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Educational Environments and Practices Associated with Enhancement of Children's Nature Connectedness in Early Childhood Education: A Scoping Review

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ABSTRACT

This scoping review explored, what kind of educational environments and practices have been used when children's nature connectedness in early childhood education has been studied. While the beneficial influence of forest preschools – and others alike based on substantial nature contact – is well-established, little is known about how ordinary early childhood education units could enhance children's nature connectedness. Earlier studies have shown nature connectedness to have wide beneficial consequences related for example to mental and physical health, prosocial, and pro-environmental inclinations. We included in the scoping review empirical studies with different setups that concerned children attending early childhood education and reported the association between certain educational environments or practices and children's nature connectedness. We searched six online databases and included 14 studies in the scoping review. We found that some practices were associated with enhanced nature connectedness more often than others. Indigenous perspectives, stories about nature, and personizing nature were associated with enhanced nature connectedness every time but only rarely mentioned. More often mentioned practices with substantially high association (over 75%) were taking walks or hikes in nature, structured play in nature, using empathy and caring or sense experiences in enhancing nature connectedness, and teaching arts and music or autonomy in nature. To a large extent, however, the existing research does not sufficiently describe what is actually done and in which kinds of surroundings: More detailed research is needed, focusing either on one educational environment or practice at a time, or conducting more specified reports of interventions consisting of several practices.

***Keywords*:** human-nature connection; biophilia; early childhood education; environmental education

The objective of this scoping review was to follow a systematic approach to map evidence regarding the kind of educational environments and practices that are associated with an enhancement of children's nature connectedness in early childhood education (ECE). During recent decades the research on human-nature connection and its effects on physical and psychological well-being, prosocial inclinations, and pro-environmental behavior have been under growing interest (systematic reviews e.g. Andersen et al., 2021; Barragan-Jason et al., 2022; Houlden et al., 2018; de Keijzer et al., 2016; Mackay & Schmitt, 2019; McMahan & Estes, 2015; Oh et al., 2017; Putra et al. 2020; Roberts et al., 2019; Shuda et al., 2020; Stevenson et al., 2018; Trøstrup et al, 2019, Twohig-Bennett & Jones, 2018; Weeland et al., 2019; Whitburn et al., 2019). The reviews

show that mere contact (i.e., exposure) with nature in itself elicits many positive effects. Moreover, it has been suggested that an added subjective experience of connectedness with nature mediates the positive effects that contact with nature can have (Liu et al., 2022). Although there are many concepts for nature connectedness, and different scales with which to measure them, most of them, related to studies with adults, have been found to correlate strongly (Tam, 2013). In the context of ECE research, for example such concepts as connection to nature, affinity toward nature, biophilia, nature appreciation, love of nature, close/empathetic/emotional relationship with nature, positive attitude toward nature, environmental consciousness, eco-friendly attitude, or nature relatedness have been in use. Nature exposure also comes in many forms: for example, forest trips, natural yards, gardening, or biowalls in the facilities. In this scoping review, the different forms of nature contact and all the different relevant concepts of subjective nature connectedness are jointly referred to as human-nature connection (HNC).

A gap in the research on environmental education – often a corner stone for enhancing nature connectedness – in early childhood education was identified 15 years ago (Davis, 2009). Since then, interest in the importance of environmental education and specifically nature connection in young children's education has been expanding rapidly (Systematic reviews, e.g. Dankiw et al., 2020; Tillmann et al., 2018; Mygind et al., 2019; Sella et al., 2023; Arola et al., 2023; Mygind et al. 2020; Johnstone et al. 2022; Putra et al. 2020; Ernst et al. 2021; Whitburn et al. 2019). Although the concepts and measurements used in research with children vary to a great extent, to our knowledge, a correlational analysis of different concepts, similar to that of Tam's (2013) of adult nature connectedness, has not been conducted. Furthermore, reviews on this topic frequently report problems such as lack of randomization, lack of control groups or before-after measures, small sample sizes, and heterogeneity of the methods used (For an overview, see for instance Beery et al., 2020). All in all, the research into children's HNC is not as advanced as it is with adults.

Previous research has emphasized outdoor situated ECE units. However, spending all or most of the time outdoors in natural areas is not easy to implement in every daycare centre, for instance in urban ECE units. It is thus of interest to review more specifically, what kind of smaller everyday choices concerning educational environments and practices are present in the studies that measure or report enhancement of nature connectedness. In this scoping review, we combine knowledge provided by varied research methods and different kinds of interventions to reach a comprehensive overview of the topic.

Young children's subjective experience of nature connectedness has been somewhat understudied compared to that of older, primary school children and adolescents. One explanation could be that until recently, when Sobko et al. (2018) provided the first validated tool for measurement, there had not been a validated measurement tool to test children under 8 years old. The methodology in the field has varied, ranging from interviewing or surveying parents or daycare personnel to "games testing", interviewing children with puppets or pictures, observing everyday life, and analyzing drawings.

Conducting a systematic review in these circumstances would be premature. A scoping review can be used to summarize findings that are heterogenous in their methods. The choice of conducting a scoping review instead of a systematic review was also justified with the exploratory aim of this review: In a scoping review, research questions can be broader and it is possible to identify in an exploratory manner certain specific characteristics in the selected sources of evidence, map them, and produce an overview of the topic. Additionally, a scoping review can be used to determine the value of undertaking a systematic review in the future by examining the extent, range, and nature of the evidence in the field of study in question. (Peters et al., 2020.)

According to a preliminary search into the databases, no reviews on this topic were found to be published or pre-published. One study with a similar approach was identified (Ardoin et al., 2020), but instead of subjective nature connectedness, the focus was on environmental education.

Research Question

The scoping review was guided by this question: "What kind of educational environments or practices applied in early childhood education are associated with enhancement of children's nature connectedness?"

Inclusion criteria

The inclusion/exclusion criteria for the review were defined using the PICOS framework (population, intervention, comparison, outcome, study design; Amir-Behghadami and Janati, 2020.)

As for **Population**, we included all studies on children attending ECE that implemented some educational environments and practices to enhance nature connectedness. We excluded studies on children with special physical or psychological conditions, single-case studies, and studies that had both ECE and primary school aged children and did not report the results separately.

Concerning **Intervention**, we included only studies that measured or reported whether there is an association between an enhanced nature connectedness of children and at least one educational environment or practice applied by the ECE unit.

As for **Comparison**, we included studies with and without a comparative design: pretest-posttest setups, control group setups, longitudinal setups, different combinations of those, and studies that merely reported the evaluations of parents or educators concerning possible changes in children.

The inclusion criterion for the **Outcome** of the study was "all relevant definitions/concepts of children's nature connectedness". Due to the research field having no settled, established definition or concept for nature connectedness, any study having to do with a relationship or emotional/cognitive connection or relatedness with nature was included. For example, concepts such as connectivity, immersion, respect, appreciation, commitment, love, affinity, and empathy toward nature, or environmental identity, consciousness, or awareness have been used.

