

## Trends and Trajectories of Ecoliteracy Research in Formal Education: A Two-Decade Bibliometric Analysis

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**Abstract:** This research aims to map trends in ecoliteracy in the education sector from the Scopus database, both at the preschool, primary education, secondary education and higher education levels in the last twenty years. Limited aspects such as time range 2004 to 2023, subject area, document type language and Open Access source with a total of 153 documents analyzed. This analysis method uses data collected using meta analysis (PRISMA) and a systematic review of the library, which is assisted by bibliometric analysis software and biblioshiny. The results show significant interest in formal education, and it will continue to increase. Australia and China have the highest level of research collaboration in education. The level of cooperation between Greece and Cyprus is also quite high. Followed by cooperation between Southeast Asian countries between Indonesia and Malaysia. This topic analysis discusses ecoliteracy in the field of formal education, tracing the evolution of the domain of ecoliteracy in education and the emerging trends within it. Research concluded by the resulting development of research related to ecoliteracy emphasizes that education offers a future strategy that involves large-scale collaboration in the field of formal education research and further study of environmental awareness in formal education.

**Keywords:** bibliometric analysis; ecoliteracy; formal education; primary education; two decade

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### Introduction

The environment makes an important contribution to human beings and the sustainability of living things, humans depend on the environment to get oxygen, food, shelter and so on, but they are also the ones who damage the environment (Bello et al., 2023; Berman, 2021; Hannah & Varuneshwaran, 2024). Environmental degradation caused by human activities has accelerated over the last few decades, resulting in various ecological challenges such as climate change, biodiversity loss, and pollution. These challenges threaten not only environmental sustainability but also human well-being and future development. Environmental damage is not only experienced by one country but involves almost all countries in the world which makes environmental issues a global issue (Rahma et al., 2022). Therefore, efforts to increase environmental awareness and responsible behavior are becoming increasingly important in addressing these global concerns. This is in line with the Sustainable Development Goals (SDGs) which pave the way for a healthy and peaceful life that is in line with ecoliteracy in the application of ecoliteracy (Hannah & Varuneshwaran, 2024).

The idea of environmental literacy began with a question from Charles E. Roth, an American environmental and education activist who asked, "How can we get to know an environmentally literate citizen?" (Panieri et al., 2024). The term ecoliteracy was popularized as known as understanding the principles of organizing ecosystems and their application to create sustainable environmentally sensitive communities or communicators (Song et al., 2024; Bello et al., 2023; Ninsiana et al., 2024; Capra, 1996). However, literacy related to ecological literacy was introduced by David W. Orr who stated the basic competencies of learning and reading, the use of knowledge, systematic thinking in collaboration between nature and the mind which emphasizes human-social and ecological coordination (Berman, 2021; Schimek, 2016). The purpose of ecoliteracy is to increase awareness and enthusiasm for both individuals and groups to have an impact on

solving environmental problems in a sustainable manner (Sigit et al., 2023; Murti et al., 2025). This question triggers the importance of critical thinking in understanding the environment as an important part of education.

If we look further in the era of globalization, countries in the world, including Indonesia, have experienced a decline in environmental quality, this is explained in the results of the study from Solarin (2019) and Hakim et al., (2023) which states that carbon emissions are one of the measures of environmental damage due to the increase in carbon emissions which results in an increase in the potential for climate change. In addition, environmental damage does not only occur in urban areas but has also begun to enter rural areas (Gunawan & Setiadi, 2023; Bamidele, 2026). Environmental problems are exacerbated by increasing industrialization. Environmental problems that are increasingly complicated make the importance of ecoliteracy in providing education to the educated community about bad habits towards the environment (Figueiredo et al., 2023; Ariyatun et al., 2024; Husamah et al., 2022; Lázár et al., 2026). The extraordinary development of science and technology, coupled with high population growth and frequent exploration of natural resources has resulted in several environmental problems such as erosion, drought, climate change, and an increase in environmental temperature (Bello et al., 2023).

Ecoliteracy provides basic knowledge, skills and initiative to contribute to sustainable environmental development. In formal and informal education, it is still important to introduce ecoliteracy both at school and in the family environment, is undeniable in shaping strong environmental awareness in future generations (van de Wetering et al., 2022). In formal education settings such as schools and universities, ecoliteracy can serve as a knowledge base for students to understand the impact of human activities on the environment (Carbonell-alcocer et al., 2023). Ecoliteracy in education has an important role in accepting, interpreting a balanced environmental system in order to be able to take decisions in steps to restore, improve and maintain minimal environmental conditions in the environment around the place of learning in school (Husamah et al., 2022; Aikowe & Mazancova, 2023; Murti et al., 2025).

