Geojournal of Tourism and Geosites
ISSN 2065-0817, E-ISSN 2065-1198

Year XVII, vol. 54, no. 2spl, 2024, p.927-940
DOI 10.30892/gtg.542spl17-1268

A BIBLIOMETRIC REVIEW OF NATURALIST ENVIRONMENTAL EDUCATION, 1937–2023

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Citation: Liu, X., Hussein, M.K., & Bin Mat Noor, M.S. (2024). A BIBLIOMETRIC REVIEW OF NATURALIST ENVIRONMENTAL EDUCATION, 1937–2023. *Geojournal of Tourism and Geosites*, 54(2spl), 927–940. https://doi.org/10.30892/gtg.542spl17-1268

Abstract: The significance of naturalist environmental education (NEE) which primarily focuses on human-nature relationships lies in its ability to mitigate detrimental influences on environmental quality and foster environmental awareness, thereby averting adverse ecological consequences. Through a bibliometric examination of the literature using Scopus, this research attempted to chart and evaluate the intellectual production associated with NEE. The findings are based on a statistical analysis of 1553 documents using the VOSviewer software. Results indicate there has been a significant increase in global scholarly focus on NEE and the pattern of publications trend follows a four-stage progression. "Social Sciences" has the greatest number of relevant articles. Keywords including education literacy and sustainable development are of utmost importance. There is clear evidence of global scientific collaboration among developed countries. It's crucial for scholars to prioritize interdisciplinary collaboration within NEE, and enhance adult environmental literacy on developing countries.

Keywords: naturalist, environmental education, bibliometric analysis, VOSviewer Scopus

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INTRODUCTION

Currently, there is a multitude of environmental crises being experienced globally, including issues such as air and water pollution, global warming, and the decrease of biodiversity. These crises have resulted in significant detrimental effects on both human civilization and the natural world (Dai et al., 2020; Tienhaara, 2010). Furthermore, there has been a noticeable decline in individuals' interaction with the natural environment (Ives et al., 2018). The absence of 'natural' interaction is crucial as societies are dependent on nature (Chu and Karr, 2017; Horlings and Kanemasu, 2015). Researchers have also found a correlation between the prevalence of chronic illnesses and mental problems and the proximity to urban regions with fewer natural areas and fewer opportunities for outdoor recreation(Vieira et al., 2022). However, mankind is gradually, although at a sluggish pace, recognizing the vulnerability of the natural environment and the ecological services it offers (Tregidga and Laine, 2022).T herefore, it is imperative to promptly address the prevailing circumstances and effectively respond to this crisis by means of the promotion of environmental consciousness and the dissemination of knowledge pertaining to ecosystem preservation and sustainability (Varela-Candamio et al., 2018).

Environmental education (EE) is a strategic approach that fosters collaborative environments, allowing diverse individuals to contribute their local knowledge, experiences, beliefs, and practices with the goals of promoting environmentally related awareness, attitudes, behavior, skills, and eventually action through education (Ardoin et al., 2020a; Hens, 2004; UNESCO, 1978). EE has played an important part in promoting active involvement in improving the long-term sustainability of human-nature relations, and the capacity to increase interest in biodiversity (Tiago et al., 2024). It maintains the primary duty of reestablishing the link between nature and communities (Ardoin and Bowers, 2020; Bob Jickling and Wals, 2008; Mastrángelo et al., 2019; Vieira et al., 2022). Against this background, Sauvé (1996) conducted an investigation pertaining to the prevailing patterns in EE, leading to the determination of 15 distinct trends or currents in this field which including naturalist (Sauvé, 1996). The naturalist current perspective posits that the objective of EE should include the promotion of individuals' affinity and connection with the natural world (Frantz and Mayer, 2014).

Nature connection refers to an individual's feeling of being affiliated with nature, whereby one perceives oneself as an essential component of the natural world (Nisbet et al., 2009).The extent of connectedness to nature which contains lifestyle, outdoor time, protection of forest lands, attention to plants and animals, etc. serves as an indicator of the level of proximity between the individual and the natural setting (Otto and Pensini, 2017).The degree of connection individuals experience with nature serves as a significant predictor of both their ecological behavior and subjective wellbeing (Mayer and Frantz, 2004; Otto and Pensini, 2017). To deepen the degree of connection individuals to nature to reach the EE goal, Naturalist environmental education (NEE) conceptualizes nature as both a repository of information, a facilitator or a

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teacher of learning (Hall and Clover, 1997) since it has the potential to enhance learners' attention, reduce stress levels, foster self-discipline, stimulate interest and pleasure in the learning process, and encourage physical activity and fitness. Nature also provides a quieter, safer, and more cooperative learning environment, as well as a setting that encourages developmentally advantageous kinds of play through a mix of "loose parts" and autonomy (Kuo et al., 2019). Recent studies have revealed that a sense of awe, subsequently fosters an increased sense of connectedness to nature (Ng et al., 2023).

Although research suggests that an increasing number of virtual teaching methods, such as virtual collaboration (Manongga and Suharti, 2022), mobile learning (Huynh et al., 2023) and artificial intelligence (An and Ma, 2024) can be used for NEE. However, direct encounters with nature are the most efficient way to employ nature as an instructor in NEE activities. These activities include engaging in gardening, caring for animals, participating in activities like playing and visiting green areas, camp programs and so on (Collado et al., 2013; Duerden and Witt, 2010a; Ernst and Theimer, 2011; Inoue et al., 2019; Zwierzchowska and Lupa, 2021). In addition, the strengthening of links is naturally related not only to the type of activity, but also to its duration. Researchers advise that environmental educators provide time for participants to just "be" in nature throughout their programs (Chawla and Cushing, 2007). Due to the effectiveness of NEE is significantly influenced by the amount of time people spend engaging with nature in an immersive manner.

Within the realm of environmental psychology, Kals et al. (1999) identified the primary determinant of affinity towards nature as the frequency of one's exposure to natural environments and the previous intensity of one's exposure to nature, particularly during infancy (Kals et al., 1999). Positive changes in environmental behavior may be shown after as few as half a day of exposure to EE in a natural setting (Sellmann and Bogner, 2013; Whitburn et al., 2023). However, achieving persistent benefits likely requires repeated and long-term exposures. The research conducted by Krettenauer et al. demonstrates that as adolescents and young adults persist in their engagement with pro-environmental behavior, they exhibit a growing inclination to endorse pro-environmental norms (Krettenauer et al., 2024).