Concerning **Study design**, we included all qualitative and quantitative empirical studies and all randomized, non-randomized, or cluster-randomized study designs. This decision was based on the presumption of finding only a few fully randomized trials. We excluded grey literature, and the included literature was restricted to peer-reviewed articles and relevant dissertations. The authors were aware that qualitative research might be more reachable in some of the grey sources. However, as the review was expected to include also non-randomized and possibly even non-comparative studies with small sample sizes, the peer-review of included material was considered important in making the results stand on firmer ground.

For more detailed information on the inclusion criteria, please contact the first author.

METHODS

We conducted this review following the PRISMA-ScR checklist for preferred reporting items for scoping reviews in accordance with an *a priori* protocol (Salmi et al., 2023, https://osf.io/jy29v/). The most central deviations from the protocol are reported and justified in the appropriate section of the methods (but a more precise list can be accessed by contacting the first author).

Search strategy

We searched six databases: PubMed, Web of Science, Scopus, ERIC (Ebsco), Education Database (ProQuest), and PsycINFO (Ebsco). In the databases that gave the option to do so, we limited the search to studies in English. The searches were conducted on 21 November 2023. Monthly alerts for subsequent hits for the search queue were ordered from Web of Science, ERIC, Education Database, and PsycINFO. The alerts did not provide articles that would have fit the inclusion criteria.

IS and VM developed the search strategy by going through relevant systematic reviews, meta-analyses, and singular studies to identify appropriate search terms. In addition, we conducted preliminary searches in the databases to refine the search queue. During the process, an information specialist evaluated the strategy, and we modified it accordingly. The search focused on three points: (1) outcome: nature connectedness, (2) population: early childhood education, and (3) intervention: educational environment or practice. For more information about the full search strategies, the first author may be contacted. We used the same search terms in all databases:

("nature contact*" OR "immersion in nature" OR "nature connect*" OR "connection to nature" OR "connection with nature" OR "commitment to nature" OR "connectedness to nature" OR "connectivity with nature" OR "connectivity to nature" OR "emotional affinity toward nature" OR "environmental identit*" OR "inclusion of nature in self" OR "inclusion with nature" OR "nature relatedness" OR "relationship with nature" OR "disposition to connect with nature" OR "human-nature" OR HNC OR "human-environment" OR "nature experience*" OR "environmental consciousness" OR "affinity with the biosphere" OR "affinity with nature" OR biophil* OR "nature-deficit disorder" OR ACHUNAS OR "nature-based" OR "enviro-kindy" OR "nature-human" OR "emotional affinity towards nature" OR "bioaffinity" OR "bio-affinity" OR "significant nature situation*")
AND
("early childhood" OR preschool* OR "child care" OR "daycare" OR "day care" OR childcare OR kindergarten OR "ECE" OR "ECEC" OR "ECEfS" OR "young child*" OR "preprimary" OR nurser* OR "early elementary" OR "early primary")
AND
("outdoor classroom*" OR "eco-school*" OR "ecoschool*" OR "nature journaling" OR "Reggio-Emilia" OR "forest school*" OR "forestschool*" OR "forest kindergarten*" OR practic* OR implement* OR program* OR strateg* OR project* OR intervention* OR method* OR "educational setting*" OR "learning activit*" OR pedagog* OR didact* OR "learning environment*" OR "educational environment*" OR "nature play*" OR "eco-early childhood education" OR "nature education*" OR "outdoor education*" OR "nature-based pre-primary program*").

In addition to the database searches, IS and VM searched additional records from the reference lists of included articles and other systematic reviews and meta-analyses conducted in the area of nature connectedness and early childhood education. IS and VM also searched their article collections for further relevant material.

Study selection

IS and MH managed the records of the search with Zotero reference management software. IS and MH processed and selected reports independently through each phase, negotiated conflicts of judgement, and acquired a third opinion whenever needed from PS.

Before screening, duplicates were removed. IS and MH then screened the titles and abstracts against the inclusion/exclusion criteria. In this phase, they included all articles that appeared to meet the inclusion criteria along with all cases where there was any uncertainty. Throughout the process, they documented all decisions of irrelevance by naming (at least one of) the specific eligibility criteria the report did not fulfill.

From the first reading in the abstract and title phase, IS selected 57 records and MH selected 44 records for the second round. Of these, there were 37 common records. After negotiations, two records were excluded from the list of IS: Johnson (2015) for not being an ECE study and Guardino et al. (2019) for including disabled children. From the list of MH, four records were excluded: Sella et al. (2023) and Johnstone et al. (2022) for being systematic reviews and two book chapters from Cutter-MacKenzie (2014a & 2014b). Therefore, 62 records in total were selected for the full-text screening phase.

The eligibility process continued with full-text screening to decide whether the obtained articles met all the inclusion criteria. In this phase, IS and MH linked reports concerning the same study together. The most often used criteria for exclusion were that the study did not (1) measure the nature connectedness of children or describe a change in it; (2) did not report any practices or educational environments; or (3) did not concern children participating ECE, or concerned them only partly and without separating the results.

The most difficult decisions concerned whether the definition or concept used could be categorized as “nature connectedness” in the sense described in this review. IS and MH excluded for instance “human–environment relationship” in Cengizoglu et al., 2022, where it was further described as “children’s perceptions about sustainability”. The latter definition did not seem to indicate an experience of being connected with nature.

IS and MH compiled a list of excluded studies to inform the reader about refined reasons for certain studies not fulfilling the eligibility criteria. The list does not include reports discarded by both reviewers due to obvious irrelevance. Rather, it includes the studies of which IS and MH had to negotiate to reach an agreement of exclusion. The full list can be accessed by contacting the first author, but for instance, there were studies where

the concept of nature connectedness was further described in a manner not consistent with our idea of subjective nature connectedness. There were also studies that otherwise fulfilled all the inclusion criteria, but did not report a *change* in the subjective nature connectedness. The results of the search and the study inclusion process are reported and presented in Figure 1, in a PRISMA flow diagram (Page et al., 2021).

As a result of the full-text screening, both IS and MH selected independently the following nine reports to be included in the review: Barrable and Booth (2020), Cordiano et al. (2019), Hu (2022), Jorgensen (2016), Lee et al. (2021), Lithoxoidou et al. (2017), Omidvar et al. (2019a), Omidvar et al. (2019b), and Yilmaz et al. (2020b). The following seven reports were selected by either IS or MH and their inclusion/exclusion was negotiated: Ashmann (2018), Boileau and Dabaja (2020), Cengizoglu et al. (2022), Deniz and Kalburan (2022), Donison and Halsall (2023), Glettler and Rauch (2020), and Yilmaz et al. (2020a). After negotiations, IS and MH included Deniz and Kalburan (2022) and Glettler and Rauch (2020). Hence, we included eleven reports in the scoping review. We identified two of these as part of the same study (Omidvar et al. 2019a and Omidvar et al. 2019b): thus, ten studies were included in the scoping review through the database search.