The environment is an important part in improving ecological understanding in education, especially for students to collaborate with each other by involving outreach activities, field trips, concept mapping environmental projects that involve students directly (Sigit et al., 2023; Bello et al., 2023). According to Goleman (2012) ecoliteracy comes from the Greek words, namely oikos (habitat) and logos (science), so that our ability to adapt in sensitivity to the ecology in which we are located becomes our ability to ecoliterate as good human beings. Understanding of ecoliteracy must start early. Ecoliteracy can also be interpreted as the ability to understand ecology and overcome environmental problems for the sake of human survival so that a balance is created between human needs and the sustainability of good environmental conditions.

The basis of this research is to find out more deeply the results of research or research novelty related to ecoliteracy for two decades from 2004–2023 as a form of mapping and finding sources of quality literature studies to answer the challenges of environmental issues, especially the increase in anxiety about ecological literacy in the world of education. Despite the growing attention given to environmental education, a comprehensive understanding of research trends, influential themes, and emerging directions in ecoliteracy studies remains limited. Mapping the development of ecoliteracy research over a long period is essential to identify knowledge gaps and provide evidence-based directions for future studies and educational practices. Indirectly, the results of this study will be able to emphasize the role of critical thinking in identifying cause-and-effect relationships in social and environmental systems to create citizens who are able to make more enlightened decisions based on information and actions taken on environmental problems (Cid & Pouyat, 2013).

Research on ecoliteracy is one of the fields that has experienced a significant increase in research that has an impact on the understanding of ecoliteracy in the world of education. For example, as the results of previous research related to ecoliteracy have been carried out by Cid & Pouyat (2013) and Abdullah (2023) which shows that the study of data sets related to ecoliteracy can explain the concept and provide facilities for conducting in-depth research in the field of ecoliteracy and social media in the future. This is in line with the research that has been carried out by (Hudha et al., 2023) which shows that research related to environmental literacy tends to be dominated by developing countries and in elementary schools there are indicators that can develop according to needs. In previous research, the global ecoliteracy trend was still universal and had not been included in the education aspect. Based on the results of this research, ecoliteracy has the potential to increase environmental awareness, especially in developing countries in the 21st century.

The difference between this research and previous research is with bibliometric analysis to provide a research overview of mapping the development of research trends in the implementation of ecoliteracy in education formal by identifying contributors such as authors, journal sources, participants/countries, used in research studies database sources Scopus and using two data analysis tools, bibliometric analysis software and biblioshiny. Bibliometric analysis is able to cover the limitations of traditional literature reviews, and can provide a big picture of academic literature (Tang et al., 2022). Mapping can reveal the accumulation of

scientific knowledge and differences in the development of findings so that bibliometric analysis can be a good and accepted solution for conducting reviews. (Donthu et al., 2021).

Despite the growing body of research on ecoliteracy, there remains a lack of systematic exploration and comprehensive mapping of existing studies, particularly within the field of education. Previous research has predominantly focused on empirical findings without providing an integrated overview of publication trends, key contributors, and thematic developments. Consequently, there is limited understanding of which research aspects have been most dominant and which areas remain underexplored. Addressing this gap is essential to support academics and practitioners in identifying emerging concepts, guiding evidence-based practices, and formulating future research agendas. This study aims to provide a comprehensive bibliometric and thematic mapping of ecoliteracy research in education over the past two decades. Specifically, this research contributes by: (1) systematically analyzing publication trends to reveal the evolution of ecoliteracy studies; (2) identifying major contributors, including leading journals, authors, and countries; (3) examining how ecoliteracy has been conceptualized and implemented within educational contexts; and (4) uncovering dominant and emerging research themes to highlight existing knowledge gaps. Accordingly, this study addresses the following research questions: 1) How to map publication trends about ecoliteracy in education over two decades? 2) Who are the main contributors in terms of source journals, and countries regarding ecoliteracy in education? 3) How has Ecoliteracy mapping been implemented in education for two decades? 4) What themes or topics have been researched so far in ecoliteracy research in education?