Furthermore, repeated programs may provide enduring impacts (Braun and Dierkes, 2017; Schultz and Tabanico, 2007; Stern et al., 2008). NEE activities can observably increase environmental awareness and behavior. According to Siegmar Otto and Pensini, the true manifestation of ecological behavior necessitates the cultivation of intrinsic motivation by inducing a sense of connection with nature (Otto and Pensini, 2017). A study was conducted to compare students who had prior experience in outdoor NEE activities with those who did not. The findings indicated that the former group had a robust and well-defined empathic connection to nature. Additionally, they had enhanced social interaction and elevated moral judgments (Ernst and Theimer, 2011). In addition, the findings of Giusti et al. (2018) suggest that children who initially exhibit connection to the natural world may benefit from an introduction to NEE, and cultivate a sense of concern for and responsibility toward nature (Giusti et al., 2018).

In response to the growing environmental crisis, EE was promoted early on as an effective tool. Along with the development of urbanisation, people have realised the importance of connecting to nature and called for the reestablishment of natural links. How to effectively establish links with nature, NEE, a subfield of EE, has become an area worth exploring.

However, even though there has been a meteoric rise in the amount of research published on the topic of EE, with several areas making significant strides forward, opinions on NEE and related matters continue to differ, such as how environmental settings interact with children (Liu and Green, 2023; Tamblyn et al., 2023), integrated NEE within other discipline curricula (Boarin and Martinez-Molina, 2022), poverty reduction in the developing world (Şekercioğlu, 2012), social ecosystem (Sato and Kitamura, 2023), NEE for sustainable tourism (Atikah et al., 2022) and so on, which still need more research. Therefore, there is a notable absence of a complete and visually presented study pertaining to the development and patterns of NEE. It is essential to conduct a thorough and comprehensive assessment of this field.

Quantitative literature review methodologies encompass systematic strategies for scrutinizing and amalgamating numerical data derived from scholarly articles or publications pertinent to a delineated research subject or inquiry. For instance, Antunes et al.adopt the Systematic Literature Review (SLR) methodology in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) Statement guidelines (Antunes et al., 2022). Hojcska and Szabó conducted secondary research, employed spatial inequality test methodologies to scrutinize the spatial disparages within natural treatment factors and medicinal water institutions utilizing secondary data (Hojcska and Szabo, 2021).

However, as a quantitative research method, bibliometric analysis has the advantages of quantitative assessment, identifying key contributors, mapping knowledge landscape, objective evaluation, and decision support. Researchers have employed bibliometric methods to explore various environmental sustainability-related topics within the scope of NEE. For instance, studies have delved into sustainable entrepreneurship education (Rosário and Raimundo, 2024), the influence of educational leadership on teachers' subjective well-being (Karakus et al., 2024), environmental sustainability disclosure in Asian countries (Wahyuningrum et al., 2023), and forest landscape planning and management (França et al., 2022). Additionally, literature has utilized CiteSpace to visually analyze the progressions in EE research using The Web of Science core collection database (Tian et al., 2024). However, attention to the NEE subfield has not been observed in the SCOPUS database. Simultaneously, science mapping or knowledge mapping is an emerging multidisciplinary discipline. Its purpose is to detect, analyze, categorize, and visually show the many manifestations of scientific interconnections within a continuously evolving knowledge landscape. Although the first publication on NEE dates back to 1937, there has been a limited number of bibliometric research conducted on this topic. Therefore, the aim of the study is to assess the existing body of NEE, including its main research scope, development trends, research areas, personnel composition, and primary objectives. The anticipated outcome is to possibly provide recommendations for further investigations within this field. The results supplemented the theoretical framework of EE and proposed strategies for sustainable development and addressing environmental crises.

Based on the results, this study concludes that there has been a significant increase in academic interest in NEE on a worldwide level, as seen by the quick growth in publications over the last six years. Furthermore, it is recommended that

interdisciplinary partnerships be fostered to facilitate future advancements in NEE research; “Social Sciences” has the highest number of relevant articles; the journal "Environmental Education Research" seems to be the predominant scholarly platform for doing research in the field; education literacy and sustainable development related keywords are all crucial terms other than “children” and “curriculum”; There is discernible global scientific collaboration primarily concentrated among developed countries; and correlation between citation preferences and national level is substantiated, while co-authorship among authors and organizations could not be undertaken. Therefore, it is imperative for academics to prioritize the exploration of multidisciplinary cooperation in the context of NEE, enhance the environmental literacy of adults, and direct their efforts toward developing countries. The limitations of this study lie in its reliance on bibliometric analyses, which primarily focus on quantitative indicators such as citation counts, author keywords, and publication frequency.

While these analyses can effectively identify patterns and trends in research output pertaining to NEE, they may lack depth in interpretation. Despite the analysis of the content of the top 10 most-cited articles, understanding the significance or ramifications of these findings necessitates supplementary context and qualitative analysis. Moreover, the subjective nature of decisions regarding the selection of databases, search terms, and inclusion criteria in bibliometric reviews introduces potential biases that may impact the outcomes and conclusions of the analysis.

MATERIALS AND METHODS

This research employs bibliometric analysis to investigate the worldwide trajectory of NEE from 1937 to 2023 (as of October 16th) by analyzing published articles in the Scopus database. Bibliometrics is a quantitative approach used to analyze and visualize the collective scientific knowledge and evolutionary trends within established domains. This technique involves systematically processing and interpreting large amounts of unstructured data in a rigorous manner (Donthu et al., 2021). By using this methodology, scholars can gain a deeper understanding of certain areas of study by assessing the productivity, patterns, trends, and influence of scholarly literature, notable authors, institutions, publishers, and countries, and identifying prospective research deficiencies (Van and Waltman, 2014; Yuan and Basha, 2023).

Data for this study were gathered from Elsevier's Scopus database. Scopus is considered to be the most suitable database for doing bibliometric analysis because of its ability to mitigate biases, hazards, and possible omissions that may arise from relying on a restricted selection of publications (Donthu et al., 2021; Wahyuningrum et al., 2023). Due to the abundance of high-quality components, it includes, e.g., 87 million documents, 1.8 billion cited references and 335 thousand books. Starting with the first publication on NEE that was indexed in the Scopus database, all subsequent publications pertaining to the topic of EE and nature were considered for inclusion in this research, up to its completion on October 16, 2023.

The primary objective of this study is to investigate the correlation and clusters of interconnected research on nature and EE. Therefore, queries were used to explore the article title, abstract, and keywords: “TITLE-ABS-KEY (("environmental education" AND "nature") OR "naturalist environmental education" OR "nature education")”. In all, 2344 documents were discovered in the preliminary search. The following discusses the subsequent application of the exclusion criteria.

The bibliometric evaluation was carried out based on the analysis of publications on the subject, following the methodological process of the sequence presented in the flowchart of Figure 1.