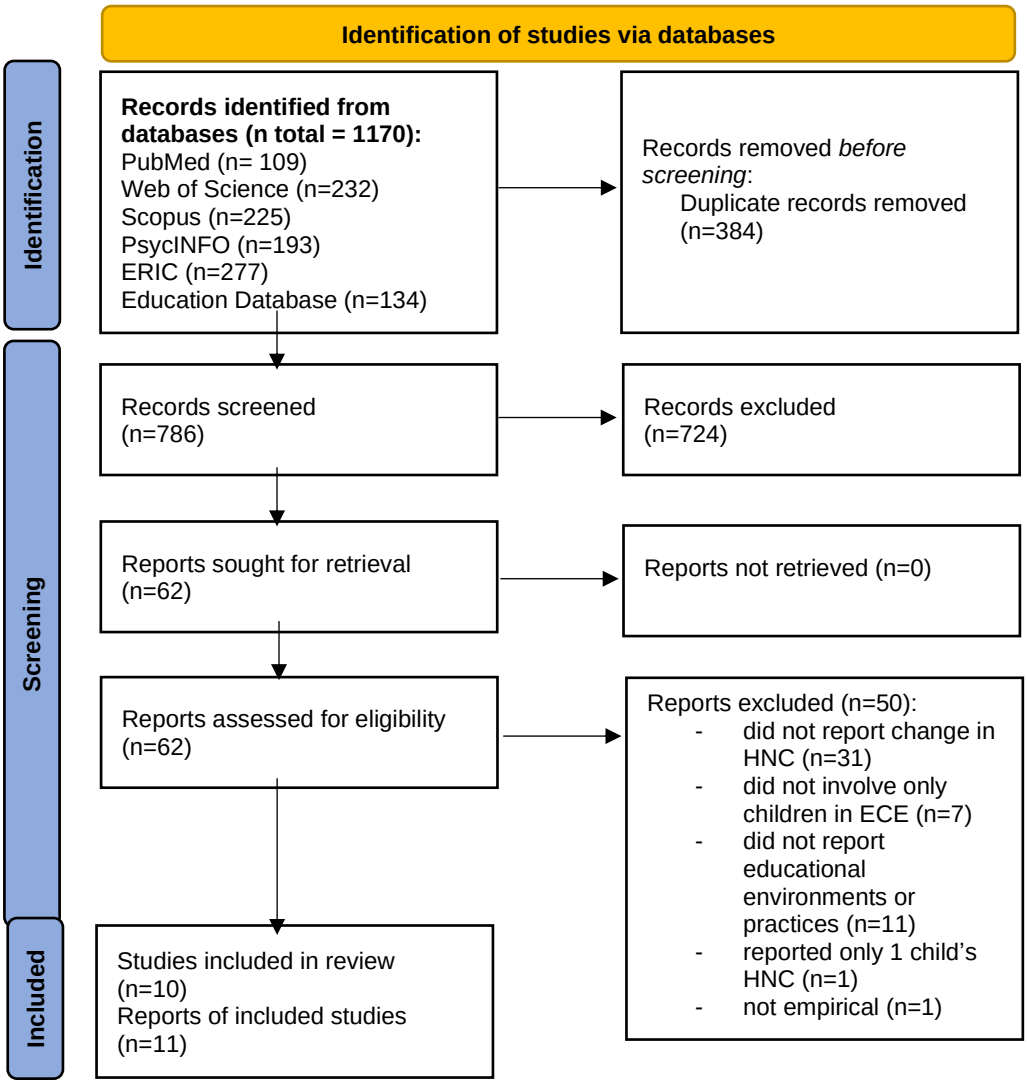

Figure 1. The PRISMA flow diagram describing the selection process.

In addition, four studies were included in the review through snowballing from the reference lists of previous, closely related systematic reviews and meta-analyses and the studies included through the eligibility process. IS and MS conducted the inclusive selection of these four articles. The articles are the following: Acar and Torquati

(2015), Cincera et al. (2017), Elliot et al. (2014), and Rice and Torquati (2013). Thus, in total, the current scoping review consists of 14 studies.

It should be noted, that the results of this review should not be taken as an overview of the status of research on nature connectedness of children participating in ECE as a whole: considerably many studies on the subject were excluded due to a lack of specific description of the environments and practices.

Data extraction

Data from the studies fulfilling eligibility criteria was managed with Zotero and Microsoft Excel. IS and VM conducted the piloting tool for extracting data from the included studies. IS and MS calibrated the piloting tool before data collection to detect possible misunderstandings, difficulties, or ambiguities.

IS extracted the data twice, first before the calibration to reach an overview and then at the same time with MS. After the independent data extraction phase, IS and MS conducted a rereading together concerning the points of disagreement, and to extract data which was added or specified in the data extraction tool during the iterative process. Any suggestions on changes to the categories or other extracted data were negotiated during the first round to achieve a unanimous final form for the data extraction tool.

Also in the data extraction phase, in cases of unclarity, PS gave a third opinion. During the process, IS and MS noticed that the topic and approach of the review resulted in multiple situations involving highly interpretative decisions: many negotiations followed, in order to reach joint interpretations. In cases where the reports offered inconsistent information about the study, IS and MS relied firstly on the knowledge provided by the result section with its tables and figures, then by conclusions, methods section, and abstract.

In the protocol, we had planned that a separate data extraction tool would be developed for qualitative studies, one following the tool used with quantitative studies to an appropriate extent. However, we had no difficulties using the same tool for quantitative and qualitative studies.

The piloting tool was created partly relying on other closely related systematic reviews and meta-analyses, partly on the Assessment framework for Children's Human Nature Situations (ACHUNAS) created by Giusti et al. 2018, the biophilic design created by Stephen Kellert (f. ex. Kellert & Calabrese 2015), pedagogy for connection created by Alexia Barrable (2019), and other sources concerning ECE and nature connectedness (e.g. Larimore, 2018; Mohammed et al., 2023). ACHUNAS is a framework that consists of 16 elements to pay attention to in nature situations: entertainment, thought-provocation, awe, mindfulness, intimacy, surprise, creative expression, physical activity, engagement of senses, involvement of mentors, involvement of animals, social/structural endorsement, structure/instructions, child-driven, challenge, and self-restoration, as well as 10 abilities of HNC that help in assessing the breadth and depth of a child's nature connectedness. Biophilic design consists of different aspects to bring nature inside the facilities; natural colors, water, fresh air, sunlight, plants, animals, natural materials, and views of nature and habitats (Kellert & Calabrese, 2015). The pedagogy for connection by Barrable (2019) involves four important elements to build nature connectedness of children: regular time spent in nature, building compassion toward non-human species, engaging in nature's beauty, and practicing mindfulness.