## Methods

This research uses a systematic review method with analysis techniques using bibliometric approaches, the VOSviewer and biblioshiny software tools which are effective in mapping research trends, research evolution and focus. (Ariyatun et al., 2024; Figueiredo et al., 2023; Hudha et al., 2023). Bibliometric analysis techniques were carried out to find research on ecoliteracy carried out in formal education which includes pre-school/Early childhood education, elementary school, middle school and higher education. Many scientific research analyzes use bibliometric analysis, this is because bibliometrics is an effective and practical approach and is the choice for mapping various literatures (Farooq, 2023; Lin et al., 2021). This research was carried out systematically using a workflow (Mohadab et al., 2020).

To ensure the relevance and quality of the literature included in this review, a set of inclusion and exclusion criteria was established. The review process was conducted systematically through several stages using the Scopus database as the primary source of data. Researchers first determined five selection criteria, namely publication period, document type, publication source, language, and open-access status. The screening process was carried out manually by examining article titles and abstracts to identify studies that were relevant to the objectives of the research. A comprehensive search strategy was then employed using Boolean operators ("AND" and "OR") to connect keywords and maximize the retrieval of relevant publications while reducing the number of irrelevant results. The search string included various terms related to ecoliteracy, environmental literacy, sustainability literacy, ecological intelligence, and eco-education, combined with educational keywords such as "education," "Teac\*," and "Learn." To capture the development of the field over an extended period, only articles published between 2004 and 2023 were included in the analysis. Publications from 2024 were excluded because the year was still ongoing at the time the study was conducted. After the search process was completed, all bibliographic data were exported in CSV (Comma-Separated Values) format for further processing and analysis.

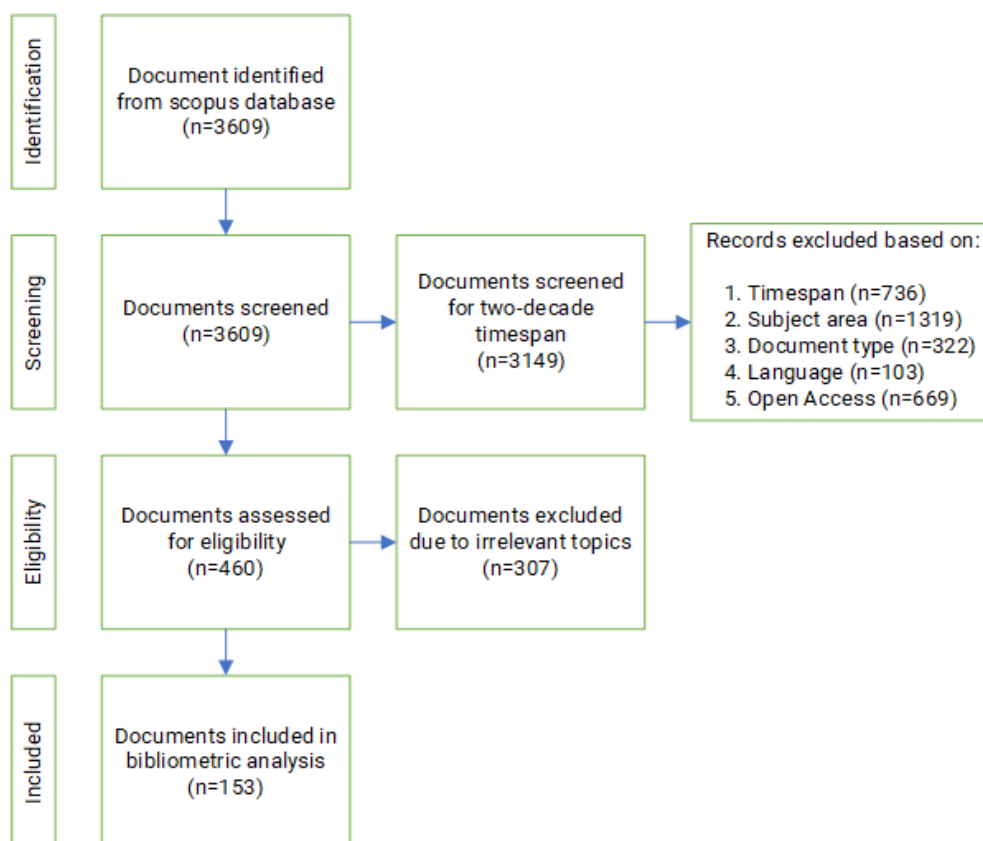
Before conducting the bibliometric analysis, researchers performed an additional manual screening to remove duplicate records and articles that did not align with the scope and focus of the study. This step was considered essential to improve the validity and reliability of the dataset used for analysis. Once the final dataset had been established, bibliometric techniques were applied using VOSviewer and R-Studio (Biblioshiny) software. These analytical tools enabled researchers to identify publication trends, visualize collaboration networks among authors and institutions, examine citation structures, and map the thematic evolution of ecoliteracy research. In addition, the software facilitated the exploration of emerging research topics and the identification of influential studies within the field. The integration of manual screening and bibliometric analysis provided a comprehensive understanding of the development of ecoliteracy research in education over the last two decades. Consequently, the findings offer valuable insights into research patterns, knowledge gaps, and future directions for advancing ecoliteracy studies in educational contexts.