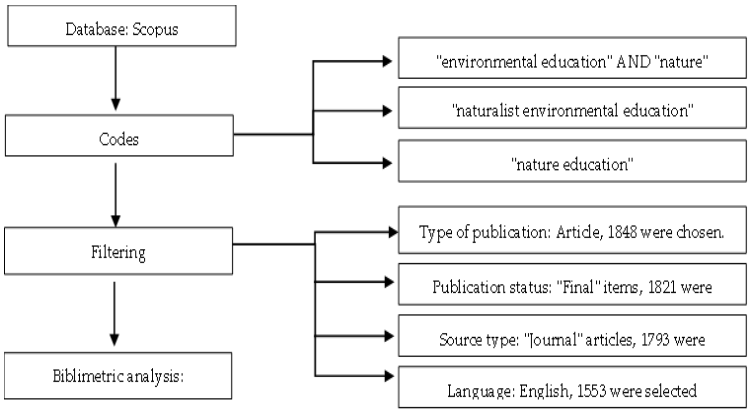

Figure 1. Flowchart of the methodological steps used to collect bibliometric data (Source: Own editing)

To begin, a filter was used to only employ "Article" documents, and from those, 1848 were chosen. Second, a filter based on article publication status was used, and 1821 "Final" items were selected. Third, we applied the source type filter, narrowing the selection to only "Journal" articles (1,793). Fourth, a language filter is implemented, with a total of 1553 articles selected from those authored in the "English" language. A dataset of 1553 articles was obtained in comma-separated value (CSV) format. The dataset included abstracts, keywords, bibliographical information, citation information, and reference information for each item. Data were compatible with VOSviewer for analysis (Van Eck and Waltman, 2010). VOS Viewer stands as a bibliometric mapping tool, facilitating the visualization of substantial volumes of bibliometric data through comprehensible and user-friendly two-dimensional maps. This software affords an impartial and methodical depiction of extensive scholarly records, ensuring that intricate details are not sacrificed in the process. Hitherto, VOS Viewer has garnered notable prominence across diverse academic disciplines, being applied to scrutinize scientific research within various domains across the sciences (Perianes-Rodriguez et al., 2016).

RESULTS AND DISCUSSION

Results

This section discusses a finding of the NEE character research that has been carried out by previous researchers. It is based on the year of publication, discipline distribution, journal titles, the citation of the article and keywords as well as the authors.

Publication trend

Figure 2 illustrates the chronological progression of publishing trends from the first essay titled "Nature, Education, and Freedom." according to the publication of Jean-Jacques Rousseau in 1937, as composed by Allan D.J. (Allan, 1937).

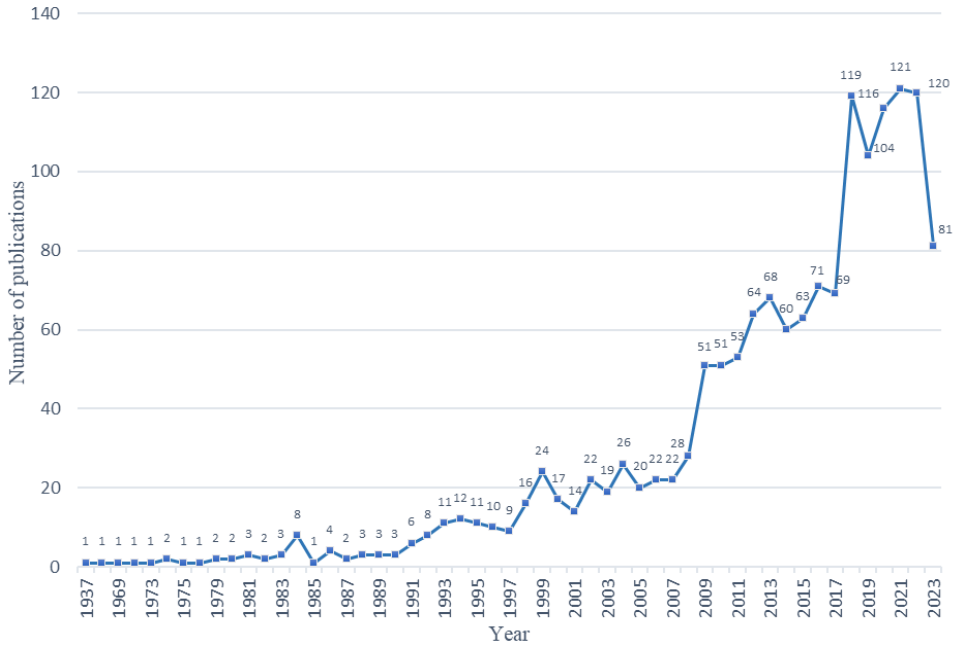

Figure 2. Document by year (Source: Own editing)

The publication trend can be seen in four stages in terms of productivity as seen in Table 1. For the first stage (1937-1992) which laid the groundwork for the more structured and intentional programs that exist today, a maximum of ten documents were released annually. 59 publications (3.79%) in total were produced throughout this period. During the second stage, spanning from 1993 to 2008, a consistent pattern of development became evident. This can be connected to the United Nations Conference on Environment and Development (UNCED) that took place in Rio de Janeiro, Brazil, on 3–14 June 1992 (Madeley, 1992). Yearly publications ranged from 11 to 28. In all, a sum of 283 publications, accounting for 18.22% of the total, were generated. Starting from 2009, the third stage (2009-2017), a threshold of a minimum of 50 articles was achieved every year, Overall, 550 publications (35.42%) were produced. One notable milestone during this period is the UN Conference on Sustainable Development Rio+20. The aforementioned event resulted in the establishment of the Paris Agreement on climate change in 2015, whereby efforts to mitigate greenhouse gas emissions by the year 2020 were reinforced (Díaz-López et al., 2023). The fourth stage covers the past six years (2018-2023), productivity increased.

Table 1. Publication trend (Source: Own editing and calculation)

Year	Number of Publication	Cited publication	Proportion	Total Citations
1937	1	1	100%	1
1948	1	0	0%	0
1969	1	1	100%	2
1970	1	1	100%	2
1973	1	0	0%	0
1974	2	1	50%	3
1975	1	0	0%	0
1977	1	1	100%	1
1979	2	1	50%	2
1980	2	1	50%	1
1981	3	1	33%	13
1982	2	2	100%	4
1983	3	2	67%	4
1984	8	6	75%	52
1985	1	0	0%	0
1986	4	3	75%	12
1987	2	2	100%	4
1988	3	2	67%	3
1989	3	2	67%	19
1990	3	1	33%	8

1991	6	5	83%	122
1992	8	5	63%	73
1993	11	9	82%	148
1994	12	12	100%	248
1995	11	10	91%	217
1996	10	9	90%	103
1997	9	8	89%	153
1998	16	15	94%	392
1999	24	23	96%	755
2000	17	15	88%	436
2001	14	14	100%	525
2002	22	20	91%	1073
2003	19	16	84%	758
2004	26	24	92%	667
2005	20	20	100%	650
2006	22	20	91%	466
2007	22	20	91%	715
2008	28	27	96%	1306
2009	51	47	92%	1345
2010	51	47	92%	2120
2011	53	49	92%	1628
2012	64	61	95%	1724
2013	68	63	93%	2264
2014	60	53	88%	1415
2015	63	55	87%	938
2016	71	64	90%	1145
2017	69	62	90%	1620
2018	119	110	92%	1786
2019	104	91	88%	1292
2020	116	102	88%	967
2021	121	102	84%	710
2022	120	78	65%	247
2023	81	32	40%	79
Total	**1553**	**1316**		**28218**

The number of articles in the previous six years accounted for 42.56% of the total publications, demonstrating that themes on NEE disclosures are expanding in prominence in academia. Despite a clear decline in the number of publications in 2019, the lower bond for annual publications in this phase climbed to 110 from the previous level of 19, with the exception of 2023, when the number of publications dropped to 81 after just three-quarters of the year had passed. The upward trend continues. Studies on this area will continue to develop in the forthcoming years.

