

Beyond Access to Nature: Nature-Based Learning, Meaningful Participation, and Outcomes for Children with Disabilities

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Abstract

Nature-based learning offers opportunities to support the participation, development, and learning of children with disabilities; however, evidence regarding its forms, enabling conditions, and outcomes remains fragmented. This systematic literature review examined what existing literature reveals about nature-based learning experiences, participation, and developmental and educational outcomes for children with disabilities. Following the PRISMA framework, 15 studies were identified and synthesized from the selected literature. The studies represented diverse approaches, including Forest School, sensory gardens, horticultural activities, outdoor adventure, wild-nature experiences, and other forms of nature-based and outdoor learning. The synthesis generated three interconnected themes: diverse nature-based learning opportunities; accessibility and support as conditions for meaningful participation; and multidimensional developmental and educational outcomes. Across the studies, nature-based experiences provided opportunities for experiential and sensory learning, exploration, movement, autonomy, and social interaction, with reported outcomes spanning social participation, emotional well-being, sensory engagement, physical development, and learning. Importantly, the findings indicate that exposure to nature alone does not ensure positive outcomes. Rather, nature provides opportunities; accessibility and support enable meaningful participation; and meaningful participation creates pathways toward developmental and educational outcomes. The evidence remains predominantly focused on autistic children, highlighting the need for research involving a broader range of disabilities. These findings underscore the importance of designing accessible, supportive, and inclusive nature-based learning experiences that enable meaningful participation for diverse learners.

Keywords: Nature-based learning; children with disabilities; meaningful participation; accessibility; inclusive education; systematic literature review

Manuscript History

Received: 22 July 2026

Revised: 25 July 2026

Accepted: 27 July 2026

How to cite

Wijastuti, A., Rofiah, K., Ainin, I. K., Minarsih, N. M. M., Shafirarosah., L. M., (2026). Beyond Access to Nature: Nature-Based Learning, Meaningful Participation, and Outcomes for Children with Disabilities. Grabkids: Journal of Special Educational Need, 06(02), 105-119

INTRODUCTION

Nature-based learning (NBL) has emerged as an increasingly influential educational approach that extends learning beyond conventional classroom settings by positioning natural environments as dynamic contexts, resources, and catalysts for meaningful learning experiences. This growing interest reflects a broader transformation in educational philosophy, which increasingly recognizes that meaningful learning is fostered not only through the acquisition of knowledge in formal classroom environments but also through authentic interactions with real-world contexts that encourage exploration, inquiry, collaboration, and experiential engagement (UNESCO, 2020; Rieckmann, 2018). Consistent with the principles of Education for Sustainable Development (ESD), contemporary educational systems are expected to prepare learners with the knowledge,

competencies, values, and dispositions necessary to address increasingly complex environmental, social, and global challenges while promoting active participation in sustainable futures (United Nations, 2015; UNESCO, 2017, 2020). Within this broader educational paradigm, nature-based learning provides a practical framework for translating these aspirations into meaningful educational experiences by connecting children directly with natural environments through outdoor learning, forest school programmes, garden-based learning, environmental education, nature play, horticultural activities, and other forms of experiential learning (Jordan & Chawla, 2019; Kuo et al., 2019; Mann et al., 2022). Growing empirical evidence consistently supports the educational value of these experiences across multiple developmental domains. Systematic reviews have demonstrated that nature-based and outdoor learning contribute positively to academic achievement, cognitive functioning, executive functioning, physical activity, social-emotional competence, mental health, environmental awareness, and psychological well-being among children (Becker et al., 2017; Fyfe-Johnson et al., 2021; Mann et al., 2022; Tillmann et al., 2018). Similarly, broader syntheses of environmental education research indicate that learning experiences situated within natural environments not only improve environmental knowledge but also foster positive attitudes toward conservation, responsible environmental behavior, and long-term engagement with sustainability issues (Ardoin et al., 2020). These findings align with evidence suggesting that experiential environmental learning is more likely than passive, classroom-based instruction to cultivate critical thinking, collaboration, problem-solving, and sustainability competencies because learners actively engage with authentic environmental phenomena rather than merely acquiring abstract concepts (Brundiers et al., 2021; Redman et al., 2021). Furthermore, Mann et al. (2022) concluded that nature-specific outdoor learning creates opportunities to simultaneously promote academic development, socio-emotional learning, and overall well-being, highlighting the multidimensional educational value of learning in natural settings. These findings suggest that natural environments should no longer be regarded merely as recreational spaces, but as pedagogically valuable settings for holistic child development.

The educational potential of nature-based learning may be particularly significant for children with disabilities, whose diverse developmental characteristics, learning preferences, and support needs are not always fully accommodated within conventional classroom-based instruction. Inclusive education recognizes that children with disabilities represent a highly heterogeneous population, encompassing individuals with autism spectrum disorder, intellectual disabilities, physical disabilities, sensory impairments, communication disorders, learning disabilities, and other developmental conditions, each of whom may require different pathways to access, engagement, and meaningful participation in learning (UNESCO, 2020; Mitchell & Sutherland, 2020). Rather than relying predominantly on language-based and teacher-directed instruction, nature-based learning provides flexible, experiential, and multisensory learning opportunities that encourage exploration, movement, observation, collaboration, and interaction with authentic environments. Such characteristics are considered particularly valuable because they allow children to engage with learning through multiple sensory modalities, personal interests, and active participation, thereby creating opportunities to strengthen communication, social interaction, autonomy, emotional regulation, and overall well-being while accommodating diverse learning profiles (Kuo et al., 2019; Villanueva & Hand, 2011). Emerging empirical evidence increasingly supports these educational possibilities. Studies involving children with developmental and neurodevelopmental conditions, particularly autistic children, have reported that participation in nature-based interventions may contribute to improvements in engagement, social participation, communication, emotional well-being, and broader dimensions of functioning (Li et al., 2023). Likewise, evidence from inclusive outdoor learning contexts suggests that natural environments can become meaningful educational spaces when instructional activities are intentionally designed to accommodate learner diversity rather than assuming homogeneous abilities. For example, Atchison et al. (2019) demonstrated that inclusive field-based learning experiences could successfully facilitate active participation among students with physical disabilities when accessibility considerations were embedded into programmed design. Collectively, these findings suggest that the educational value of nature-based learning lies not only in exposure to natural environments but also in its capacity to provide flexible and authentic learning experiences that can be adapted to diverse learner characteristics.