**Table 1.** Inclusion and exclusion criteria

| Criteria     | Inclusion                  | Exclusion                          |
|--------------|----------------------------|------------------------------------|
| Timespan     | 2004-2023                  | Articles Under 2004-above 2023     |
| Subject Area | Articles in social science | Articles other than social science |

| Criteria      | Inclusion                       | Exclusion                                                                                            |
|---------------|---------------------------------|------------------------------------------------------------------------------------------------------|
| Document Type | Articles                        | Books, book chapter, proceedings, reviews                                                            |
| Language      | English                         | Articles in languages other than English                                                             |
| Source Type   | Journal                         | Book Series, Trade Journal, Conference Proceeding                                                    |
| Open Access   | Articles Open Access            | Articles not Access                                                                                  |
| Focus         | Ecoliteracy in Formal Education | Adoption of ecoliteracy outside of School (Industry, earth and plant, art, bussines, health, energy) |

Based on the inclusion and exclusion criteria **Table 1**, researchers can focus more on creating specific search boundaries starting from timespan, subject area, document type, language, source type, open access and focus of the scope of the study. Providing clear boundaries can help literature review research to analyze data (Lubis & Yus, 2024; Donthu et al., 2021). To clarify the mapping of the stages, researchers used the Prisma Method for Screening Protocol as follows:



**Figure 1.** Prisma Method for Screening Protocol

Presentation of research data collected using Meta analysis (PRISMA) and a systematic review of the library, as presented in **Figure 1**. The keywords used by the researcher use keywords that have been taken directly from the Scopus database with a result of 3609 scientific publications. Furthermore, a time limit was implemented from 2004 to 2023 for the last two decades resulting in 3149 articles, meaning that 463 publications were removed. Next, scanning was carried out based on Timespan criteria, scientific articles were removed (n=736), subject area criteria were removed (n=1319), Document Type criteria were found (n=322) articles, English language criteria were (n=103), and Open Access criteria were removed. (n=669). So, the remaining scanning results obtained 460 articles.

The number of articles from the Scopus database is 460 articles which will later be analyzed more deeply again. Furthermore, the 460 articles were analyzed again using the focus criteria of ecoliteracy in education, and the availability of documents contained in the database, resulting in 307 articles that were not relevant to the research subject which were not used. Articles that do not meet the scope of the education sector, such as industry, health, society, economic business, tourism, are not used for further analysis, only within the scope of education and are relevant to the ecoliteracy criteria used, researchers do not include research results in the review analysis results category. (2 documents) and non-Q (2 documents), so that the final results of the subsequent analysis were 153 articles that were considered relevant to the focus topic of this research, so that 153 articles in CSV format could be considered for meta data according to the main question in this research.

## Result and Discussion

### Data Analysis

Data analysis is related to the activities of researchers who carry out performance analysis and scientific mapping, the two main techniques in identifying bibliometric analysis techniques (Donthu et al., 2021). The analysis of the work carried out is related to year of publication, type of document, language, affiliation, author, source of origin, country and citation (Lubis & Yus, 2024). Meanwhile, scientific mapping focuses on the relationship between research components such as Co-authorship and emerging keywords (Bond et al., 2021). Evaluation of research productivity may be possible in various research fields (Yan & Zhiping, 2023). Data analysis using VOSviewer software and the R-package in the R-studio bibliometric package is often referred to and known as the R biblioshiny package. Both are open access applications for conducting comprehensive and in-depth scientific mapping studies (Wang & Jia, 2023). Biblioshiny is used to analyze data and identify themes that develop through the evolution of major trends and provide graphical data presentations, images and visualization mapping. (Dao et al., 2023; Hudha et al., 2023; Rojas-Sánchez et al., 2023).

