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Introduction To Ecology for Young Children: Systematic Literature Review and Bibliometric Analysis

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Abstract
An early introduction to ecology is an important foundation for developing environmental awareness and pro-environmental behavior throughout life. This study aims to map the development of global research on the introduction of ecology in the context of Early Childhood Education (PAUD) through a Systematic Literature Review (SLR) approach complemented by bibliometric analysis. Data were obtained from 199 articles indexed by Scopus and Google Scholar published between 2015 and 2025. The analysis included mapping research themes, citation networks, publication trends, and identifying research gaps. The analysis identified six main theme clusters: (1) family and community ecology, (2) nature and green space experiences, (3) social ecology and child development, (4) digital ecology, (5) physical environment and health, and (6) environmental identity formation. Bibliometric findings indicate that research output peaked in 2017 with 33 articles, then gradually declined after 2020. Five significant research gaps were identified, including a lack of studies from the Southeast Asian context, particularly Indonesia, limited evidence-based intervention design, and the absence of longitudinal studies of long-term impacts. This research provides a theoretical and empirical basis for the development of contextual and evidence-based ecology-based PAUD programs in Indonesia.

Keywords:
early childhood education; ecology; nature-based learning; systematic literature review; bibliometric analysis; environmental identity

A. INTRODUCTION

The phenomenon of environmental damage resulting in disasters is a global issue that requires attention. According to data compiled by WALHI, temperatures in Indonesia have currently risen by 1.10°C, and forests have decreased by 650 million hectares (WALHI, 2021). These conditions trigger climate change, more commonly known as global warming, which will have long-term consequences, including extreme weather and natural disasters such as floods and landslides.

Another issue more closely related to everyday environmental damage is waste. By 2024, 65.75% of unmanaged waste, or 25,389,734 tons per year, will be generated (Ministry of Environment and Forestry, 2024). This waste is predominantly household waste. Improper waste management, such as burning, can lead to other problems, including the formation of microplastic particles during rainfall (Sj & Mrc, 2025). Rainwater, considered a source of water, can become a source of disease due to its microplastic content, which can cause inflammation in body tissues (Muhawarman, 2025).

This phenomenon of environmental degradation is not solely the responsibility of governments or institutions but also an individual responsibility, as the human population occupies 75% of the Earth's surface (UNEP, 2022), thereby potentially damaging the existing natural environment. Therefore, awareness of environmental protection is a behavior that everyone should have.

Research in educational neuroscience shows that early-life ecological experiences have a significant impact on children's cognitive, emotional, and social development. Exposure to nature, living things, and ecological systems not only stimulates children's natural curiosity but also builds a foundation for understanding the interconnectedness of life, which is at the core of ecological literacy.

Although its urgency is recognized globally, implementing ecology in the PAUD curriculum still faces various challenges. In Indonesia, the current early childhood education curriculum does not explicitly integrate ecology learning as a separate domain. As a result, approaches to introducing nature and the environment are often incidental, unstructured, and not based on current research evidence.

This study aims to (1) map global publication and citation patterns related to ecology and early childhood, (2) identify the thematic structure of research specifically relevant to ecological education for young children, (3) identify gaps in the existing evidence, and (4) interpret the implications of these patterns for early childhood education. The study's contribution lies in linking broad bibliometric mapping with a focused thematic synthesis.

B. METHODS

This study employed a Systematic Literature Review (SLR) integrated with bibliometric analysis. Reporting was guided by PRISMA 2020 (Page et al., 2021). The review used two analytical corpora: (1) a retrieval corpus of 199 records for broad bibliometric description and (2) a focused thematic corpus of 25 articles that satisfied the substantive relevance criteria for ecological education in early childhood. The two corpora therefore answer different questions: the 199-record corpus describes the breadth and structure of the search landscape, while the 25-article corpus supports close thematic interpretation.

The literature search used Scopus and Google Scholar, with Google Scholar retrieval conducted through Publish or Perish (PoP) version 8. The search string combined population terms and ecological/environmental terms: ["early childhood" OR "young children" OR "preschool" OR "kindergarten"] AND ["ecology" OR "ecological" OR "nature-based" OR "environment*" OR "green space" OR "outdoor"]. The search covered publications from January 2015 to May 2025 and included English- and Indonesian-language records. The exact date on which the database searches were executed should be reported from the authors' search log because that date is not documented in the submitted manuscript. Search results were exported for screening and subsequent bibliometric/thematic processing.

Before thematic synthesis, records were screened for substantive relevance to children aged 0–8 years and to education, care, development, nature, ecology, or environmental learning. Duplicate records retrieved across databases should be removed before final screening. The submitted manuscript does not document the number of duplicates, so the exact deduplication count should be recorded in the screening record. The final thematic corpus comprised 25 articles. The 199-record corpus was retained for broad bibliometric analysis so that the review could also demonstrate how much of the retrieved literature used “ecology” in broader biological, epidemiological, digital, or social meanings.