In the final data extraction tool, the information gathered of the educational environments and practices were: the name of the intervention or practice if any; general description of the intervention; the total length of the intervention; frequency of the intervention; the duration of the intervention; the study setup/ experimental design if any; if there was no experimental design, how the change was described; changes conducted in the yard as part of the intervention; (at least or only) occasional trips to nature; every day in nature; (only) every week in nature; place attachment (i.e. often in the same natural place); hikes or walks; observation or exploration; gardening; unstructured play or activities; structured play or activities; risky play (such as climbing trees); free hang-around time, that was not playing or some specific activity; meditation or mindfulness; solitary time in nature (without the immediate presence of adults or peers: they may be close by but not in contact); and play or art with natural or loose parts inside/outside. Furthermore, we checked whether the intervention focuses specifically on sense experiences, or giving opportunities for helping, caring, empathy, or imagination and creativity as means to enhance nature connectedness. Other included practices and environments were personizing nature (such as giving names and inventing life stories to trees); the influence of peers in enhancing

nature connectedness; fairytales or stories about nature; discussions about nature; contact with animals; pictures or posters of nature in the facilities; house plants; planting from seeds or scratches; a natural view from the window; other indoor natural or biophilic elements (natural colors, water, fresh air, sunlight, natural materials); additional goal with nature connectedness to teach mathematics, sciences, arts and music, social skills, empathy, and emotional development, or autonomy, self-care, resilience and self-confidence; and, implementing indigenous perspectives as means to enhance nature connectedness (for example, Native American poetry). The latter was added in the iterative process and was detected with key words (Indigenous, aboriginal, native, ancestral, animism, Indian). During the construction, calibration, and iterative data extraction, some of the information planned to be extracted in the protocol was amended. For the full metadata of the final data extraction tool or the full list of amendments, please contact the first author.

Data analysis and presentation

Although we did not restrict the searches with any time limits, the included studies were all quite recent, the oldest one being conducted 11 years ago. Six of the studies were conducted during this decade, eight of the studies during 2010's. The included studies were dominantly Western-based: six of them were conducted in USA or Canada, seven in different countries in Europe, one in Turkey, and one in South-Korea. Furthermore, the sample in this review was predominantly based on urban children: none of the studies reported having studied only rural ECE units, and only one had both rural and urban ECE units included.

Of the 14 studies selected for the review, none reported having a randomized study design. Three studies had a sample of over 100 children, two studies had a sample of 50-60 children and most of the studies (9) had a sample of less than 36 children. The biggest sample size was 419 children, while the smallest was 20 children. Three studies used a pretest-posttest setup, three used a control group, and two had a longitudinal setup. Different mixtures of these setups were used in four studies. The duration of the interventions or study periods varied from 4 weeks to 2 years: one study lasted 2 years, three studies had a duration of one school year, three studies used interventions of 7-10 months, two studies lasted 1-3 months and the rest (5) did not use pretest-posttest or longitudinal setups. Two studies had no comparative setup at all: they conducted the measurements only one time without a control group. Four studies were qualitative, six studies were quantitative, and the rest (4) were both qualitative and quantitative. Half of the studies used statistical analysis.

The measurements used were versatile, and often more than one method was used. Ten studies reported interviews with children, five studies reported questionnaires or interviews with either parents or the educators, and five studies reported observation. Action research, experimental research, game-like assessment, drawings, narratives, photography, and questionnaires with pictures were all mentioned one or two times.

The concepts used for nature connectedness varied to a great extent. Connection to nature was used by four studies, affinity toward/with nature by three studies, and biophilia by two studies; other concepts used were nature appreciation, love of nature, close relationship with nature, emotional connection and positive attitude toward nature, sense of wonder and environmental consciousness, eco-friendly attitude, empathetic relationship with nature, biophilic tendencies, empathy and prosocial behavior toward peers and nature, and nature relatedness. Often, the studies did not restrict themselves to just one concept or description.

Ten studies reported a positive change in the nature connectedness of children. The change in children was further described in many ways. For instance, children were found to be more interested in the emotional needs of other beings, to be more eager to take action, and to place more value on the ecosystem; to develop more prosocial behavior toward nature; to have more pro-environmental or nature-friendly attitudes; to creatively build a personal relationship to the natural world; to become intertwined with and create meaning within the natural environment; or, to love being outdoors and be interested in nature.

Two studies reported no change, and two had controversial results: In Omidvar et al. (2019), over half of the participating children did not seem to understand the picture-assisted questions, for they answered to all either "yes" or "no" – as a whole, the sample did not show enhanced nature connectedness, but among the children who understood the questions, enhanced nature connectedness was detected. In Glettler et al. (2020), the comparison with a control group showed some similarities and some disparities when it comes to nature connectedness; in the test group all children "clearly" loved nature, but in the control group the children only eventually "learned to appreciate the outdoor time". However, in both groups, children "feel very strongly about

their natural environment, react emotionally in situations when they experience something that they perceive as harmful to nature."

The studies reported several limitations with regard to their own research practices. Small sample sizes, problems with diversity of the sample, and the exclusion of the influence of other factors were most often mentioned. As this is not a systematic review, we did not conduct risk of bias assessments, and thus, the findings presented are only indicative at best. For detailed information about the studies, see Table 1.

Half of the participating ECE units in the reviewed studies spent time in nature daily. Two studies concerned units that spent all their time in nature, one study reported nature trips weekly and one only occasionally. The rest of the studies (3) did not report how often nature was visited. Moreover, an overlook on the short descriptions on the interventions in table 1 shows, that nine of the studies emphasized more, or deeper, outdoor time.

Some of the studies measured the effects of only one specific intervention. These included setting up a biowall inside the facilities (Lee 2021), changes in the yard (Rice & Torquati 2013), and gardening (Deniz & Kalburan 2022). Other studies implemented different kinds of multimethod pedagogical approaches. Some reported the educational environments and practices with great detail, but many studies were not specific in describing the methods used. This was a distinctive problem: the most often used categorization in our scoping review was "usage not specified": it was categorized in 60% of the cases, while "yes, this was used" was categorized in 36% and "no, this was not used" in 4% of the cases. Therefore, all the results should be taken with caution: it is possible that many of the environments and practices were present in more studies than this review is able to show.

The most reported environments and practices were the use of creativity and imagination (9), observation and exploration (9), discussions about nature (9), child-centeredness (8), and contacts with animals (8) (see Figure 2). Furthermore, different pedagogical goals along with enhancement of nature connectedness were often implemented – teaching autonomy (9), social skills, empathy, emotional development (9), and arts and music (8).

As Figure 2 shows, the least used methods were meditation and mindfulness (in none of the studies), playing and doing art with natural or loose materials inside the facilities, changes in the yard, and natural view from the window (in one study each). These may be things that the original researchers did not collect information about, or did not find important enough to report in the articles, so one cannot infer that these methods were not used: only, that they were not reported.

Table 1.
Introduction to the selected studies.