This research also uses VOSViewer software to assist data analysis. Link quality and quantitation networks can be represented graphically by VOSViewer. The size of the network and the interconnection paths connecting it and can represent the significance and strength of the existing links (Kushairi & Ahmi, 2021). The findings of this study offer a systematic and comprehensive summary of the entire subject related to the evolution of research trends on ecoliteracy in education. Data analysis and mapping techniques in the scientific network analysis process involve at least two main components: 1) cluster analysis, 2) thematic evolution analysis. Researchers will also express and discuss data analysis findings in the form of tables, graphs and pictures to provide meaningful information so that readers can understand it.

### Descriptive Analysis

In the results section of the description of this in-depth analysis, it has been found that the documents that have been reviewed are quantitative data contributing to the domain of ecoliteracy in the field of education. The results of system analysis using Biblioshiny contain data from 2007 to 2023, the Scopus database contains 308 publication sources for 153 articles. Articles from 2004 to 2006 were removed, this was based on scanning results and the feasibility of identifying articles that were suitable for analysis. so that starting from 2004-2006 it was abolished. Based on scanning results from 2004-2006, it was found that in 2004-2006 no article source was found, and it was not included in the scanning data.

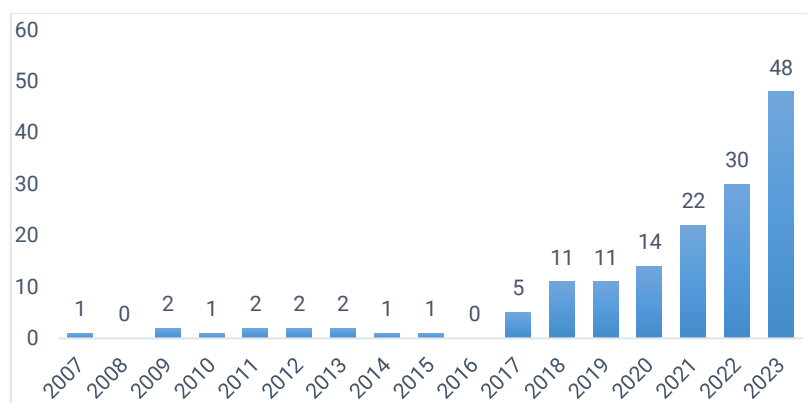
**Table 2.** Overview of descriptive analysis

| Summary                         | Findings  |
|---------------------------------|-----------|
| Timespan                        | 2007:2023 |
| Sources (Journals, Books, etc)  | 84        |
| Documents                       | 153       |
| Keywords Plus (ID)              | 155       |
| Author's Keywords (DE)          | 515       |
| Authors                         | 525       |
| Authors of single-authored docs | 15        |
| Single-authored docs            | 15        |
| Co-Authors per Doc              | 3.48      |
| International co-authorships %  | 19.61     |
| Article                         | 153       |

Since the time span used in the Scopus database is from 2007 to 2023. Reference sources such as journals, books, etc. are 84 sources, then the documents analyzed succeeded in getting 153 documents, with keywords plus author ID as many as 155. Meanwhile, Author's keywords (DE) were 515 with a total of 525 authors and 15 people with a single author. The author correspondence was found in 19.61 and 153 document articles.

### Annual Research Development Patterns and Impact-related contribution of journal

Education is important in contributing to understanding the environment. This can be seen from the pattern of research development from year to year. The majority of articles discussing ecoliteracy in education published from 2007 to 2023 have experienced an increase. In 2008 and 2016, no articles were found, this was because there were no articles that met the criteria determined by the researchers in **Table 1**. The increase began to be significant and sustainable from 2017 (5 articles) to 2023 (48 articles).

