, S. (2020). "Outdoor learning" in *Encyclopedia of teacher education*. ed. M. A. Peters (Singapore: Springer), 1–6.

OECD. (2019). *OECD skills strategy 2019: Skills to shape a better future*. Paris: OECD Publishing.

Organisation for Economic Cooperation Development (2012). *Better Skills, Better Jobs, Better Lives: A Strategic Approach to Skills Policies* Organisation for Economic Cooperation Development.

Organisation for Economic Cooperation Development (2013). *PISA 2012 results: Ready to learn (volume III): Students' engagement, Drive and Self-Beliefs* OECD Publishing.

Organisation for Economic Cooperation Development. (2015). *The ABC of gender equality in education: Aptitude, behaviour, confidence (9264230025)*.

Pallant, J. (2010). *SPSS survival manual: A step by step guide to data analysis using SPSS* (*4th*) Edn. Berkshire: McGraw-Hill Education.

Pendergast, D. (2022). *Conversations that matter: Rethinking teaching and teacher tducation in a post pandemic world*. Brisbane, Queensland: Griffith University.

Price, A. (2015). Improving school attendance: can participation in outdoor learning influence attendance for young people with social, emotional and behavioural difficulties? *J. Advent. Educ. Outdoor Learn.* 15, 110–122. doi: 10.1080/14729679.2013.850732

Priest, S., and Gass, M. (2005). *Effective leadership in adventure programming* (*2nd*). Champaign, Ill: Human Kinetics.

Richmond, D., Sibthorp, J., Gookin, J., Annarella, S., and Ferri, S. (2018). Complementing classroom learning through outdoor adventure education: out-of-school-time experiences that make a difference. *J. Advent. Educ. Outdoor Learn.* 18, 36–52. doi: 10.1080/14729679.2017.1324313

Ruiz-Gallardo, J.-R., Verde, A., and Valdés, A. (2013). Garden-based learning: an experience with "at risk" secondary education students. *J. Environ. Educ.* 44, 252–270. doi: 10.1080/00958964.2013.786669

Ryan, R. M., and Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *Am. Psychol.* 55, 68–78. doi: 10.1037/0003-066X.55.1.68

Scoular, C., Ramalingam, D., Duckworth, D., and Heard, J. (2020). *Assessment of general capabilities: Skills for the 21st century learner. Final Report*. Camberwell, VIC. Available at: https://research.acer.edu.au/ar_misc/47

Sibthorp, J., Furman, N., Paisley, K., Gookin, J., and Schumann, S. (2011). Mechanisms of learning transfer in adventure education: qualitative results from the NOLS transfer survey. *J. Exp. Educ.* 34, 109–126. doi: 10.1177/105382591103400202

Tomaszewski, W., Xiang, N., and Western, M. (2020). Student engagement as a mediator of the effects of socio-economic status on academic performance among secondary school students in Australia. *Br. Educ. Res. J.* 46, 610–630. doi: 10.1002/berj.3599

Tramonte, L., and Willms, J. (2012). "Anxiety and emotional discomfort in the school environment: The interplay of school processes, learning strategies, and children's mental health," in *Public Health - Social and Behavioral Health*. ed. J. Maddock (Rijeka, Croatia: InTech), 461–476.

Trilling, B. (2009). *21st century skills: Learning for life in our times* (*1st Edn.*). San Francisco, CA: Jossey-Bass.

White, R. L., Bennie, A., Vasconcellos, D., Cinelli, R., Hilland, T., Owen, K. B., et al. (2021). Self-determination theory in physical education: a systematic review of qualitative studies. *Teach. Teach. Educ.* 99:103247. doi: 10.1016/j.tate.2020.103247

Willms, J. D. (2015). *Student Engagement and Wellbeing in NSW*. NSW Education & Communities, Centre for Education Statistics and Evaluation. Available at: https://www.cese.nsw.gov.au/images/stories/PDF/LearningCurve7_TTFM_May2015.pdf

Willms, J. D., Frieson, S., and Milton, P. (2009). What did you do in school today? Transforming classrooms through social, academic, and intellectual engagement. (First National Report). Toronto, Canada: Canadian Education Association. AVailable at: http://www.cea-ace.ca/sites/cea-ace.ca/files/cea-2009-wdydist.pdf

World Economic Forum. (2015). New vision for education: Unlocking the potential of technology. Geneva, Switzerland. Available at: http://www3.weforum.org/docs/WEFUSA_NewVisionforEducation_Report2015.pdf

Yazzie-Mintz, E. (2006). *Voices of students on engagement. A report on the 2006 high school survey of student Engagement*. Bloomington, Indiana: Center for Evaluation and Education Policy.

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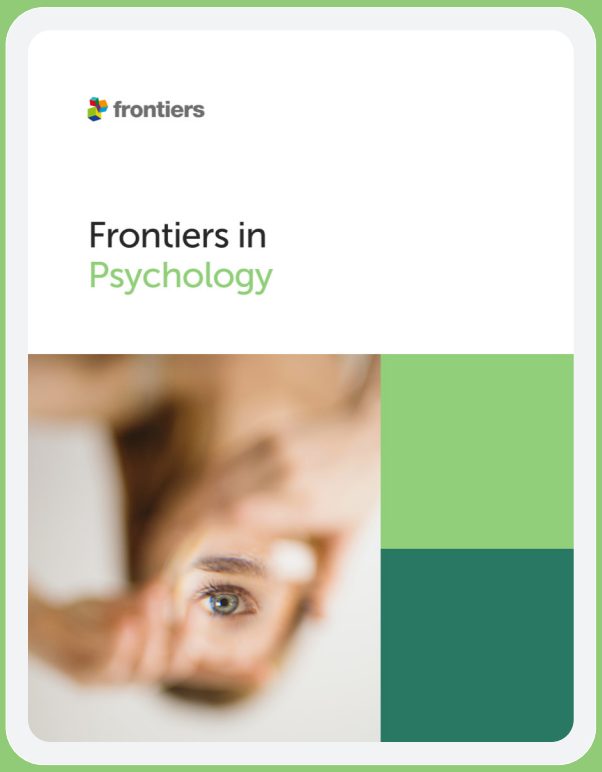

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