Study and country	**Change in HNC**	**Qualitative/ quantitative & set-up**	**N/ test group (**control group**)**	**Intervention or program**	**Methods**	**HNC concept**	**Findings**	**List of limitations by the authors**
Cordiano et al. (2019), USA	no	quantitative pretest-posttest (1 school year), control group & longitudinal	12 (14)	Nature-based pre-primary program based on Eco!Wonder, with more outdoor time than required in the program (90% of time between 9.00-11-45)	Children's Attitudes Toward Nature (CATN, created for the study), rating forms completed by parents and educators	Nature appreciation	No significant differences were found between the traditional and the nature-based groups	Generalizability: small sample with high socio-economic background; no control group; not randomized; also the control group participated in Eco!Wonder.
Lithodoxiou et al. (2017), Greece	yes	quantitative & qualitative pretest-posttest (1 school year) & control group	17 (no mention about the size of control group)	Diverse methods during the schoolyear to improve environmental ecocentric orientation and especially empathetic relationship to nature	Interview, action research, experimental research	Empathetic relationship with nature	Children in the experimental group were (1) more interested in the emotional needs of other beings, (2) more eager to take action, (3) more emotionally active and (4) placed more value of the ecosystem than children in the control group. Furthermore, their environmental orientation increased while egocentrism and society - centered orientation were reduced.	Does not list limitations.
Elliot et al. (2014), Canada	yes	quantitative & qualitative pretest-posttest (7 months) & control group	21 (22)	Own program with forest school as a model, guiding principles: (a) connecting deeply with nature through play; (b) local ways of knowing and understanding; (c) physical and mental health; (d) learning collaboratively as part of an empathetic community, and (e) the environment as a co-teacher.	Observation, interviews, game-like assessments (Evans et al., 2007), digital photography by children and researchers, drawings, and narratives.	Nature relatedness	There was a (nonsignificant) trend for children in the nature kindergarten to have higher nature relatedness scores at the beginning of the school year. The initially nonsignificant difference between groups turned into a significant cumulative difference by the end of the year: scores in nature kindergarten increased, those of control group declined.	Small sample size.
Acar & Torquati (2015),	yes	qualitative	50 interviews	Own program that provided extended	Running record observations	Empathy and prosocial behavior	Children are able to develop prosocial behaviors toward nature	Does not list limitations.

USA		longitudinal (two years) & control group	more observed	experiences in natural settings and supported children's development of empathy and prosocial behavior toward peers and nature.	(2 years), interviews with children	toward peers and nature	through well-planned and -implemented activities in nature.	
Cincera et al. (2017), Czech Republic	yes	qualitative & quantitative pretest-posttest (8 months)	419	Eco-school: students design their own action plan for improving their school's environmental policy whereas teachers help with facilitating the process.	Interview with a picture-based questionnaire for children, interview with teachers	Connectedness to nature	Statistically significant increase in the children's pro-environmental attitudes.	No control-group; possible variation in the way in which teachers administered the questionnaires.
Lee et al. (2021), South Korea	yes	quantitative pretest-posttest (3 months)	60	Installing a biowall	Children's Attitudes Toward Scale-Preschool version (CATC-PV) (Hur, 2001; Musser and Diamond, 1999): an interview with pictures	Eco-friendly attitude	The children's eco-friendly attitude scores were higher 3 months after the installation of the biowall (compared to pre-installation scores). Under the two subcategories for the eco-friendly score, the Nature Friendly Attitude improved, while Environmental Conservation Attitude did not significantly improve over the course of the study.	The potential for children's maturation over the course of the experiment excluded; the influence of other environmental factors excluded; subject group should be bigger and broader.
Yilmaz et al. (2020), Turkey	yes	Quantitative pretest-posttest (1 month)	40	Nature-based education program with 12 semi-structured activities in a natural area.	Children's Biophilia Measure (Rice & Torquati, 2013): Visually supported scale	Affinity toward nature (biophilia) / biophilic tendencies	The results showed that a short-term, nature-based education program in a natural area was effective in terms of increasing children's affinity toward nature. The improvement in children's level of biophilia after the implementation of the program was statistically significant.	The nature-based education program was short in time, a longer program could be more effective to measure the effect; lack of any follow-up data.
Hu (2022), Canada	yes	qualitative longitudinal (school year)	28	Nature journaling	Qualitative action study: lesson plans, student work samples, researcher's reflective journals	Connection to nature	Nature journaling is indicative of creatively building personal relationships with the natural world.	Does not list limitations.
Jorgensen (2016), Norway	yes	qualitative longitudinal (10 months)	34	Daily practice of staying outdoors in nature-	Sensory ethnography (Pink, 2009) observation,	Sense of wonder, environmental consciousness	The study contributes to the understanding of preschool environmental education. The two main	Does not list limitations, but mentions that "The Norwegian culture

				dominated areas.	informal conversations, photographs		concepts, 'the sense of wonder' and environmental consciousness, are ways to elucidate how the children were intertwined with and created meaning within the natural environment.	is regarded as having a positive attitude to outdoor activities (…) This is to be considered as a cultural aspect of influence on the practice".
Barrable & Booth (2020), United Kingdom	yes	qualitative control group	132 (84)	Nature nurseries: settings that have a continuous outdoor provision, with no permanent indoor access.	Connection to Nature Index for Parents of Preschool Children (CNI-PPC, Sobko et al., 2018)	Connection to nature	Children in nature nurseries tended to score higher in CNI-PPC than children in traditional nurseries. Children's connection to nature was connected to parental nature connection, and total time spent in attendance of an outdoor nursery.	Parental reporting shows adult's perception, which has been shown to have low consistency with self-reports; no evidence of causality.
Glettler et al. (2020), Austria	partially	quantitative control group	15 (14)	Outdoor learning: mornings from 8:30 am to 1:30 pm outdoors	Semi-structured interviews with children and educators, observation, and a questionnaire for parents	Close relationship with nature, emotional connection and positive attitude toward nature	All children in the test group loved being outdoors and were interested in nature, but there was more variance in the control group (also nature-oriented primary school, but not a forest school/kindergarten). Children in both groups felt very strongly about their natural environment, and reacted emotionally in situations when they experienced something that they perceived as harmful to nature.	The authors call for studies on the influence of parents' attitudes, background information (cultural, family history), and longitudinal studies.
Rice & Torquati (2013), USA	no	quantitative control group	68 (46)	Outdoor classrooms: a specific program for enhancement of the outdoor play area to increase children's access to nature.	A semi-structured, role-playing interview using puppets	Affinity for nature / biophilia	There were no significant differences between the total biophilia scores of children attending ECE with and without natural playground elements.	Ambivalence with the concept of green-ness of a yard; mostly families with high education and income; lack of measurement of (1) time spent in other natural areas, (2) how much time spent in nature, (3) teachers' and parents' attitudes toward nature, (4) how long the child has participated in the program.
Omidvar et al. (2019a, 2019b), Canada	partially	qualitative & quantitative no comparative setup	20	Reggio Emilia pedagogy, where the educators have "respect for the natural	Games Testing for Emotional, Cognitive and Attitudinal Affinity with the Biosphere	Cognitive, emotional, and attitudinal affinity with nature	Among the children who seemed to understand the questions (11/20), the responses show some emotional	Children's weak emotional bioaffinity may be due to the deficiencies of the pedagogical