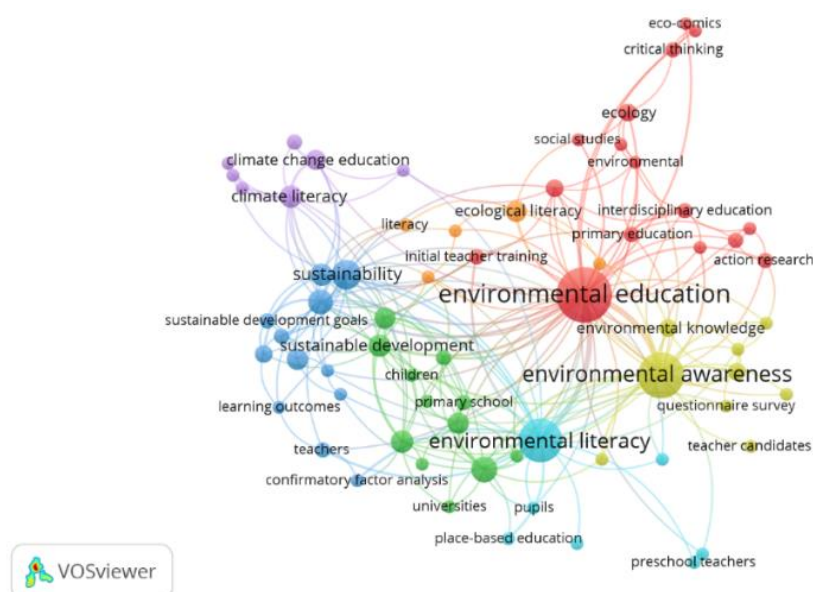


**Figure 2.** Annual Citation Growth

In **Figure 2**, annual publication growth there is significant development in ecoliteracy research in education. Rapid development can be seen starting in 2017 with the discovery of a number of relevant documents of 5, This could be due to the increasing issue of climate change integration of ESD (Education for Sustainable Development) and global policies such as the SDGs (Leal Filho et al., 2023). This rapid development continues to increase until 2023 amounting to 48 documents, and is predicted to increase. Meanwhile, the number of citations has fluctuated, but there is still an increase in terms of Annual Citation Growth in **Table 2**.

The highest impact-related contribution of journals and ranked first in the most productive journal is Sustainability (Switzerland) with 31 documents. This finding indicates that sustainability-related issues have become a major focus in the development of ecoliteracy research within educational contexts. The dominance of this journal also reflects the interdisciplinary nature of ecoliteracy, which integrates environmental, social, and educational perspectives. Eurasia Journal of Mathematics, Science and Technology Education was ranked second with 7 documents. Education Sciences was ranked third with 6 documents, demonstrating a growing interest in examining ecoliteracy from broader educational and pedagogical perspectives. Meanwhile, the International Journal of Sustainability in Higher Education, Jurnal Pendidikan IPA Indonesia, and Review of International Geographical Education Online were ranked fourth, fifth, and sixth, respectively, with 4 documents each relating to ecoliteracy in education. The presence of journals from different educational disciplines suggests that ecoliteracy has attracted attention from diverse research communities. Overall, the distribution of publications across these journals highlights the increasing recognition of ecoliteracy as an important area of research for promoting environmental awareness and sustainable education practices.

### **The most frequently discussed themes and Thematic Evolution**



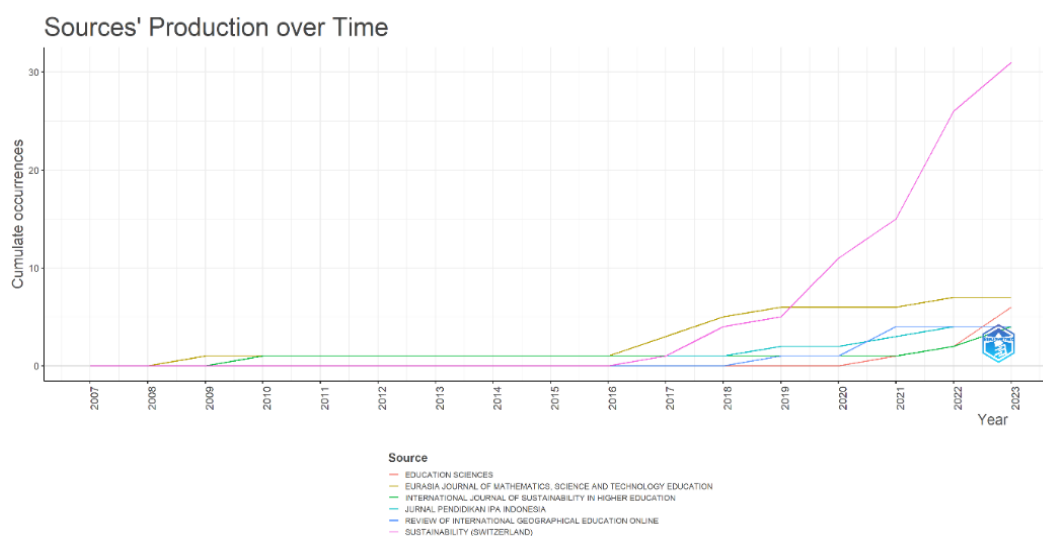
**Figure 3.** Mapping research trends over two decades