Inclusion and Exclusion Criteria

The age criterion of 0–8 years was operationalized by treating a study as eligible when its target population, participants, or clearly identified developmental focus fell within this age range. Studies with mixed-age samples were eligible only when findings for children aged 0–8 could be identified separately or when early childhood was the explicit focus. Studies in which the early-childhood component could not be separated were excluded from the thematic corpus

Inclusion Criteria	Exclusion Criteria
Articles about children aged 0–8 years	Articles about children over 8 years old
Relating to ecology, nature, or the environment	Ecology in a purely biological sense (not educational)
The context of education, care, or child development	Articles without abstracts or empirical data
Published 2015–2025 in English/Indonesian	Duplicate or retracted articles
Indexed by Scopus or Google Scholar	Non-peer reviewed proceedings

Article Selection Process: PRISMA Protocol

The selection process followed the PRISMA 2020 sequence of identification, screening, eligibility assessment, and inclusion. Identification yielded 199 records. After title/abstract screening and full-text eligibility assessment, 25 articles were retained for focused thematic analysis, while the complete set of 199 retrieved records was used for broad bibliometric analysis. Because the original screening log supplied with the manuscript does not report stage-specific exclusions or the number of duplicates, those figures should not be reconstructed retrospectively; they should be entered from the authors' screening record in the PRISMA flow diagram. The 174-record difference between retrieval and thematic inclusion represents records not retained in the focused corpus, but it cannot, by itself be assigned to a particular PRISMA stage.

Data Analysis

Two complementary analytical procedures were used. First, the 199-record bibliometric corpus was examined descriptively for annual publication output, citation distribution, journal distribution, and influential records. Second, the 25-article thematic corpus was analyzed inductively through thematic synthesis. Articles were coded according to their substantive contribution and could contribute to more than one thematic cluster when they addressed multiple dimensions of ecological learning or child development. This explains why the reported cluster frequencies exceed 25 and should not be interpreted as mutually exclusive article counts. The manuscript should additionally report the exact bibliometric software and version used for network mapping, if applicable, from the authors' analysis record; this information is not documented in the submitted manuscript.