				world, which provides children with an integration of self and nature". (Omidvar et al. 2019b, 221.)	(Giusti et. al., 2014), interviews, observation, inventory (according to biophilic design)		affinity with nature, but not in the whole sample. According to Omidvar et al., contrary to the values of Reggio Emilia pedagogical approach, in this study the teachers' emphasis on anthropocentric goals was higher than on nature-related educational goals.	approach itself, its implementation in the two ECE units tested, the research instrument in testing bio-affinity amongst this age group, or its application in this context.
Deniz & Kalburan (2022), Turkey	yes	quantitative no comparative setup	20-60 (4 x teacher interview. Does not report specific group sizes)	School gardening	Semi-structured interviews	Love of nature	The educators reported that school gardening had positive effects on the development of a love of nature and ecological sustainability knowledge.	Small size of the study group, only interviews.

To reach an understanding of which educational environments and practices were present when an enhancement of nature connectedness was reported, cross-tabulations were conducted. The results indicate that there is no one means that was present in all 10 studies that reported enhancement in nature connectedness.

All the studies that reported using Indigenous perspectives (key words used here were Indigenous, aboriginal, native, ancestral, animism, and Indian; in practice, they showed for example as poetry), personizing nature (for example, giving a name and coming up with a life story for a tree) and telling stories about nature, reported an enhanced nature connectedness. However, they were mentioned only rarely: Indigenous practices and personizing nature in three studies, storytelling in four. Also, those ECE units that reported spending all their time in nature all reported enhanced nature connectedness, but there was only two of them.

The use of (1) empathy and caring and (2) sense experiences as tools to enhance nature connectedness, (3) hikes or walking in nature, and (4) structured play in nature were associated with enhanced nature connectedness in 83% of the cases (in five out of six studies). Of the studies that reported regular visits to the same place (place attachment), 71% also reported enhanced nature connectedness (five out of seven studies). Teaching arts and music in nature was associated with enhanced nature connectedness 75% of the times they were mentioned (six out of eight studies) and out of studies that mentioned teaching self-care, autonomy, self-confidence, responsibility, or resilience, 78% reported positive changes in nature connectedness (seven out of nine studies).

(1) Observation and exploration, and (2) creativity and imagination as means to enhance nature connectedness, (3) social, emotional and empathetic development as a co-goal, and (4) discussions about nature were often used methods (all were reported nine times), out of which 67% reported positive changes in the nature connectedness of children. Enhancing social skills, empathy and other emotional development as a co-goal were also mentioned in nine studies, out of which 67% reported positive changes.

Of the seven studies that reported spending time in nature daily, 57% reported enhanced nature connectedness. The same applied to using unstructured play as a method. Child-centeredness and contact with animals were both reported by eight studies, of which 62% reported enhancement in nature connectedness, gardening was reported in six studies, out of which half reported enhanced nature connectedness, and 40% of studies that reported playing or doing art with natural or loose materials outside (two out of five studies) reported nature connectedness. Playing and doing art with natural or loose materials inside and natural views from the windows were both reported by one study only. Neither reported enhanced nature connectedness.

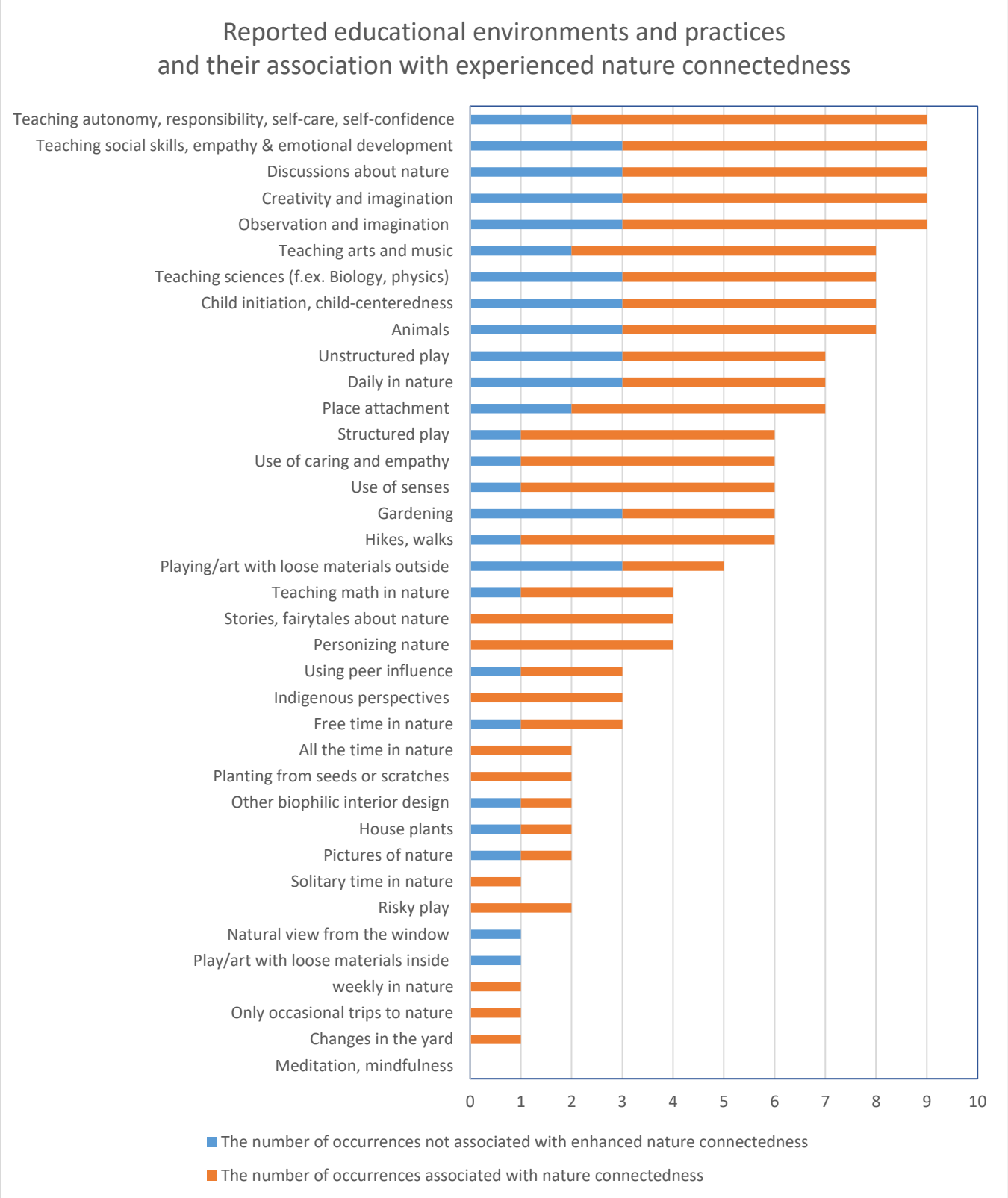

Figure 2. The number of reported educational environments and practices and their association with experienced nature connectedness.