The results of research trend mapping related to ecoliteracy in education using VOSviewer identified 67 keyword items grouped into seven clusters, indicating the diversity of research themes within the field. Cluster 1, represented in red, consisted of 15 keywords, including action research, critical thinking, eco-comics, ecology, environmental education, interdisciplinary education, STEM, teacher training, and primary education. This cluster reflects the strong relationship between ecoliteracy and innovative pedagogical approaches aimed at developing environmental understanding and critical thinking skills among learners. Cluster 2, shown in green, contained 12 keywords such as air pollution, climate change, awareness, knowledge, sustainable development, primary school, and universities. The concentration of these keywords suggests that environmental challenges and sustainability issues have become important contexts for promoting ecoliteracy across different educational levels. Meanwhile, Cluster 3, represented in blue, also included 12 keywords, such as ecoliteracy, education for sustainable development, sustainability literacy, environmental issues, higher education, and teachers. The presence of these keywords demonstrates the close connection between ecoliteracy and broader sustainability-oriented educational frameworks that seek to prepare learners for environmental citizenship.

The remaining clusters further illustrate the multidimensional nature of ecoliteracy research. Cluster 4, represented in yellow, contained nine keywords related to environmental attitudes, environmental awareness, environmental behaviour, environmental knowledge, preschool education, and teacher candidates. These themes highlight the importance of fostering positive environmental values and behaviours from an early age, particularly among future educators. Cluster 5, shown in purple, consisted of seven keywords, including climate change education, climate literacy, outdoor education, self-efficacy, teacher education, and pre-service teachers. This cluster emphasizes the growing role of teacher preparation and climate-related competencies in supporting environmental learning. Cluster 6, represented in light blue, also included seven keywords such as environmental literacy, place-based education, professional development, problem-based learning, preschool teachers, and pupils. These keywords indicate the increasing adoption of contextual and experiential learning approaches to strengthen ecoliteracy. Finally, Cluster 7, shown in orange, consisted of five keywords: ecological literacy, environmental problems, literacy, perceptions, and students. This cluster reflects the fundamental focus of ecoliteracy research on learners' understanding and perceptions of environmental issues (**Figure 3**).

The temporal analysis of keyword development revealed significant changes in research trends over time. Between 2007 and 2012, only two dominant themes emerged, namely environmental awareness and environmental education, indicating that research during this period primarily focused on developing basic environmental understanding and awareness. The term ecoliteracy had not yet appeared as a prominent research topic during these years. From 2013 to 2018, ecoliteracy began to emerge as a distinct area of investigation, marking a shift toward more comprehensive discussions of environmental knowledge, values, and action competencies. The growth of ecoliteracy research became even more evident between 2019 and 2023, when several interconnected themes such as sustainability, environmental literacy, environmental education, and ecoliteracy developed simultaneously. This progression suggests an increasing recognition of the need to integrate sustainability principles into educational practices. Overall, the evolution of these themes demonstrates how ecoliteracy has transformed from a peripheral concept into a central focus within environmental and sustainability education research.

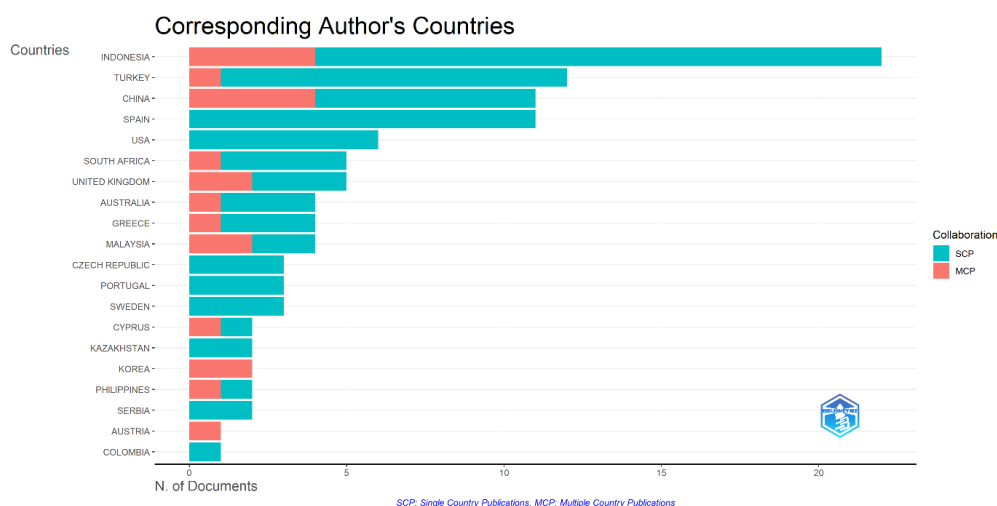
### Impact-related contribution of source