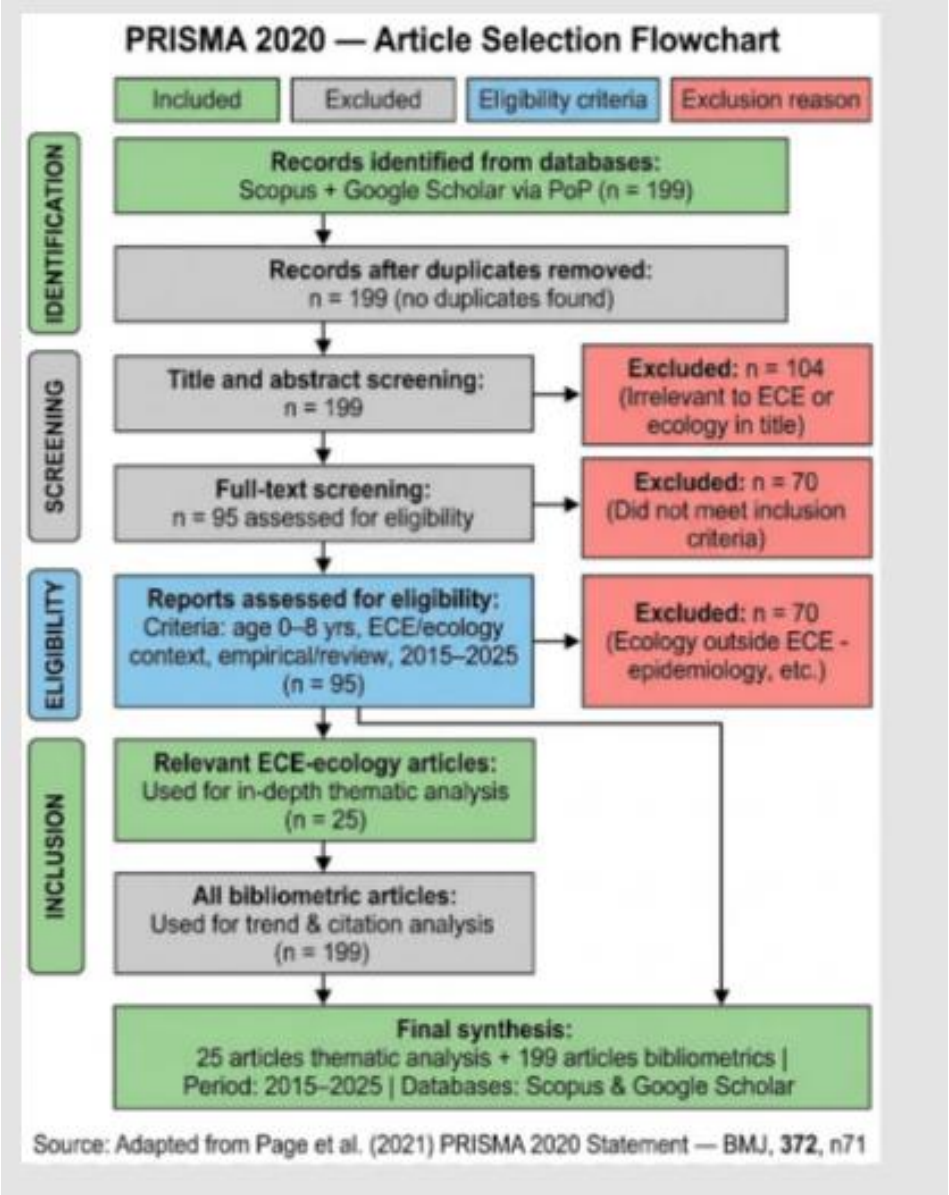


Image1. Prisma Article Selection

C. RESULT & DISCUSSION

Bibliometric Analysis Results

Temporal Publication Trends

An analysis of the 199-record bibliometric corpus revealed varying publication patterns during 2015–2025. Research production peaked in 2017 at 33 records (16.6% of the total), followed by 28 records in 2018 and 2019. Output declined after 2020, with 16 records in 2021, 8 in 2022, and 8 in 2023. The decline should be interpreted descriptively rather than as evidence of a causal effect of COVID-19, because the present review does not test the reasons for year-to-year changes.

Only 25 of the 199 retrieved records (12.6%) were directly relevant to the focused topic of ecological education and ecological experiences in early childhood and were therefore retained for thematic synthesis. The remaining records were nevertheless useful for bibliometric mapping because many used “ecology” in broader biological, epidemiological, microbial, social, or digital contexts. Thus, the 199-record analysis describes the semantic breadth of the search landscape, whereas the 25-article analysis

provides the evidence base for claims specifically about early childhood ecological education. The relatively small focused corpus also indicates that the educational meaning of "ecology" remains less developed and more fragmented than the broader use of the term.

Citation Profile and Influential Articles

The total citations of the 199 articles were 8,811 with an average of 44.3 citations per article. The highest cited articles were Barr (2019) on Growing Up in the Digital Age: Early Learning and Family Media Ecology with 249 citations (35.6 citations/year), followed by Rigolon (2017) on Parks and Young People with 198 citations (22.0 citations/year), and Norwood et al. (2019) on the effects of nature exposure on child development with 112 citations (16.0 citations/year).

The citation distribution shows a highly right-skewed pattern, with 6.5% of articles (n=13) receiving more than 100 citations, while 59.3% of articles (n=118) receiving only 15–30 citations. This indicates that some articles serve as foundational works, serving as key references in the field.

Journal Profile

Articles were distributed across 89 different journals, demonstrating the interdisciplinary nature of the field. The journals with the most articles were PLOS ONE (n=7), PLOS Neglected Tropical Diseases (n=6), and Child Abuse and Neglect (n=4). For journals specifically covering ECCD research, Landscape and Urban Planning was the most dominant, with three highly influential articles by Rigolon (2017), Norwood et al. (2019), and van Heezik et al. (2021).

Thematic Analysis Results

A thematic analysis of 25 relevant articles identified six main theme clusters that shape the research landscape on ecological recognition in early childhood education:

Cluster 1: Family and Community Ecology (n=22)

This largest cluster encompasses research examining how the ecological context of families and communities influences child development. Key themes include parenting styles that support or hinder children's connection to nature, the influence of the home environment on cognitive and social development, and the role of community involvement in supporting children's ecological experiences.

Cluster 2: Nature Experience and Green Space (n=16)

This cluster documents the specific benefits of exposure to nature and green spaces for child development. Norwood et al. (2019) demonstrated that even passive exposure to nature has positive effects on children's attention, emotional regulation, and social behavior. Rigolon (2017) analyzed equity in access to quality parks and found significant disparities by socioeconomic background.

Cluster 3: Social Ecology and Child Development (n=11)

This cluster explores Bronfenbrenner's perspective on how different layers of the ecological system interact to influence child development. Mollborn (2016) shows how the ecology of child development at the micro, meso, exo, and macro levels collectively influences elementary school readiness.

Cluster 4: Digital Ecology (n=7)

This cluster, represented primarily by the work of Arnott (2016, 2019) and Barr (2019), examines how digital technologies shape children's social and learning ecologies. Interestingly, some research within this cluster suggests that digital content about nature can be an effective entry point for introducing ecological concepts to children with limited access to green spaces.