However, growing evidence also indicates that access to nature does not automatically result in inclusive learning experiences. Children with disabilities frequently encounter physical, sensory, communication, pedagogical, and social barriers that restrict meaningful participation in outdoor educational activities. Uneven terrain, inaccessible pathways, inadequate transportation, unsuitable facilities, and non-adapted learning equipment may limit participation for children with physical disabilities, while unpredictable environmental stimuli—including sounds, textures, weather conditions, and visual complexity—may create additional

challenges for children with sensory processing differences. Similarly, children with communication disabilities may experience exclusion when learning activities rely primarily on spoken language without appropriate visual supports, augmentative and alternative communication (AAC), sign-supported communication, or other accessible communication systems. These barriers illustrate that disability should not be understood solely as an individual characteristic but as the result of interactions between individuals and environmental, social, communicative, and institutional contexts that either facilitate or restrict participation (United Nations, 2006; World Health Organization & World Bank, 2011). Consequently, realizing the educational potential of nature-based learning requires greater attention to accessibility, inclusive practices, and the removal of barriers that may prevent children with disabilities from fully benefiting from these learning experiences.

Ensuring that nature-based learning is genuinely inclusive requires moving beyond simply providing opportunities for children to access outdoor environments toward creating learning experiences that enable meaningful participation for learners with diverse abilities and support needs. Accessibility in nature-based learning therefore extends far beyond physical access to natural spaces. Rather, it encompasses the extent to which children are able to understand learning activities, communicate with others, interact with natural materials, make choices, engage in collaborative learning, and participate independently or with appropriate support throughout the learning process. This perspective aligns with the principles of inclusive education, which emphasize the removal of barriers to learning and participation and the creation of educational environments that are responsive to learner diversity rather than expecting learners to adapt to inflexible educational systems (Ainscow, 2020; UNESCO, 2020). Consequently, inclusive nature-based learning requires careful consideration of physical, sensory, communicative, pedagogical, and social accessibility when designing and implementing educational activities. From a practical perspective, inclusive practices within nature-based learning may involve a wide range of environmental, instructional, and interpersonal adaptations. These include accessible pathways and outdoor facilities, adapted learning materials and equipment, sensory accommodations, visual supports, assistive technologies, augmentative and alternative communication (AAC), differentiated instruction, structured routines, peer-mediated support, and individualized scaffolding that enable children with diverse disabilities to participate meaningfully in shared learning experiences. Such adaptations reflect the broader principle that educational equity is achieved not by providing identical learning experiences for every learner but by ensuring that each child receives the support necessary to participate and learn successfully (Mitchell & Sutherland, 2020; UNESCO, 2020). Evidence from inclusive outdoor education further demonstrates that participation is strengthened when learning environments are intentionally designed according to principles of accessibility and learner-centered pedagogy rather than relying on retrospective accommodations after barriers have emerged (Atchison et al., 2019). These findings suggest that accessibility should be understood as an integral component of educational quality rather than merely a technical or environmental consideration.

The concept of participation further strengthens this perspective by shifting attention from physical presence to meaningful involvement in learning. According to the International Classification of Functioning, Disability and Health (ICF), participation refers to an individual's involvement in life situations and is shaped by continuous interactions between personal functioning and contextual factors (World Health Organization, 2001). Accordingly, a child may be physically present within an outdoor learning activity yet remain excluded from communication, collaborative problem-solving, decision-making, peer interaction, or authentic engagement with learning tasks. From this perspective, accessibility represents the conditions that enable participation, whereas participation reflects the extent to which children are actively involved in educational experiences. This understanding is also consistent with the social and rights-based models of disability, which emphasize that exclusion arises not solely from individual impairments but from environmental, social, communication, and institutional barriers that limit opportunities for participation (United Nations, 2006; World Health Organization & World Bank, 2011). Taken together, these perspectives indicate that evaluating the effectiveness of nature-based learning for children with disabilities requires consideration not only of educational outcomes but also of the accessibility strategies, inclusive practices, and participation processes through which those outcomes are achieved. These dimensions provide an essential conceptual framework for understanding how inclusive nature-based learning should be designed, implemented, and evaluated across diverse educational settings.

Despite the growing body of research demonstrating the educational value of nature-based learning, the evidence concerning children with disabilities remains fragmented across disability groups, educational contexts, and disciplinary fields. Existing systematic reviews have established that nature-specific outdoor