It is evident that not all research publications have been cited. Excepted for the first stage, the proportions of cited publications reached 100% in 1994, 2001, 2005. Overall, the average proportion was 77%. There was a significant variation seen in the quantity of citations received. Publications that were published in the year 2013 seem to have garnered significant influence, as seen by their very high citation count of 2264.

Subject Area

A total of 1553 papers included 25 distinct study fields. The distribution of the top ten topic areas relevant to NEE is illustrated in Table 2. Most articles (38.15%) are applicable to the field of "Social Sciences" (1046 publications), followed in relevance by “Environmental Science” (747 publications), “Agricultural and Biological Sciences” (205 publications), “Energy” (101 publications), “Arts and Humanities” (87 publications) and “Earth and Planetary Sciences” (78 publications).

Table 2. Top ten subject area (Source: Own editing and calculation)

Subject Area	Total Publications	Percentage (%)
Social Sciences	1046	38.15%
Environmental Science	747	27.24%
Agricultural and Biological Sciences	205	7.48%
Energy	101	3.68%
Arts and Humanities	87	3.17%
Earth and Planetary Sciences	78	2.84%
Psychology	76	2.77%
Engineering	72	2.63%
Business, Management and Accounting	69	2.52%
Computer Science	62	2.26%

Journal Titles

Research on the NEE is documented across 570 publication sources, each contributing a minimum of one publication. Table 3 presents a comprehensive compilation of the top fifteen journals in terms of productivity. The most prominent journal is Environmental Education Research, which published 167 articles (10.75%). The primary objective of this journal

is to promote the advancement of research-based and academic knowledge in the field of environmental and sustainability education. Followed by the Journal of Sustainability (Switzerland) (66 articles, 4.25%). This journal is dedicated to the comprehensive examination of environmental and socio-economic subjects related to sustainable development. As a result, it has gained significant recognition and serves as a suitable platform for academics specializing in this area. Australian Journal of Environmental Education ranked third, with 61 articles accounting for 3.93% of its content, serves as a platform for the dissemination of information and the presentation of arguments that aim to foster discourse around educational approaches that effectively cultivate awareness, comprehension, and proactive engagement in matters pertaining to environmental and social justice. These prestigious publications share a commitment to sustainable development in their respective areas.

Table 3. Most active journal title (Source: Own editing and calculation)

Rank	Source Title	Total Publications	Percentage (%)
1	Environmental Education Research	167	10.75%
2	Sustainability (Switzerland)	66	4.25%
3	Australian Journal of Environmental Education	61	3.93%
4	Journal of Environmental Education	60	3.86%
5	International Research in Geographical and Environmental Education	27	1.74%
6	Journal of Environmental Protection and Ecology	23	1.48%
7	Journal of Environmental Studies and Sciences	21	1.35%
8	International Journal of Science Education	17	1.09%
9	Applied Environmental Education and Communication	16	1.03%
10	Environmental Conservation	15	0.97%
11	International Journal of Environmental and Science Education	15	0.97%
12	International Journal of Environmental Research and Public Health	15	0.97%
13	Frontiers in Psychology	13	0.84%
14	Journal of Outdoor and Environmental Education	12	0.77%
15	Urban Forestry and Urban Greening	12	0.77%
16	Others	1013	65.23%

Author Keywords

Facilitating comprehension of the distribution and connections among primary research themes related to NEE was achieved through the application of co-occurrence analysis. This analytical method allows for the exploration of internal relationships within a specific academic subject (Gao et al., 2020).

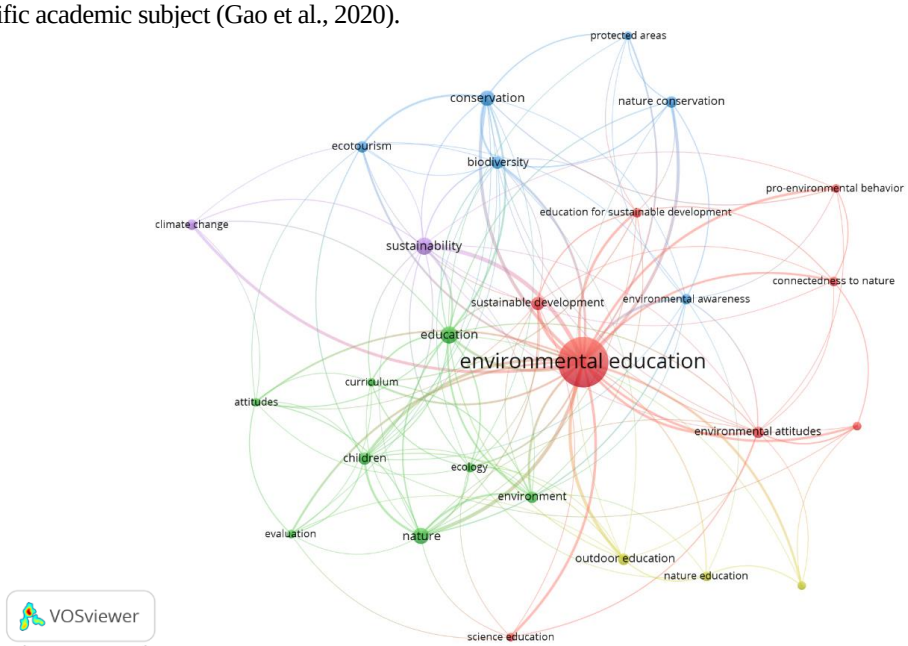

Figure 3. Co-occurrence network by author keywords– colored based on clusters (Source: Own editing with VOSviewer)

By establishing a minimum occurrence threshold of 15, a total of 3821 keywords were detected, out of which 27 managed to meet the established minimum requirement. The result created a graph with 5 clusters, each with a different focus (Figure 3). Cluster 1(red) focuses on EE attitudes, knowledge, behavior for sustainable development, and connectedness to nature. Cluster 2 (green) emphasizes education curriculum with nature and evaluation. Cluster 3 (blue) highlights the conservation and biodiversity. Cluster 4 (yellow) emphasizes outdoor education and Cluster 5 (purple) focuses on sustainability. Cluster 2's overall link strength of 271 indicates that it contains the most frequent phrases on the theme of natural connections. The keyword "environmental education" appears more frequently and has a stronger overall link strength than any other produced term, making it the dominant term in Cluster 1. Cluster 5 is connected to Cluster 3 in some way and focus on conservation and protecting nature, which are the results and aim of NEE. With the lowest total link strength of 55 among all five clusters, outdoor education, and nature education are the two topics majority covered under Cluster 4. Table 4 presents a comprehensive listing of all

keywords derived from associated publications, presented in a clustered view. All clusters contain keywords relating to both education literacy (e.g., "environmental knowledge", "environmental awareness", "attitudes", "behavior") and sustainable development (e.g., "ecology", "biodiversity", "nature conservation", "climate change"). The top ten keywords that are most often used are environmental education, education, sustainability, nature, conservation, sustainable development, biodiversity, children, outdoor education, and nature conservation. However, only the second cluster specifically concerns about population (children).