Cluster 5: Physical Environment and Health (n=7)

This cluster documents the relationship between the quality of the physical environment and children's health and well-being. Air pollution, access to open space,

and the quality of the residential environment have been shown to have significant impacts on the physical and cognitive development of early childhood.

Cluster 6: Environmental Identity Formation (n=5)

The smallest cluster yet with the strongest theoretical implications. Prévot et al. (2018) showed that childhood nature experiences are the strongest predictor of adult environmental identity. Green (2017) expanded on this cluster by showing how Alaska's indigenous cultural context uniquely shapes children's environmental identity. Simsar (2021) provided a non-Western perspective from Turkey on preschoolers' awareness of their ecological footprint.

D. DISCUSSION

Interpretation of Publication Trends

The publication peak in 2017 and the subsequent decline should be interpreted with caution. The bibliometric dataset describes publication output but cannot establish why output changed over time. Possible explanations discussed in the literature include changes in research priorities, disruptions to field-based research during the COVID-19 period, and publication time lags; these remain plausible interpretations rather than findings directly demonstrated by the present analysis.

The 12.6% proportion of focused articles is more informative when the two analytical corpora are kept distinct. The broad search retrieved substantial literature in which “ecology” referred to biological, epidemiological, social, or digital systems, but only 25 records addressed the substantive intersection of ecology and early childhood in sufficient detail for thematic synthesis. This indicates a conceptual fragmentation in the field and supports the need for clearer operational definitions in future reviews.

Implications of Thematic Findings

The dominance of family and community ecology aligns with Bronfenbrenner's ecological systems theory, which conceptualizes child development as embedded within interacting environmental systems. For early childhood ecological education, this implies that classroom activities are more likely to be meaningful when reinforced by family practices, community environments, and opportunities for direct engagement with nature.

The digital ecology cluster adds an important contemporary dimension. Digital resources may provide representations of nature or support learning when direct access to green space is constrained. However, the present review does not provide sufficient evidence to conclude that digital ecology is superior to direct nature-based experience. Future intervention studies should compare or combine digital and experiential approaches and measure specific learning and behavioral outcomes.

E. Research Gap and Research Agenda

Based on the bibliometric and thematic analysis that has been conducted, five main research gaps have been identified that need to be prioritized on the future research agenda:

First, there is a lack of research on Southeast Asia, particularly Indonesia. None of the 199 identified articles focused on the context of ecological education in Indonesia. Given Indonesia's extraordinary biodiversity and unique local ecosystems, which can be rich sources of ecological learning, this gap represents a significant opportunity for Indonesian early childhood education researchers.

Second, there is a lack of evidence-based intervention designs for early childhood education (ECE). The majority of research is descriptive-observational. Experimental or quasi-experimental studies on the effectiveness of structured ecology programs for children aged 3–6 are still very rare, even though this type of research is crucial for developing evidence-based policies.

Third, there is a lack of longitudinal studies. Virtually no research has tracked the long-term impact of early ecological experiences on pro-environmental behavior, ecological literacy, and life choices in adulthood. Such longitudinal studies would provide the strongest evidence yet on the significance of investing in early childhood ecological education.

Fourth, research on the systematic integration of ecology curriculum into formal early childhood education (ECE) is limited. Existing studies tend to focus on informal nature experiences. Research on how ecological concepts can be systematically and progressively integrated into formal ECE curricula is urgently needed.

Fifth, the absence of an ecological perspective based on local wisdom. Almost all research relies on Western theoretical frameworks. Research that integrates local wisdom about nature and ecology into children's education would be highly relevant, especially in the context of Indonesian society, which has a rich cultural tradition regarding the relationship between humans and nature.

F. CONCLUSION

This study has successfully mapped the development of global research on the introduction of ecology in the context of early childhood education (ECE) through an SLR integrated with bibliometric analysis of 199 indexed articles for the period 2015–2025. The main findings indicate that research in this field, although still relatively young, has developed six complementary thematic clusters: family and community ecology; nature experiences and green spaces; social ecology and child development; digital ecology; physical environment and health; and environmental identity formation.

Five significant research gaps were identified, with the lack of research in the Indonesian context being the most pressing to address. These findings provide a strong foundation for Indonesian early childhood education researchers to develop an original, context-specific research agenda for introducing ecology in local early childhood education settings.

Practically, this study recommends three things to stakeholders of early childhood education in Indonesia: (1) the development of an early childhood education curriculum that explicitly integrates the domain of ecological education by considering Indonesia's rich biodiversity and local wisdom; (2) increasing investment in longitudinal and experimental research on the impact of ecological introduction programs; and (3) the development of a national network of researchers focused on early childhood ecological education.

A limitation of this study is the database used, which may not have captured all relevant research published in local Indonesian-language journals. Further research is recommended to expand the database's scope and include Indonesian-language research not indexed in international databases

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