learning can promote academic achievement, socio-emotional development, environmental awareness, and well-being among children in general (Mann et al., 2022). Other reviews have synthesized evidence for specific populations, particularly autistic children, highlighting the potential of nature-based interventions to improve engagement, communication, social participation, and emotional outcomes (Li et al., 2023). While these studies provide valuable insights into the potential benefits of nature-based experiences, they predominantly emphasize intervention effectiveness or developmental outcomes, with comparatively limited attention given to the broader conditions that enable inclusive participation, including accessibility, environmental adaptations, communication supports, pedagogical modifications, and inclusive implementation across diverse disability groups. Consequently, current knowledge remains dispersed across different disciplines, intervention models, and disability categories, making it difficult to develop a comprehensive understanding of how nature-based learning can be designed to support equitable participation for all children with disabilities. This limitation reflects a broader challenge identified within both inclusive education and sustainability research. Recent scholarship has argued that disability perspectives continue to be insufficiently represented within Education for Sustainable Development (ESD), environmental education, and sustainability-related policies and practices, despite international commitments to inclusive and equitable education (Rončević & Rieckmann, 2025; Salvatore & Wolbring, 2022). Similarly, scholars have highlighted that accessibility is frequently conceptualized in terms of physical infrastructure, while pedagogical accessibility, communication accessibility, and meaningful participation remain substantially underexplored within environmental and outdoor learning contexts. Such limitations suggest that inclusion within nature-based learning cannot be evaluated solely by determining whether children participate in outdoor activities, but also requires understanding how learning environments are intentionally adapted to accommodate diverse functional profiles, communication needs, sensory characteristics, and educational support. Without this broader perspective, evidence regarding the effectiveness of nature-based learning risks overlooking the mechanisms through which inclusive educational experiences are created.

Furthermore, disability represents a highly heterogeneous concept, and evidence generated from one disability group cannot be assumed to apply equally to others. Children with physical, sensory, intellectual, communication, neurodevelopmental, and multiple disabilities often encounter distinct environmental, pedagogical, technological, and social barriers that require different forms of support to achieve meaningful participation. Consequently, synthesizing the literature across diverse disability groups is essential not only to identify the educational outcomes associated with nature-based learning but also to examine which populations have been represented, and where important gaps in knowledge remain.

Accordingly, this systematic review, conducted and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines (Page et al., 2021), synthesized empirical evidence on accessible and inclusive nature-based learning for children with disabilities. Unlike prior reviews that have addressed either nature-based educational outcomes in general populations or intervention effectiveness within a single disability group (e.g., autism), this review is distinctive in explicitly linking three elements that have so far been examined separately: the diversity of nature-based learning opportunities, the accessibility and support conditions that enable participation, and the resulting developmental and educational outcomes, synthesized jointly across multiple disability groups.

METHOD

Study Selection

The systematic database searches identified 842 records from Scopus ($n = 276$), Web of Science Core Collection ($n = 238$), ERIC ($n = 148$), APA PsycINFO ($n = 112$), and MEDLINE/PubMed ($n = 68$). An additional 93 records were identified through supplementary search methods, including backward citation searching ($n = 54$), forward citation searching ($n = 28$), and reference-list screening of relevant reviews ($n = 11$). This resulted in 935 records being identified. After removing 217 duplicate records, 718 unique records remained for title and abstract screening. Of these, 637 records were excluded because they did not meet the eligibility criteria, including irrelevant topic ($n = 476$), wrong population ($n = 96$), and inappropriate study design or publication type ($n = 65$). Consequently, 81 reports were sought for retrieval, of which 10 could not be retrieved (full text unavailable, $n = 8$; could not be obtained, $n = 2$). The remaining 71 reports were assessed for full-text eligibility. Following full-text assessment, 56 reports were excluded because they did not satisfy the inclusion criteria, including absence of a meaningful nature-based learning activity ($n = 22$), absence of disability-specific data ($n = 13$), participants not being children with disabilities ($n = 7$), inappropriate study design or publication type ($n = 6$), nature exposure only without a structured learning activity ($n = 5$), and

insufficient empirical data ($n = 3$). Ultimately, 15 studies met all inclusion criteria and were included in the final systematic review.

Data Extraction and Risk of Bias Assessment

Data from each included study were extracted using a standardized form covering author(s) and year, country, participant characteristics and disability type, the nature-based or outdoor learning activity, study design, and reported participation and outcome findings. Studies were not excluded on the basis of methodological quality alone, but quality appraisal informed the interpretation of findings across the three themes.

PRISMA Phases

Phase 1: Identification

The identification phase involved a systematic search of the literature across multiple electronic databases to capture studies examining nature-based learning and related educational or developmental activities for children with disabilities. Searches were conducted in Scopus, Web of Science (WoS), ERIC, and PubMed/MEDLINE, supplemented by backward and forward citation searching of relevant articles. These databases were selected to provide multidisciplinary coverage across education, special and inclusive education, disability, psychology, child development, and health-related research.

The search strategy was developed around three main concepts: nature-based learning, children with disabilities, and children or adolescents. Search terms related to nature-based learning included “nature-based learning,” “nature-based education,” “outdoor learning,” “outdoor education,” “forest school,” “garden-based learning,” “school garden,” “horticultural education,” “sensory garden,” “environmental education,” “nature play,” “outdoor classroom,” and “nature-based activities.” These terms were combined using the Boolean operator AND with disability-related terms, including *disab**, “special educational needs,” SEND, autism, “developmental disabilities,” “intellectual disabilities,” “physical disabilities,” “learning disabilities,” “hearing impairment,” “visual impairment,” and “multiple disabilities.” Population-related terms such as *child**, *adolescen**, *student**, *pupil**, *preschool**, and “early childhood” were also incorporated. An example of the core search strategy applied in Scopus was:

```
TITLE-ABS-KEY (("nature-based learning" OR "nature based
education" OR "outdoor learning" OR "outdoor education" OR "forest
school*" OR "garden-based learning" OR "school garden*" OR
horticulture* OR "sensory garden*" OR "environmental education" OR
"nature play" OR "outdoor classroom*") AND (disab* OR "special
educational needs" OR SEND OR autism OR autistic OR "developmental
disabilit*" OR "intellectual disabilit*" OR "physical disabilit*" OR
"learning disabilit*" OR "hearing impair*" OR "visual impair*" OR
"multiple disabilit*") AND (child* OR adolescen* OR student* OR
pupil* OR preschool* OR "early childhood"))
```

The syntax was adapted according to the indexing structure and search functions of each database. Supplementary citation searching was also conducted because terminology in this field varied considerably across disciplines and publication periods. In particular, relevant studies did not always explicitly use the term nature-based learning, instead using terms such as Forest School, sensory garden, outdoor education, or horticultural learning. All records identified during this phase were exported for reference management, deduplication, and subsequent screening.