Table 4. Keywords by clusters (Source: Own editing and calculation)

Cluster	Keywords	Occurrences	Total Link Strength
Cluster1 (red）	connectedness to nature	21	17
	education for sustainable development	21	24
	environmental attitudes	28	29
	environmental education	528	309
	environmental knowledge	17	19
	pro-environmental behavior	18	18
	science education	15	18
	sustainable development	41	33
Cluster2 （green）	attitudes	16	18
	children	32	40
	curriculum	15	22
	ecology	20	23
	education	66	60
	environment	28	32
	evaluation	16	17
	nature	54	59
Cluster3 (blue)	biodiversity	34	33
	conservation	48	51
	ecotourism	29	21
	environmental awareness	26	26
	nature conservation	30	27
	protected areas	17	13
Cluster4 (yellow)	environmental literacy	17	15
	nature education	20	10
	outdoor education	31	30
Cluster5 (purple)	climate change	25	21
	sustainability	61	57

Figure 4 shows the evolution of keyword trends in NEE from 2013 to 2023. Connectedness to nature, pro-environmental behavior, environmental attitudes, nature education, outdoor education, and climate change have become concerns in recent years.

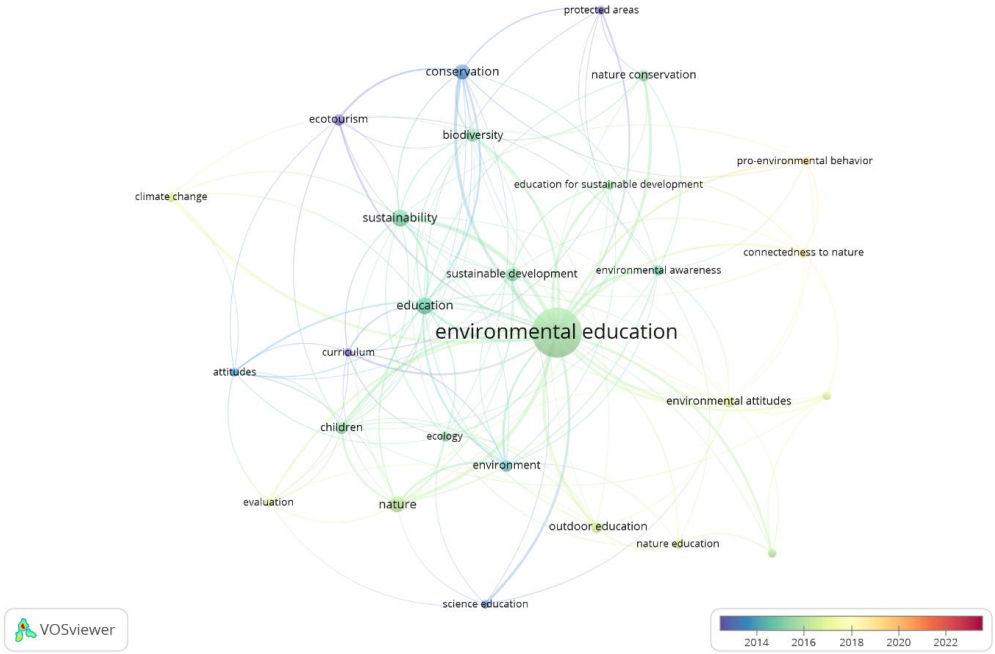

Figure 4. Co-occurrence network by author keywords–year of publication (Source: Own editing with VOSviewer)

Citation Analysis

Table 5 of the results presents the 10 most influential works on the subject of NEE, as assessed using citation analysis. The most-cited paper investigated the impact of EE on nature-relatedness and explored the relationship between varying degrees of

nature-relatedness and levels of happiness (Nisbet et al., 2011). Since its publication in 2011, this article has garnered a total of 401 citations. The study with the second largest number of citations has introduced a nature index that assesses children's emotional attitude towards the natural world. This index has four dimensions, namely: (a) the pleasure of nature, (b) empathy towards creatures, (c) an awareness of oneness, and (d) a sense of responsibility (Cheng and Monroe, 2012). A total of 399 citations have been made to this article since it has been published in 2012. Globalizing influences, according to the third research, are having a profound effect on EE as seen by the push to transform it into education for sustainable development (Jickling and Wals, 2008). The fourth article posits that there is merit in advocating for the development of public initiatives aimed at generating databases, as they have the potential to significantly contribute to the field of conservation biogeography. Furthermore, these databases may play a crucial role in fostering the re-establishment of the bond between people and nature (Devictor et al., 2010).

The citations of articles from the third to the fifth are all greater than 300, of these, the fifth article, published in 2017, examines nature-based EE as a comprehensive approach to enhancing ecological behavior. This approach integrates the acquisition of environmental knowledge with the promotion of an intrinsic motivator, specifically the sense of connectedness to nature. Notably, This paper draws attention to a significant research void, whereby the specific nature-based EE approach that yields this benefit remains unclear (Otto and Pensini, 2017).

The top 10 most-cited articles center their research endeavors on the following four thematic pillars. Among others, four of these ten articles are centered around connectedness to nature and EE. Including the influence of EE on nature connectedness and well-being (Nisbet et al., 2011), environmental knowledge and connectedness to nature related to ecological behaviour (Otto and Pensini, 2017), connection to nature influences people's intention to participate in NEE activities (Cheng and Monroe, 2012). Meanwhile, EE programs promoting connectedness with nature (Liefländer et al., 2013).

Two articles explore the impact of instructional formats and processes on learning outcomes associated with EE,one focuses on the relationship between nature experience type and learning outcomes (Duerden and Witt, 2010b), and the other incorporates the integration of citizen science serves to enhance biogeographical studies and contribute meaningfully to the establishment of large-scale conservation target-setting initiatives (Devictor et al., 2010).