DISCUSSION

Main results

We examined early childhood educational environments and practices in studies of children's nature connectedness. Some educational environments and practices were found to be more often linked with enhanced nature connectedness than others. An association of over 75% with enhanced nature connectedness (out of the practices which were reported more than twice) was discovered with Indigenous perspectives, personizing nature, telling stories about nature, structured playing or activities in nature, taking walks or hikes in nature, using sense experiences or using empathy and caring as tools to enhance nature connectedness, and teaching autonomy, arts, or sciences as a co-goal when in nature.

Personizing nature, telling stories, and Indigenous perspectives were associated with enhanced nature connectedness in 100% of the cases, but were all only rarely mentioned. Gaining more robust knowledge about their association with enhanced nature connectedness would be advisable before drawing any conclusions: Therefore, these methods could particularly be something that future studies could focus on. Yilmaz et al. (2020a), for instance, have already studied the use of storytelling. However, they did not measure nature connectedness but a more knowledge-based understanding of human-nature connection. In their study, only one story was read to the participants. In future research, it would be interesting to delve deeper into the world of stories by comparing different kinds of stories and their effect on nature connectedness in particular. For example, the role of raising empathy through stories would be of special interest due to the link between empathy and nature connectedness, of which indications were also found in this scoping review.

Personizing nature and Indigenous perspectives are both broad concepts with versatile implementation options. Indigenous perspectives arose as an item from the selected studies in the iterative data extraction phase. As an item, “Indigenous perspectives” was not in this study a specific program or a practice: we measured it with mentions of relevant keywords, without any requirements of specifically described practices. Whether there are some specific practices involved and to what extent these practices are parallel with the other items in this review – such as telling stories, personizing nature, or emphasizing empathetic responding – should be studied more carefully in the future. Moreover, it would be worth considering, whether Indigenous perspectives could in an educational context refer to something like a tone, an atmosphere, or a way to approach or attend to the natural world practiced in everyday life, or whether merely for instance reading Native American poetry would have the same possible effects in itself. We consider this a rich and interesting line of research in the future. A cross-cultural approach would also be beneficial in further studies concerning Indigenous perspectives in the context of early childhood education.

As for personizing nature, future studies concerning its implementation should take careful notice of not turning it into possibly harmful anthropomorphizing, where a child might think of other life forms having human needs; for instance, that a worm or a cricket would need a little house with a little bed to be happy. While giving living entities personal characters to increase empathy could be considered something to encourage, building little cardboard homes for them and trapping them there would not. Due to this difference, mentions of this kind of harmful anthropomorphizing were left out from this item in our data extraction process. Using empathy-inducing strategies as a tool was itself strongly associated with enhanced nature connectedness: In future studies, personizing nature could be one specific means to be tested in which to enhance empathy toward nature.

As a whole, the results of this review indicate that there is variance in the effectiveness of programs and interventions aimed at enhancing the nature connectedness of children. For instance, of the studies where children visited nature daily, only 57% reported enhanced nature connectedness. However, all the studies that reported children spending all their time in nature reported enhancement of nature connectedness, but little can be drawn from this result since there were only two of them in this review. Place attachment (regular visits to the same natural area) is often seen as important in enhancing nature connectedness (see for instance Basu et al., 2020). In this scoping review, place attachment was not always connected with an enhanced nature connectedness: in almost one-third (29%) of the cases it was not. One possible explanation for why in our scoping review daily nature exposure and place attachment were not often associated with enhanced nature connectedness may be that the tools and

study designs used in the included studies were not able to detect change in nature connectedness reliably. One frequent limitation in measuring nature connectedness of children this young has been the ceiling effect (Barrable & Booth, 2020). Another reason for these observations – that daily nature exposure nor place attachment may not necessarily be enough by themselves to enhance nature connectedness – is that it might matter what is done when in nature situations; it is not enough just to provide them. As Giusti and colleagues (2018) found, there are many qualities that can be present in nature situations that become significant for children. To support the development of children's HNC, it is important to provide nature situations with a set of several different qualities. We see this as a valuable line of research in the future. A comprehensive reporting of the different qualities would, however, be of utmost importance to allow and foster future practical implementation.

Half of the included studies concerned substantially long interventions of over half a year up to two years. This can be considered important, for while sometimes conceptualized as a temporary state of mind, nature connectedness has also been viewed as something fairly stable, changing only slowly, thus resembling closely personality traits (Whitburn et al., 2019). However, indications of a fast change were provided in this review by Yilmaz et al. (2020), who conducted visits to natural areas over four weeks and were able to show a statistically significant difference in children's affinity toward nature. In these kinds of short-term interventions, it would be important in the future to do follow-up measurements to see, whether the change that was detected was of a permanent kind or only temporary. This would give valuable information for the theoretical considerations concerning nature connectedness and its duration.
While most of the studies had fairly small samples, there was one study that had a significantly large sample of 419 children (Cincera et al., 2017). It used a pretest-posttest setup in an eight-month-intervention of an Eco-school approach where the children were given a chance to plan their own environmental education program. They found a statistically significant increase in nature connectedness of children after the intervention. In the future, conducting studies of this magnitude would be beneficial in extending the scientific rigor of the knowledge we have on nature connectedness and the practices or environments that affect it.

Limitations of the included studies and the scoping review

Given that all the included studies were conducted with urban children and almost all in Western countries, an approach that would emphasize diversity more would be beneficial in the future to increase the generalizability of the results. Comparative studies between Western and non-Western cultures would be needed, as well as comparisons between rural and urban children.

The motive behind the objective of this scoping review was to provide information to those ECE units that are not able to visit nature daily. However, among the selected studies, nine out of fourteen studies were conducted in urban ECE units with access to natural areas. Future research would benefit from comparing units with regular nature exposure and without one. Conducting pretest-posttest interventions in such versatile environments would give more robust and specified information on the effect of these interventions in circumstances where visiting natural areas is not part of everyday routines compared to those where it is.

While we endorse the idea of Giusti et al. (2018), that there is no one means by which the nature connectedness of children could be enhanced, we do consider it also valuable to conduct interventions that concentrate on measuring the effect of some specific practice. Great examples of such studies are Deniz and Kalburan's (2022) school gardening intervention and Lee's (2021) biowall installation. However, also these kinds of studies would benefit from a comparative setup where the same intervention is conducted in ECE units with different circumstances. Gathering observational data from the participating units' educational environments and practices would further increase the understanding of possible differences between the units and their effect on the results.