Phase 2: Screening

All records retrieved from the databases and supplementary searches were exported in compatible bibliographic formats and imported into Rayyan, a web-based systematic review application designed to facilitate title and abstract screening and study selection (Ouzzani et al., 2016). Duplicate records were identified and removed before eligibility screening. Screening was conducted in two stages. First, titles and abstracts were assessed against the predefined inclusion and exclusion criteria. Studies were retained when they involved children or adolescents with disabilities, developmental disabilities or delays, neurodevelopmental conditions, or special educational needs and disabilities (SEND), and included

meaningful engagement with natural environments or natural elements through an educational, developmental, or participatory activity.

Studies were excluded at this stage when they focused exclusively on typically developing children without separately identifiable disability-related data, adult populations, passive exposure to green space, or activities in which the outdoor environment was merely a location rather than a meaningful component of the learning experience. For example, conventional outdoor sports and physical education were not considered nature-based learning unless interaction with nature constituted an integral component of the activity. Potentially eligible studies proceeded to full-text screening. Particular attention was given to distinguishing nature-based learning from other uses of the term “natural.” Studies referring to natural learning environments only in the sense of everyday or naturally occurring settings were not automatically included. They were retained only when children meaningfully interacted with nature or natural elements as part of their learning or developmental experiences. The screening process also identified considerable variation in the terminology used to describe relevant activities. To accommodate this diversity without compromising conceptual consistency, potentially eligible activities were grouped into broad categories including Forest School and woodland learning, garden- and horticulture-based activities, sensory gardens and nature play, outdoor adventure and exploration, outdoor science and environmental learning, and other meaningful nature-based educational or developmental experiences.

Phase 3: Eligibility and Included Studies

Full-text articles retained after title and abstract screening were assessed in detail against the predefined eligibility criteria. Studies were required to report primary empirical research involving children with disabilities or SEND who actively participated in a meaningful nature-based educational, developmental, or participatory experience. The main reasons for full-text exclusion were an absence of a meaningful nature-based component, an ineligible population, inability to distinguish findings for children with disabilities, passive nature exposure without active participation, non-empirical publication type, and interventions that were exclusively clinical or therapeutic without an identifiable educational, developmental, or participation-related component.

Following full-text eligibility assessment, 15 studies met all inclusion criteria and were included in the final qualitative synthesis. The final studies represented a heterogeneous evidence base encompassing different disability populations, educational and developmental settings, and forms of nature-based learning. Autistic children and broader SEND populations were most frequently represented, while evidence concerning children with physical, sensory, communication, and multiple disabilities was comparatively limited. The included nature-based activities were subsequently organized into conceptually related categories for synthesis rather than treating each terminology used by the original authors as a separate intervention type. The analysis focused on three overarching dimensions emerging across the 15 studies: (1) nature as an alternative and experiential learning environment, (2) nature as a context for participation and development, and (3) accessibility and support as conditions for meaningful nature-based learning (see Table 1). The complete process of identification, duplicate removal, screening, full-text eligibility assessment, exclusion, and final inclusion of 15 studies is presented in the PRISMA 2020 flow diagram (Figure 1)

PRISMA 2020 Flow Diagram for New Systematic Reviews
 Accessible and Inclusive Nature-Based Learning for Children with Disabilities