Two papers examine the current state of EE, which is moving toward sustainable (Jickling and Wals, 2008) and global education (Cambray, 2003). The remaining articles examine environmental conceptualizations (Sadler et al., 2004) and the relationship between environmental awareness and environmental behaviour (Ramayah et al., 2012).

Table 5. Top ten cited articles (Source: Own editing and calculation)

Citations	Author(s)	Article Title	Year	Source Title	Methodology
401	Nisbet E.K.; Zelenski J.M.; Murphy S.A.	Happiness is in our Nature: Exploring Nature Relatedness as a Contributor to Subjective Well-Being	2011	Journal of Happiness Studies	Quantitative methodology (Multiple regression analyses)
399	Cheng J.C.-H.; Monroe M.C.	Connection to nature: Children's affective attitude toward nature	2012	Environment and Behavior	Quantitative methodology (Factor analyses and Path analysis)
384	Jickling B.; Wals A.E.J.	Globalization and environmental education: Looking beyond sustainable development	2008	Journal of Curriculum Studies	Qualitative methodology (Textual analysis)
356	Devictor V.; Whittaker R.J.; Beltrame C.	Beyond scarcity: Citizen science programs as useful tools for conservation biogeography	2010	Diversity and Distributions	Qualitative methodology (Textual analysis)
327	Otto S.; Pensini P.	Nature-based environmental education of children: Environmental knowledge and connectedness to nature, together, are related to ecological behavior	2017	Global Environmental Change	Quantitative methodology (Unconditional maximum likelihood method and Rasch models)
279	Sadler T.D.; Chambers F.W.; Zeidler D.L.	Student conceptualizations of the nature of science in response to a socioscientific issue	2004	International Journal of Science Education	Mixed methods (Inductive analysis and Path analysis)
277	Ramayah T.; Lee J.W.C.; Lim S.	Sustaining the environment through recycling: An empirical study	2012	Journal of Environmental Management	Quantitative methodology (Structural Equation Modelling)
253	Cambray J.A.	Impact on indigenous species biodiversity caused by the globalisation of alien recreational freshwater fisheries	2003	Hydrobiologia	Qualitative methodology (Textual analysis)
239	Liefländer A.K.; Fröhlich G.; Bogner F.X.; Schultz P.W.	Promoting connectedness with nature through environmental education	2013	Environmental Education Research	Quantitative methodology (Path analysis)
222	Duerden M.D.; Witt P.A.	The impact of direct and indirect experiences on the development of environmental knowledge, attitudes, and behavior	2010	Journal of Environmental Psychology	Mixed-methods (Grounded theory Zero-order correlation comparisons and hierarchical regressions)

Authorship

A collective of 1484 authors made contributions to the research on NEE. Table 6 presents a comprehensive overview of the 20 most productive and highly cited authors, with a specific focus on those who have collaborated on a minimum of three research articles. In terms of the most prominent authors, Bonnett M. from the UK is the most prolific author who also publishes the most cited papers with 7 publications and 506 citations. However, his C/P figure only ranked third. C/P value (Number of Citations/ Number of Publications) which calculates the average number of citations in a particular article. Meanwhile, although

Jickling B. and Liefländer A.K. are not ranked very high, they have the highest C/P, 147.33 and 103 respectively. Payne P. and Simmons D. ranked second and third, with a total of six articles published by them.

Table 6. Top 20 most productive authors (Source: Own editing and calculation)

Author	Publications	Citations	C/P	Countries
Bonnett M.	7	506	72.29	UK
Payne P.	6	168	28.00	Australia
Simmons D.	6	118	19.67	US
Gough N.	5	101	20.20	Australia
Liefländer A.K.	4	412	103.00	Germany
Ballantyne R.	4	236	59.00	Australia
Zimmerman H.T.; McClain L.R.	4	72	18.00	US
Connell S.	4	68	17.00	Australia
Hovardas T.	4	67	16.75	Greece
Kopnina H.	4	45	11.25	Netherlands
Wilson R.A.	4	40	10.00	US
Kleespies M.W.	4	35	8.75	Germany
Tsevreni I.	4	16	4.00	Greece
Beery T.	4	151	37.75	Sweden
Jickling B.	3	442	147.33	Canada
Ernst J.	3	202	67.33	US
Fletcher R.	3	153	51.00	Netherlands
Goldman D.	3	118	39.33	Israel
Dickinson E.	3	112	37.33	US
Bonnett M.	7	506	72.29	UK

Table 7. Top Ten Productive Countries (Source: Own editing and calculation)

Country	Number of Publications(P)	Citations(C)	C/P	Total Link Strength
United States	393	8349	21.24	60
United Kingdom	136	3933	28.92	49
Australia	124	2628	21.19	33
Canada	88	1789	20.33	25
Germany	75	2386	31.81	23
China	72	1176	16.33	27
Brazil	64	571	8.92	15
Turkey	60	449	7.48	5
Spain	56	761	13.59	25
Greece	41	473	11.54	7

Co-authorship research significantly contributes to the enhancement and enrichment of academic research endeavors within nations. By sharing their skills and experiences, such partnerships facilitate the generation of novel solutions to various difficulties and concerns (Montoya et al., 2018). The analysis of the international co-authorship network covered only nations with at least 20 total publications. Twenty-two nations out of a total of 120 met the requirements. Table 7 is a compilation of the 10 most productive countries, consisting of five European nations, three American nations, one Asian nation, and one Oceanian nation. The United States, the United Kingdom, and Australia are the top three nations. Regarding publications, The United States demonstrates a comparative advantage over a number of other nations in the area of NEE. Despite having a smaller total number of publications, Germany and the United Kingdom rank well in this category according to the C/P value.

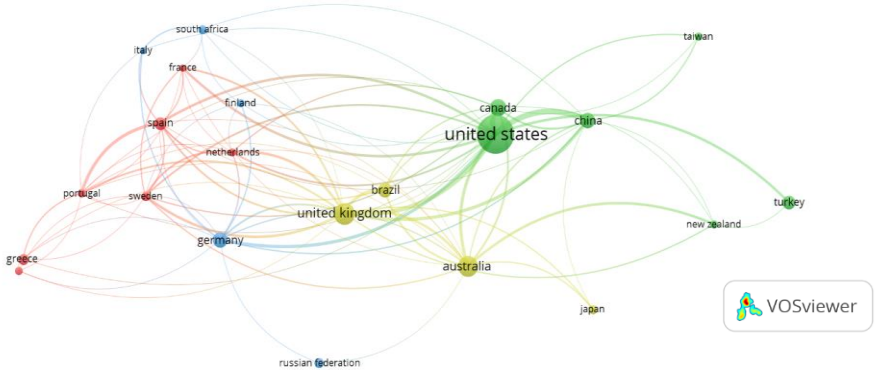

Figure 5. Co-Authorship analysis by countries. Source: own edition (Source: Own editing with VOSviewer)

Figure 5 illustrates the nationwide network. Utilizing clustering methods to categorize nations according to their co-authorship patterns may facilitate the identification of communities comprised of nations exhibiting comparable patterns of cooperation. The node's size increases proportionally with the number of articles produced inside a certain country, while the connections between nodes symbolize the degree of collaboration between two nations. A thicker line denotes a higher level of cooperation.