As already acknowledged, the studies used varied methodologies and conceptualizations. None of the studies used the same methodology as others. However, some studies used pre-existing methods: For instance, in Canada, Omidvar et al. (2019) used a measurement developed by Giusti et al. (2014) in Sweden (Games Testing for Emotional, Cognitive and Attitudinal Affinity with the Biosphere). Both studies involved ECE units implementing the same pedagogical approach (Reggio Emilia) which according to Omidvar (2019b, 221) values the natural world highly and

provides children with an integration of nature and self. Because it seemed that many of the children did not understand the questions, Omidvar and colleagues hypothesized in their conclusions, that among other things one reason why they did not find an effect on nature connectedness but Giusti and colleagues did, might be because the test should be adapted to Canadian children. Later, the adaptation was conducted (MacKeen et al., 2020) and a positive connection was found. However, in this study, or the study of Giusti and colleagues, no educational environments or practices were reported so they were excluded from the current scoping review.

The lack of a correlational study between the different measurements and concepts similar to that of Tam's (2013) concerning studies on adult HNC also limits the possibilities of concluding whether the studies included in this scoping review measured the same underlying construct with their differing tools and concepts. Given the heterogeneity of concepts and measurements, we do not recommend conducting a systematic review at the moment.

The research gap found fifteen years ago (Davis, 2009) concerning studies of young children's environmental education has definitely shrunk down, but similar to earlier reviews on closely related issues, we also must conclude that more work is yet to be done with the unification of methodology and the rigor of study designs. All the studies included in the review were nonrandomized (or at least did not report randomization). None of the studies controlled for how much the children spent time in nature when not in daycare, nor did they control for the nature connectedness of the educators, with only one controlling for the nature connectedness of the parents, although all these factors can have a substantial effect on children's nature connectedness as well as the evaluations of the educators and parents about it. Three studies did not even report how often children were visiting nature. In the future, these factors should be taken into more careful consideration when researching nature connectedness of children.

Due to the nature of the scoping review, which focuses on mapping out the landscape of existing research without critically appraising study quality, this review cannot definitively comment on the effectiveness of the educational practices under investigation. Another limitation of the current scoping review is the substantial amount of interpretation that the classification of data needs. To some degree, it can be doubted, whether the results would be exactly the same if conducted by other researchers. Although most of the conclusions were easily negotiated, they are tinted with the knowledge, outlooks, and intuitions of the decision-makers. For example, IS and MS concluded together that every time singing in natural environments was mentioned, it was interpreted as "music as a co-goal", for it was reasoned that singing songs in the ECE context is one main method of achieving this goal. Another pair of reviewers might have reached a different conclusion.

Situating the results to the theoretical background

To situate the results of this scoping review to the research field in general, it is useful to compare the results to the theoretical frameworks on which the data collection tool was constructed. The included ACHUNAS items received mixed results. Three items were associated with an enhanced nature connectedness over 75% of the time: engagement of senses, creative expression (creativity & imagination), and structure and instructions (structured play or activities). Thought-provocation (discussions about nature), creative expression (arts and music as a co-goal), social/cultural endorsement (influence of peers), child-driven situations, and involvement of animals were associated with nature connectedness in 57-74% of the cases. Challenging situations (risky play, 2 mentions) and intimacy (solitary time in nature, 1 mention) were a 100% match, but with only a few occurrences. Mindfulness received no mentions.

Items connected to biophilic design were mentioned very rarely, which is surprising considering the vast number of studies conducted concerning biophilic design in general and in educational contexts. Perhaps researchers of biophilia have not been as interested in experiences of nature connectedness as they have been in the direct effect of nature's presence (exposure to nature) on a wide variety of issues, especially related to health (see e.g. Gillis & Galabrese, 2015). In this review, pictures of nature, house plants, and "other biophilic design" were each mentioned in two studies. For each measure, the other one reported enhanced nature connectedness while the other one did

not. Playing and making art with natural or loose materials and natural views from windows were mentioned in one study each, and neither reported enhanced nature connectedness.

Of the elements in Alexia Barrable's (2019) pedagogy for connection, building compassion toward non-human species as a means to enhance nature connectedness was in this review linked with enhanced nature connectedness in 83% of the cases. Barrable also mentions "anthropomorphizing" nature (which we decided to call "personizing" nature to avoid misunderstandings) as a means to build compassion. Every time personizing was mentioned, the study also reported enhanced nature connectedness. The third element in Barrable's pedagogy, mindfulness, was not mentioned in any of the studies, but this does not mean it was not used, only that it was not reported. For instance, in Hu's (2022) study on nature journaling, a closely similar practice was mentioned: a "sit spot", where it was the plan to sit quietly, notice what is going on around, and then document it on the journal. It was because of the act of documentation that IS and MS decided to not interpret this as mindfulness. Finally, according to Barrable, engaging in nature's beauty can be conducted by noticing, discussing, and doing art; we did not have "noticing beauty" in our data template, but discussions (67%) and art (75%) were fairly often linked with enhanced nature connectedness.

According to our review, the association between nature connectedness and practices drawn from these theoretical frameworks that would specifically need more research in the future would be meditation or mindfulness in nature, biophilic design in the facilities, challenging situations, intimacy, and noticing beauty. These practices seem to have received only limited attention so far.

Conclusion

The results of this scoping review show that the educational environments and practices are often not sufficiently reported in the studies concerning nature connectedness of children. In the future, studies that focus specifically on more detailed reporting would be needed in order to meet the practical goal of this review to provide useful, detailed information for practitioners as well as researchers on the topic. This could involve studies that focus on the effects of one specific intervention (such as the biowall in Lee, 2021), studies that implement and report carefully an intervention with a set of several different qualities, studies with a comparative approach, and studies that document and report widely the educational environments and practices, taking into account the influence of other relevant factors than those implemented in the intervention. Finally, we would be delighted to see special attention paid in the future to the "bubbling under" practices that received only a few mentions but were associated with enhanced nature connectedness each time: Indigenous perspectives, personizing nature, and telling stories about nature. Even though Indigenous perspectives were mentioned rarely as such, it may be that it represents a more all-encompassing educational atmosphere, underlying thus possibly many of the other items in this review.
All and all, a lot has been already done in the field, but a lot still remains to be discovered.

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Author contributions
The contributions of each author in the review process were the following: IS, VM, and PS contributed to the development of the selection criteria, the data extraction criteria, and the search strategy and read, provided feedback, and approved the manuscript of the protocol. MH and MS approved the protocol in February 2024. IS and MH conducted the selection process and amended the selection criteria when facing problems. IS and MS conducted the data extraction as an iterative process. PS gave a third opinion in cases of disagreement in the selection and data extraction phases. IS conducted the analyses. PS supervised the process. IS wrote the first draft of the report, and all authors read, provided feedback, and approved the final version of the review.

Conflicts of interest

There is no conflict of interest in this project.

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