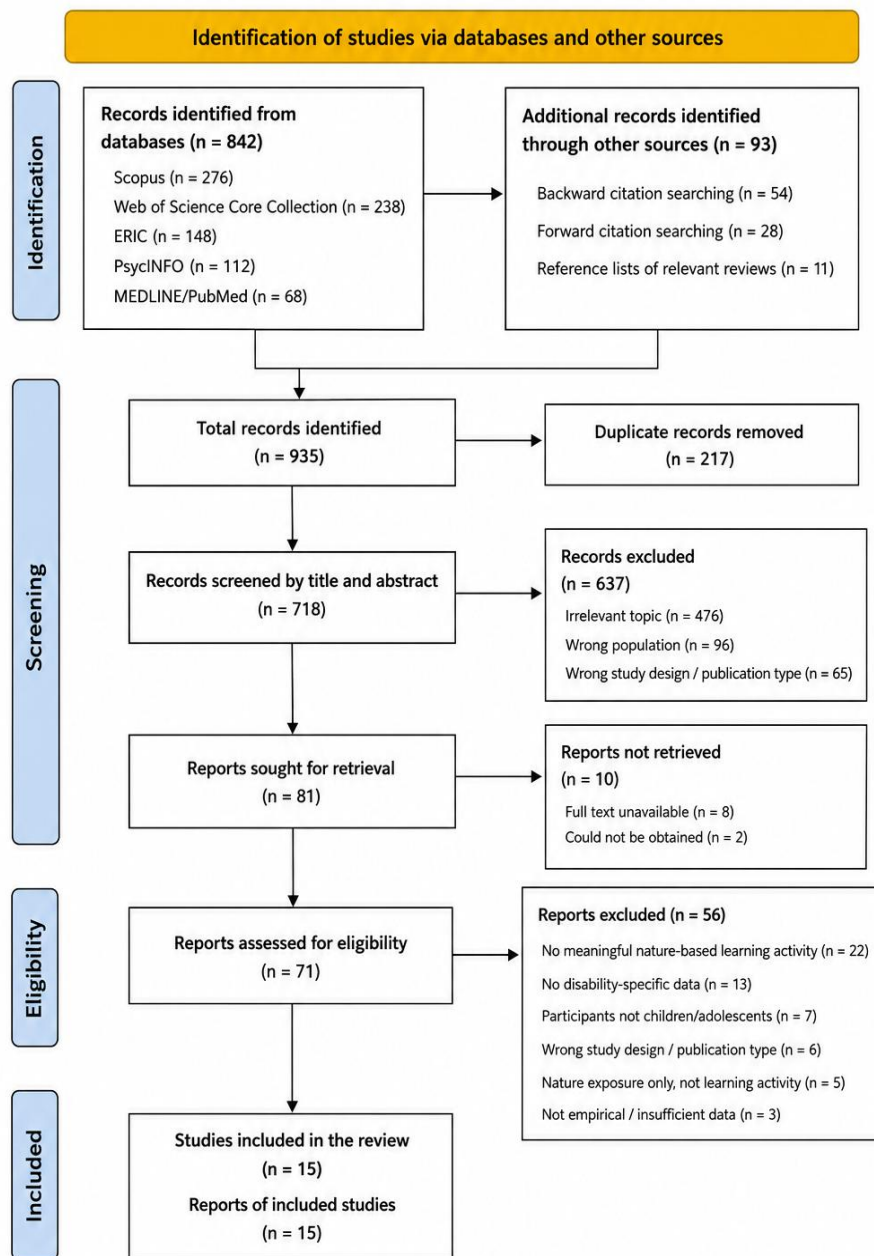


Figure 1. The systematic literature review process based on PRISMA

The 15 studies included in this systematic review demonstrate considerable diversity in the application of nature-based and outdoor learning for children with disabilities, encompassing Forest School, sensory gardens, horticultural activities, outdoor adventure, wild-nature experiences, structured outdoor play, and inclusive outdoor education. The literature spans multiple countries and disability groups, although research involving autistic children predominates, indicating comparatively limited evidence for children with intellectual, physical, sensory, and multiple disabilities. Across studies, natural environments provided opportunities for experiential and multisensory learning, social interaction, autonomy, physical activity, and emotional well-being. However, the findings also indicate that simply providing access to outdoor or natural environments does not necessarily ensure positive outcomes. Environmental accessibility, appropriate adaptations, responsive practitioner support, and opportunities for meaningful participation emerged as important conditions through which nature-based learning opportunities may contribute to developmental and educational outcomes for children with disabilities.

Table 1. Articles Included in the Systematic Analysis of the Literature Review

No.	Researchers & Date	Country	Article Title	Participants / Disability	Nature-Based / Outdoor Learning Activity
1	Friedman, Morrison, & Shibata (2025)	USA, UK & Canada	Practitioner Perspectives on Nature-Based Learning for Autistic Children	Autistic children represented through 14 NBL practitioners	Forest School, horticultural activities, formal nature-based learning, and learning in natural environments
2	Friedman, Gibson, Jones, & Hughes (2024)	United Kingdom	'A New Adventure': A Case Study of Autistic Children at Forest School	25 autistic children	Forest School, child-led nature engagement, exploration, play, and outdoor learning
3	Ziegler & Morrier (2022)	USA	Increasing Social Interactions of Preschool Children With Autism Through Cooperative Outdoor Play	32 preschool children, including 9 children with ASD	Structured cooperative outdoor play and Buddy Game during outdoor recess
4	Friedman & Morrison (2021)	USA	"I Just Want to Stay Out There All Day": A Case Study of Two Special Educators and Five Autistic Children Learning Outside at School	5 autistic children	School-based outdoor and nature-based learning
5	Galbraith & Lancaster (2020)	Australia	Children with Autism in Wild Nature: Exploring Australian Parent Perceptions Using Photovoice	Children with autism	Experiences and participation in wild and natural environments
6	Li, Larsen, Yang, Wang, Zhai, & Sullivan (2019)	China	Exposure to Nature for Children with Autism Spectrum Disorder: Benefits, Caveats, and Barriers	Children with ASD	Engagement with and exposure to natural environments
7	Morrier & Ziegler (2018)	USA	I Wanna Play Too: Factors Related to Changes in Social Behavior for Children With and Without Autism Spectrum Disorder After Implementation of a Structured Outdoor Play Curriculum	35 toddlers/preschoolers, including 10 children with ASD	Structured outdoor cooperative play curriculum
8	Bradley & Male (2017)	United Kingdom	'Forest School Is Muddy and I Like It': Perspectives of Young Children with Autism Spectrum Disorders, Their Parents and Educational Professionals	Young children with ASD	Forest School, woodland exploration, natural play, and child-led learning
9	Zachor, Vardi, Baron-Eitan, Brodai-Meir, Ginossar, & Ben-Itzhak (2017)	Israel	The Effectiveness of an Outdoor Adventure Programme for Young Children with Autism Spectrum Disorder: A Controlled Study	Young children with ASD	Outdoor adventure and nature-based activities
10	Haney et al. (2014)	USA	Park-Based Afterschool Program to Improve Cardiovascular Health and Physical Fitness in Children with Disabilities	Children with disabilities	Park-based outdoor activities and structured physical activities

11	Hussein (2012)	United Kingdom	The Influence of Sensory Gardens on the Behaviour of Children with Special Educational Needs	Children with special educational needs	Sensory gardens and multisensory engagement with natural elements
12	Kim, Park, Song, & Son (2012)	South Korea	Horticultural Therapy Program for the Improvement of Attention and Sociality in Children with Intellectual Disabilities	24 children with intellectual disabilities	Gardening, planting, cultivation, plant-based learning, and horticultural activities
13	Roe & Aspinall (2011)	United Kingdom	The Restorative Outcomes of Forest School and Conventional School in Young People with Good and Poor Behaviour	Young people with good and poor behavioural functioning	Forest School and woodland-based experiences
14	Hussein (2010)	United Kingdom	Using the Sensory Garden as a Tool to Enhance the Educational Development and Social Interaction of Children with Special Needs	Children with special educational needs	Sensory garden learning, sensory exploration, and interaction with natural environments
15	Brodin (2009)	Sweden / European context	Inclusion Through Access to Outdoor Education: Learning in Motion (LIM)	People with disabilities, including children and young people with intellectual disabilities	Inclusive outdoor education, nature-based experiences, and accessible outdoor participation