This network consists of 4 clusters and 91 links. A total of 197 link strength. The United States, the United Kingdom, Spain, and Germany each make substantial contributions to academic publications within their clusters. The United States, United Kingdom, and Australia have the highest overall link strengths among the 22 nations, with values of 60, 39, and 33 respectively. Consequently, these countries are characterized by robust interconnections. Besides, the United States, the United Kingdom, and China have a stronger collaborative links since the minimum link strength is no less than 6 between them. And, in terms of publications, the US, UK, Australia, Germany, and Canada rank top 5. However, the lack of extensive partnerships among authors and organizations prevented the possibility of co-authorship.

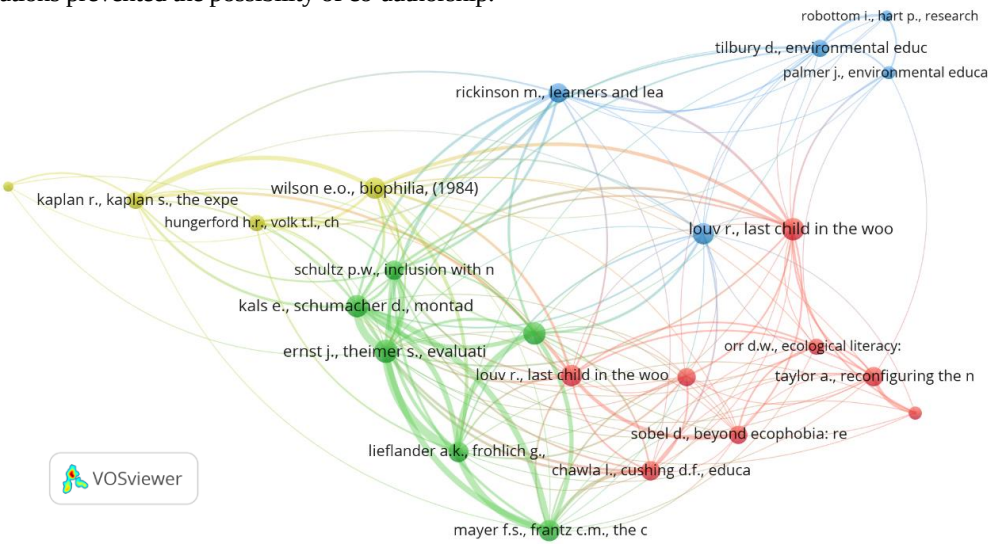

Figure 6. Co-cited reference (Source: Own editing with VOSviewer)

Co-citations

Co-citation occurs when two documents receive a citation from the same third document(Garfield, 1979). It measures how often two documents are cited together by other documents and is useful for grasping research trends and intellectual structure (Chen et al., 2001; White and Griffith, 1981).

A visualized bibliographic map is shown in Figure 6 consists of four main clusters resulting from the analysis of co-citation of references in NEE. All 60,792 citations were generated, and 23 of them met the minimal requirement of 14. Each node represents a single paper, and the connections between them show how those publications are related to one another. The overall connection strength increases as the circumference increases. The thicker the line, the closer the tie or proximity between articles.

Table 8 shows cluster 2(Green) has the most intellectual tie, receiving 293 link strength. It ranks second in the number of citations (137), given that both works involve striving for a better understanding of the concept and scope of the term "measure of feeling emotionally connected to nature". Followed by Cluster 1 (Red) with 167 total links cited 167 times. An important theme discussed in this cluster is the importance of childhood experiences in nature. Cluster 3(Blue) ranks third in terms of both links (88) and citations (93). Key topics deliberated in the cluster include the EE process, place-based approaches, and practices. Cluster 4 (yellow) focuses on EE behavior reports 86 links cited 79 times and ranks fourth. In addition, "Louv R., Last child in the woods: saving our children from nature-deficit disorder" appeared as highest link strength (64) followed by "Evaluating the effects of EE programming on connectedness to nature, EE research" and "Emotional affinity toward nature as a motivational basis to protect nature, environment and behavior", both have 59 and 56 link strength respectively.

Table 8. Overview of the four co-cited reference clusters (Source: Own editing and calculation)

Cluster	Cited Reference	Cita-tions	Total Link Strength
Cluster 1 (red)	Louv R., Last child in the woods: saving our children from nature-deficit disorder, (2005), (2008)	73	64
	Chawla L., Cushing D.F., Education for strategic environmental behavior, environmental education research, 13, 4, pp. 437-452, (2007)	15	26
	Taylor A., Reconfiguring the natures of childhood, (2013)	15	20
	Sobel D., Beyond ecophobia: reclaiming the heart in nature education, (1996)	15	17
	Chawla L., Life paths into effective environmental action, the journal of environmental education, 31,1,15-26, (1999)	18	16
	Orr D.W., Ecological literacy: education and the transition to a postmodern world, (1992)	17	13
	Barad K., Meeting the universe halfway: quantum physics and the entanglement of matter and meaning, (2007)	14	11
Cluster 2 (green)	Ernst J., Theimer S., Evaluating the effects of environmental education programming on connectedness to nature, environmental education research, 17, 5, pp. 577-598, (2011)	22	59
	Kals E., Schumacher D., Montada L., Emotional affinity toward nature as a motivational basis to protect nature, environment and behavior, 31, 2, pp. 178-202, (1999)	20	56
	Lieflander A.K., Frohlich G., Bogner F.X., Schultz P.W., Promoting connectedness with nature through environmental education, environmental education research, 19, 3, pp. 370-384, (2013)	20	52
	Mayer F.S., Frantz C.M., The connectedness to nature scale: a measure of individuals' feeling in community with nature, journal of environmental psychology, 24, 4, pp. 503-515, (2004)	17	46

	Lollmuss A., Agyeman J., Mind the gap: why do people act environmentally and what are the barriers to pro-environmental behavior?, environmental education research, 8, 3, pp. 239-260, (2002)	39	43
	Schultz P.W., Inclusion with nature: the psychology of human-nature relations, psychology of sustainable development, pp. 61-78, (2002)	19	37
Cluster 3 (blue)	Rickinson M., Learners and learning in environmental education: a critical review of the evidence, environmental education research, 7, 3, pp. 207-320, (2001)	26	31
	Gruenewald D.A., The best of both worlds: a critical pedagogy of place, educational researcher, 32, 4, 3-12, (2003)	14	22
	Tilbury D., Environmental education for sustainability: defining the new focus of environmental education in the 1990s, environmental education research, 1, 2, pp. 195-212, (1995)	20	17
	Palmer J., Environmental education in the 21st century: theory, practice, progress and promise, (1998)	14	10
	Robottom I., Hart P., Research in environmental education: engaging the debate, (1993)	19	8
Cluster 4 yellow	Wilson E.O., Biophilia, (1984)	31	39
	Kaplan R., Kaplan S., The experience of nature: a psychological perspective, (1989)	16	24
	Hungerford H.R., Volk T.L., Changing learner behavior through environmental education, the journal of environmental education, 21, 3, pp. 8-21, (1990)	18	18
	Louv R., Last child in the woods, (2005)	14	5