RESULTS AND DISCUSSION

Before presenting the three themes, it is useful to summarize how the 15 included studies were arrived at. Keywords combined three concepts—nature-based/outdoor learning, disability, and children/adolescents—searched across Scopus, Web of Science, ERIC, APA PsycINFO, and MEDLINE/PubMed, supplemented by citation searching (see Method for the full search string). Of 935 records identified, 718 remained after de-duplication; 81 proceeded to full-text review, and 15 met all eligibility criteria. The included studies originated from the United Kingdom, United States, Australia, China, Israel, South Korea, and Sweden, and used a mix of qualitative case studies, quasi-experimental designs, and mixed-methods approaches, most frequently focused on autistic children.

Characteristics of the Included Studies

A total of 15 studies published between 2009 and 2025 were included in the final synthesis. The studies represented diverse geographical contexts, including the United Kingdom, United States, Australia, China, Israel, South Korea, Sweden/European contexts, and cross-national research involving the United States, United Kingdom, and Canada. Collectively, the studies examined a range of nature-based and outdoor approaches, including Forest School, sensory gardens, horticultural activities, wild-nature experiences, outdoor adventure programmers, inclusive outdoor education, park-based programmers, structured outdoor play, and broader nature-based learning (Bradley & Male, 2017; Brodin, 2009; Friedman & Morrison, 2021; Friedman et al., 2024, 2025; Galbraith & Lancaster, 2020; Hussein, 2010, 2012; Kim et al., 2012; Li et al., 2019; Morrier & Ziegler, 2018; Zachor et al., 2017; Ziegler & Morrier, 2022).

The populations represented across the studies were heterogeneous, although autistic children constituted the most frequently studied group (Bradley & Male, 2017; Friedman & Morrison, 2021; Friedman et al., 2024, 2025; Galbraith & Lancaster, 2020; Li et al., 2019; Morrier & Ziegler, 2018; Zachor et al., 2017; Ziegler & Morrier, 2022). Other studies included children with intellectual disabilities, children with broadly defined special educational needs, children with disabilities, and young people experiencing behavioral difficulties (Brodin, 2009; Haney et al., 2014; Hussein, 2010, 2012; Kim et al., 2012; Roe & Aspinall, 2011). This distribution indicates that the existing literature remains concentrated on autism, with comparatively limited evidence concerning children with physical, sensory, communication, and multiple disabilities. The synthesis of the included studies generated three interconnected themes: (1) diverse nature-based learning opportunities, (2) accessibility and support as conditions for meaningful participation, and (3) multidimensional developmental and educational outcomes.

Theme 1. Diverse Nature-Based Learning Opportunities

The first theme demonstrates that nature-based learning for children with disabilities encompasses a broad range of educational experiences rather than a single intervention or pedagogical model. Across the included studies, learning opportunities ranged from relatively structured programmes, such as horticultural activities and outdoor adventure interventions, to flexible and child-led experiences within forests, gardens, and other natural environments (Bradley & Male, 2017; Friedman & Morrison, 2021; Friedman et al., 2024; Hussein, 2010, 2012; Kim et al., 2012; Zachor et al., 2017).

Forest School emerged as one of the most prominent nature-based approaches, particularly in studies involving autistic children. These studies described woodland and natural environments as providing opportunities for exploration, movement, play, sensory engagement, decision-making, and social interaction beyond conventional classroom routines (Bradley & Male, 2017; Friedman & Morrison, 2021; Friedman et al., 2024). Rather than prescribing identical activities for all learners, Forest School environments frequently provided children with greater flexibility in determining what they explored, how they participated, and the pace of their engagement. Sensory gardens represented another distinctive form of nature-based experience. Hussein (2010, 2012) demonstrated how intentionally designed gardens could provide children with special educational needs with opportunities to engage with natural elements through multiple sensory modalities, including sight, touch, smell, sound, and movement. Such environments expanded learning beyond conventional academic tasks by creating opportunities for sensory exploration, interaction, and engagement within accessible natural spaces.

Horticultural activities similarly provided structured opportunities for children to interact directly with plants and natural materials. Kim et al. (2012), for example, implemented a six-month horticultural programme with children with intellectual disabilities that incorporated planting, cultivating plants, harvesting, and plant-based creative activities. Importantly, the programme was informed by the Korean special education science curriculum, illustrating how nature-based activities can be connected explicitly with educational objectives rather than functioning solely as recreation.

Other studies extended nature-based opportunities into wild-nature experiences and outdoor adventure. Galbraith and Lancaster (2020) explored autistic children's experiences of wild nature, while Zachor et al. (2017) examined a structured outdoor adventure programme for young autistic children. These studies suggest that less-controlled natural environments may provide distinctive opportunities for physical exploration, challenge, autonomy, sensory experiences, and engagement with the environment. However, an important distinction emerged between nature-based learning and activities that simply occur outdoors. Friedman et al. (2025) defined nature-based learning as learning in which natural settings or natural elements are intentionally integral to the lesson, activity, or experience. This distinction is important because outdoor recess, playground activities, and park-based programmes do not necessarily constitute nature-based learning merely because they take place outside. The included literature therefore reflects a continuum in the extent to which nature itself functions as an active component of the learning process.

Theme 2. Accessibility and Support as Conditions for Meaningful Participation

The second theme demonstrates that access to nature does not automatically result in meaningful participation. Across the studies, children's ability to benefit from nature-based opportunities was influenced by the accessibility of environments and activities, the availability of appropriate support, the flexibility of learning experiences, and the responsiveness of adults facilitating participation (Brodin, 2009; Bradley & Male, 2017; Friedman & Morrison, 2021; Friedman et al., 2024, 2025; Li et al., 2019). Accessibility emerged as a multidimensional concept extending beyond physical access. The literature identified potential physical, sensory, social, communication, environmental, and pedagogical barriers that may influence how children with disabilities participate in natural environments (Brodin, 2009; Friedman et al., 2025; Hussein, 2010, 2012; Li et al., 2019). For example, unpredictable sensory experiences, environmental conditions, unfamiliar spaces, communication demands, mobility barriers, and inflexible activities may restrict participation even when children are physically present in an outdoor setting.

Brodin (2009) particularly emphasized the relationship between outdoor education, accessibility, and inclusion. The study highlighted the importance of environmental adaptation, appropriate equipment, assistive resources, and pedagogical planning in enabling people with disabilities to participate in outdoor experiences. This perspective suggests that barriers to nature-based learning should not be understood solely as limitations within individual children but as arising from the interaction between learner characteristics, environmental demands, and available supports. The role of adults was particularly prominent across the literature. Teachers, Forest School practitioners, therapists, parents, and other facilitators acted as mediators between children and the opportunities offered by natural environments (Bradley & Male, 2017; Friedman & Morrison, 2021;

Friedman et al., 2024, 2025; Galbraith & Lancaster, 2020). Their roles included adapting activities, facilitating communication and peer interaction, managing risk, providing emotional support, recognizing individual preferences, and determining when to provide assistance or allow children greater independence.

Friedman et al. (2025), based on interviews with 14 practitioners from the United States, United Kingdom, and Canada, identified environmental affordances, complex practitioner roles, and trust as central dimensions of nature-based learning with autistic children. The findings emphasized that practitioners actively shape how children encounter and engage with nature rather than simply supervising their presence outdoors. Structured support was also evident in outdoor social-play interventions. Morrier and Ziegler (2018) found that a structured outdoor-play curriculum involving familiar songs, movement, and cooperative games increased social interactions among young children with and without autism. Similarly, Ziegler and Morrier (2022) reported increased social bids from autistic preschool children toward their neurotypical peers following implementation of a structured cooperative outdoor-play program. Although these interventions were more strongly focused on structured outdoor participation than direct engagement with nature, they reinforce the importance of intentional environmental and pedagogical support in enabling participation. Across the studies, meaningful participation therefore appeared most likely when children were provided with choice, environmental accessibility, individualized support, responsive adults, appropriate levels of structure, and opportunities for autonomy (Brodin, 2009; Bradley & Male, 2017; Friedman & Morrison, 2021; Friedman et al., 2024, 2025). Accessibility and support thus functioned as a critical bridge between the opportunities offered by nature and children's actual participation in those opportunities.

Theme 3. Multidimensional Developmental and Educational Outcomes

The third theme concerns the diverse outcomes associated with participation in nature-based and outdoor learning. Rather than demonstrating a single dominant benefit, the included studies identified interconnected outcomes across social, emotional, behavioral, sensory, physical, and educational domains (Bradley & Male, 2017; Friedman & Morrison, 2021; Friedman et al., 2024; Hussein, 2010, 2012; Kim et al., 2012; Morrier & Ziegler, 2018; Roe & Aspinall, 2011; Zachor et al., 2017; Ziegler & Morrier, 2022).

Subtheme 1: Social Interaction and Participation

Social development and participation represented one of the most consistently identified outcome domains. Nature-based and outdoor environments created opportunities for shared exploration, cooperative activities, peer engagement, communication, and interaction with adults (Bradley & Male, 2017; Friedman et al., 2024; Hussein, 2010; Kim et al., 2012). Kim et al. (2012), for example, found that children with intellectual disabilities who participated in a six-month horticultural program demonstrated significantly higher sociality scores than children in the control group, although differences in attention were not statistically significant. This finding suggests that structured engagement with plants and horticultural activities may provide a meaningful context for cooperation and social interaction.

Outdoor-play studies also reported improvements in social participation. Morrier and Ziegler (2018) found increases in overall social interactions following implementation of the Buddy Game outdoor-play curriculum, while Ziegler and Morrier (2022) demonstrated increases in social bids from autistic children toward neurotypical peers (Morrier & Ziegler, 2018; Ziegler & Morrier, 2022). Together, these findings indicate that natural and outdoor environments can provide alternative contexts for social participation, particularly when activities create shared purposes, cooperative experiences, and opportunities for spontaneous or supported interaction.

Subtheme 2: Emotional Well-Being, Regulation, and Autonomy

A second cluster of findings concerned emotional well-being, behavioral regulation, confidence, and autonomy. Forest School and other natural environments were frequently characterized by greater flexibility, opportunities for movement, and less rigidly structured forms of engagement than conventional classroom environments (Bradley & Male, 2017; Friedman & Morrison, 2021; Friedman et al., 2024; Roe & Aspinall, 2011). For autistic children in particular, opportunities to make choices, explore preferred interests, move freely, and regulate the pace of participation appeared to contribute to positive experiences of nature-based learning (Bradley & Male, 2017; Friedman & Morrison, 2021; Friedman et al., 2024). Wild-nature experiences similarly provided opportunities for exploration and engagement that differed from highly structured educational settings (Galbraith & Lancaster, 2020).

The evidence, however, also indicates that natural environments should not automatically be characterized as calming or beneficial for every child. Individual sensory preferences, environmental unpredictability, weather, physical accessibility, and unfamiliar experiences may create challenges for some children (Friedman

et al., 2025; Li et al., 2019). Thus, emotional and regulatory benefits appear dependent on the interaction between the individual child, the characteristics of the environment, and the support provided.