DISCUSSION

Owing to the escalating global incidence of environmental crises and rapid urbanization, there has been a substantial and expeditious expansion of research in the domain of NEE. Nevertheless, the proliferation of scholarly papers pertaining to NEE has posed a considerable challenge for both academics and practitioners in attaining a comprehensive grasp of this subject matter. Therefore, drawing upon many research dimensions, this study presents a bibliometric analysis of research about NEE. The results for each of these categories are discussed as follows: NEE literature has seen a rising tide of publication since 2009, indicating growing interest in the field, which may be associated with a sequence of global environmental calamities (Ho et al., 2023). More significantly, the heightened rate of urbanization has given rise to an increasing disconnection between children and the natural environment, commonly referred to as nature-deficit disorder (Alvarez et al., 2022; Das et al., 2023). In light of the global concerns at hand, a considerable number of individuals within the academic, corporate, and governmental spheres see NEE as a potential avenue for addressing these societal issues (Sharma et al., 2023; Vieira et al., 2022).

NEE is a multidisciplinary area that incorporates elements from several disciplines (Ardoin et al., 2020b; Hens, 2004). According to an analysis of study topics by Scopus, the majority (65.39%) of current studies in the field of NEE fall into the categories of "Social Sciences" and "Environmental Science. "Furthermore, it is worth noting that a significant proportion, namely eight out of the top ten referenced publications, were centered on the field of behavioral psychology. Although there were references to information from many cross-disciplinary domains such as Agricultural and Biological Sciences, Energy, and Business, the frequencies of these references were rather low. This may be related to the inclusion of researchers from diverse academic fields in empirical projects introduces certain difficulties, such as effective communication across disciplinary and professional boundaries. Additionally, collaboration between researchers is infrequent in these cases (Hasan et al., 2023). However, scholars propose increased efforts to explore opportunities for addressing complex environmental issues by integrating various interdisciplinary theoretical and methodological approaches (Mattor et al., 2014).

Leveraging both keyword co-occurrence analysis and co-citation of references analysis, this study discerns hotspots, research trends, and thematic areas. The result of keywords shows that natural education-related terms appeared in all keyword clusters, such as “education attitudes”, “environmental knowledge”, “outdoor education”, “curriculum” and “sustainability”. This indicates that the main topics covered in NEE research are centred on enhancing nature sustainability through EE approaches. Conversely, only one cluster noted population, the keywords “children” just appeared one time, accounting for only 2.5 percent total.

Meanwhile, only one of four clusters of co-citation discussed the importance of childhood experiences in nature. None keywords or clusters mentioned adults, this may be related to the argument that age is closely related to the formation of environmental awareness and strengthening connectedness to nature is more sustainable before the age of 11 (Liefländer et al., 2013). A significant observation is that none of the top 20 most productive and highly cited authors come from developing countries. Meanwhile, co-authorship analysis indicates that international collaborations are predominantly concentrated in a select few European, American, Asian, and Oceanian countries. This may be related to the extent to which education focuses on sustainability issues (Zhang et al., 2022), educational inequality (Dietrichson et al., 2017), policies, and incomes (Ivanov and Zviagintsev, 2023). However, districts with little presence such as the Middle East and Africa are significant regions of NEE since they have gained global attention for their unique weather, natural and cultural resource abundance, and environmental vulnerability (Saud et al., 2023).In addition, according to keyword trends, connectedness to nature, nature education, outdoor education, and climate change have become concerns in recent years. Therefore, international cooperation should be strengthened to rationalize the development of regions that can provide educational resources for NEE.

CONCLUSION

To grasp the trends in research publication, subject areas, popular source titles, author keyword clusters, notable authors, co-authorship networks, and co-citation patterns, this study conducted bibliometric analyses on NEE research spanning from 1937 to October 16, 2023. By investigating the Scopus database for terms linked to NEE, the research performed all analyses using a dataset of 1553 documents using the VOSviewer program. Implications of the research are as following. This research is the first attempt to use bibliometric analysis as a means of offering a comprehensive overview of EE pertaining to natural occurrences. Findings provide quantitative data on fundamental knowledge, which may be employed to identify areas of research that need more investigation and to develop strategies for future research

endeavors. Additionally, officials involved in EE may use the findings of this research to make better-informed decisions on resource allocation and spending priorities. Furthermore, the acquisition of knowledge from this research will contribute to the formulation of domestic and global approaches towards achieving sustainable development with NEE.

Some limitations exists in terms of the research. Firstly, because of variations in the bibliometric article samples, the bibliometric analysis may be constrained if it is based on combinations of search queries. Second, this study only considered the Scopus database. The inclusion of article samples from the Web of Sciences (WoS) database in conjunction with data extracted from many databases has the potential to enhance the comprehensiveness and depth of bibliometric studies in the future. Thirdly, the article sample was only selected from publications that were authored and published in the English language. It is encouraged to perform more inquiry into the global extent of English and non-English papers in this field to facilitate similar research endeavors. Finally, The VOSviewer program may provide inaccurate and convoluted results as a consequence of treating singular and plural variations of the same phrase as distinct words (e.g., "environmental attitudes" and "environmental attitude"). Hence, it would be advantageous for future studies to either enhance the existing VOSviewer program or include supplementary tools for network analysis and visualization. Additionally, this study demonstrates that the prevailing method for addressing NEE is by means of outdoor education, focusing on the cultivation of environmental literacy and nurturing a connection with nature. The primary target audience is primarily children, and the evaluation of EE is employed to advance sustainable development. Thus, future study directions might give more coping strategies at a time when mankind is facing an ecological crisis.

Author Contributions: Conceptualization, X. L.; methodology, X. L.; software, X L.; validation, X.L. and M.K.H. and M.S.B.M.; data curation, X.L.; writing - original draft preparation, X.L.; writing - review and editing, X.L.; visualization, X.L.; supervision, M.K.H. and M.S.B.M.; All authors have read and agreed to the published version of the manuscript.

Funding: Not applicable.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study may be obtained on request from the corresponding author.

Acknowledgments: We would like to thank editor and reviewers for their constructive comments and feedback for the improvement this manuscript.

Conflicts of Interest: The authors declare no conflict of interest.

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Article history: Received: 06.03.2024 Revised: 05.06.2024 Accepted: 24.06.2024 Available online: 28.06.2024