Subtheme 3: Learning, Sensory Engagement, and Physical Development

Nature-based environments also created opportunities for learning through direct, experiential, multisensory engagement. Sensory gardens enabled children to encounter different textures, smells, sounds, visual stimuli, plants, and environmental features, thereby providing learning experiences beyond conventional classroom instruction (Hussein, 2010, 2012). Horticultural programmers combined practical engagement with plants with structured educational activities. Kim et al. (2012) incorporated gardening and plant-based activities derived from elements of a special education science curriculum, illustrating the potential for nature-based experiences to connect experiential activity with formal educational objectives.

Forest School and outdoor adventure programmers additionally provided opportunities for movement, problem-solving, exploration, decision-making, risk negotiation, and engagement with real-world environments (Bradley & Male, 2017; Friedman & Morrison, 2021; Friedman et al., 2024; Zachor et al., 2017). Park-based activities also highlighted potential physical-health outcomes for children with disabilities (Haney et al., 2014). Collectively, these findings suggest that one distinctive characteristic of nature-based learning is its potential to engage multiple developmental domains simultaneously. For example, planting a garden may involve sensory exploration, motor activity, scientific learning, responsibility, communication, cooperation, and decision-making, while Forest School exploration may simultaneously involve movement, problem-solving, social interaction, autonomy, and emotional regulation (Friedman & Morrison, 2021; Friedman et al., 2024; Kim et al., 2012).

Across the 15 included studies, the findings indicate an interconnected pathway through which nature-based learning may contribute to outcomes for children with disabilities which is illustrated as Figure 2. First, natural environments provide diverse learning opportunities, including sensory exploration, movement, play, horticulture, environmental interaction, adventure, and experiential learning (Bradley & Male, 2017; Friedman & Morrison, 2021; Hussein, 2010, 2012; Kim et al., 2012; Zachor et al., 2017). Second, these opportunities do not automatically become accessible experiences. Environmental accessibility, individualized adaptation, adult facilitation, appropriate structure, communication support, and responsive pedagogical practices influence whether children can engage with the opportunities available (Brodin, 2009; Friedman et al., 2025; Li et al., 2019). Third, when appropriate accessibility and support are present, children have greater opportunities for meaningful participation, characterized by engagement, choice, autonomy, interaction, exploration, and belonging (Bradley & Male, 2017; Friedman & Morrison, 2021; Friedman et al., 2024, 2025). Finally, meaningful participation creates conditions through which developmental and educational outcomes may emerge, including social interaction, communication, emotional well-being, autonomy, sensory engagement, physical activity, and experiential learning (Hussein, 2010, 2012; Kim et al., 2012; Morrier & Ziegler, 2018; Zachor et al., 2017; Ziegler & Morrier, 2022).



Figure 2. The relationship between 15 studies

A notable research gap was also identified across the 15 studies. The evidence base remains strongly concentrated on autistic children, while substantially less research has examined nature-based learning among children with intellectual, physical, sensory, communication, and multiple disabilities (Bradley & Male, 2017; Friedman & Morrison, 2021; Friedman et al., 2024, 2025; Galbraith & Lancaster, 2020; Li et al., 2019). Although studies such as Kim et al. (2012) extend the evidence to children with intellectual disabilities, broader representation of disability groups remains limited. Future research therefore needs to clarify what forms of nature-based learning are effective, for whom, under what environmental and support conditions, and through which mechanisms meaningful participation contributes to educational and developmental outcomes.

CONCLUSION

This systematic review demonstrates that nature-based learning offers diverse opportunities for children with disabilities to engage in experiential, sensory, social, and educational activities across settings such as Forest Schools, sensory gardens, horticultural programmes, and other natural environments. The findings reveal an interconnected process in which nature provides opportunities; accessibility and support enable meaningful participation; and meaningful participation creates pathways toward developmental and educational outcomes. These outcomes encompass social interaction, emotional well-being, autonomy, sensory engagement, physical development, and learning. Importantly, the findings suggest that exposure to nature alone is insufficient; the potential of nature-based learning depends on accessible environments, appropriate support, and opportunities for children to participate in ways that are meaningful to them. As the existing evidence remains predominantly focused on autistic children, future research should include a broader range of disabilities and examine how inclusive nature-based learning can be designed to support equitable participation and outcomes across diverse groups of children.

ACKNOWLEDGEMENT

This study was supported by the Community Service Program (Program Pengabdian kepada Masyarakat/PKM), Universitas Negeri Surabaya (UNESA), Indonesia. The authors gratefully acknowledge the financial and institutional support provided by Universitas Negeri Surabaya throughout the implementation of the project. The authors also sincerely thank the participating schools, teachers, and all collaborators who contributed to the implementation of the community service programme and supported the dissemination of its outcomes through this systematic review. The findings presented in this article represent one of the scientific outputs of the PKM programme.

AUTHOR CONTRIBUTIONS

The authors contributed to this study according to the CRediT (Contributor Roles Taxonomy) as follows:

AW: Conceptualization, Supervision, KR: Conceptualization, Methodology, Validation, Data Curation, Formal Analysis, Investigation, IKA: Supervision, Project Administration, Writing, Review & Editing. S: Methodology, Validation, Formal Analysis, Writing, Review & Editing. NMMM: Investigation, Validation, Resources, Writing. LMS: Data Curation, Formal Analysis, Investigation, Visualization & Editing.

DECLARATION OF COMPETING INTEREST

The authors declare no known financial conflicts of interest or personal relationships that could have influenced the work reported in this manuscript.

DECLARATION OF ETHICS

The authors declare that the research and writing of this manuscript adhere to ethical standards of research and publication, in accordance with scientific principles, and are free from plagiarism.

DECLARATION OF ASSISTIVE TECHNOLOGIES IN THE WRITING PROCESS

The authors declare that Generative Artificial Intelligence and other assistive technologies were not excessively utilized in the research and writing processes of this manuscript.

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