**Figure 4.** Publication sources Quantity documents on ecoliteracy in education

Explanatory data can be seen the journal with the most significant increase in citations since 2017 is the sustainability (Switzerland) and Eurasian Journal of Mathematics, Science, and Technology. This is due to the publication receiving the highest number of citations, with 66 TC citations per year (4.13) (**Figure 4**). Apart from that, several authors from other publications received fewer citations. For example, based on studies from Jan Van Eck ([van Eck & Waltman, 2020](#)) explains that the citation attribute provides data regarding the total number of citations associated with a particular document, all countries, authors, sources or group affiliations. The same thing was also conveyed ([Gao et al., 2022](#)) that presenting citations can provide information regarding the total number of citations related to the same thing. This phenomenon shows that the article makes a major contribution to the field being discussed together. Of course, providing mandatory references in the field can expand one article to another.

### Impact-related contribution of countries



**Figure 5.** Corresponding Author's Countries

The analysis of international collaboration patterns in ecoliteracy research in education reveals a growing network of cooperation among countries (**Figure 5**). The collaboration between China and Australia showed the highest frequency, with two recorded collaborative links on the topic of ecoliteracy in education. Similarly, Greece and Cyprus demonstrated the same frequency of collaboration, indicating a close research partnership within the region. Indonesia and Malaysia also exhibited two collaborative connections, reflecting the increasing interest in ecoliteracy research across Southeast Asia. The presence of these collaborative networks suggests that environmental and sustainability issues are being addressed through international research partnerships that facilitate the exchange of knowledge, expertise, and educational practices. Furthermore, countries represented by darker colors on the collaboration map indicate stronger levels of cooperation and greater research engagement. These findings highlight the importance of cross-national collaboration in advancing ecoliteracy research and promoting the development of innovative educational approaches to address global environmental challenges.

In addition to collaboration patterns, the analysis of corresponding authors' countries provides insight into the geographical distribution of scholarly contributions in the field. Based on Figure 8, Indonesia emerged as the most productive corresponding author country, contributing 22 articles related to ecoliteracy in education. Turkey ranked second with 12 articles, followed by China and Spain with more than 11 article documents each. The United States contributed 6 articles, while South Africa and the United Kingdom each produced 5 documents. Australia, Greece, and Malaysia each accounted for 4 article documents, demonstrating a moderate level of research productivity in the field. Meanwhile, the Czech Republic, Portugal, and Sweden each contributed 3 articles, whereas Cyprus, Kazakhstan, Korea, the Philippines, and Serbia each produced 2 article documents. Austria and Colombia recorded the lowest contribution, with only 1 article document each. Overall, these findings indicate that Indonesia plays a leading role in the development of ecoliteracy research in education, both in terms of publication productivity and scholarly engagement. The dominance of Indonesian corresponding authors also suggests a growing national commitment to integrating environmental literacy and sustainability issues into educational research and practice.

## Discussion

The application of ecoliteracy in education accompanied by empirical data is presented in comprehensive study results using bibliometric analysis. Documentation of research trends, main characteristics of research and terms in the main domain of this research is to offer insight into theoretical studies and also the development of ecoliteracy in the world of education. This research reveals that the production of documents on ecoliteracy research in formal education in particular has increased every year from 2007 to 2023. The application of ecoliteracy in education can be through various forms of research material development starting from learning models (Safitri et al., 2024; Ismawati et al., 2024), through digital media teaching materials (Vioresa et al., 2022), proverbial culture (Kim et al., 2017) and comic books (Usman et al., 2024). This shows that in efforts to increase ecoliteracy in the world of education, apart from experiencing the number of research documents that have been published, we also experience various aspects of topics used in the learning process in the classroom. The relationship between ecoliteracy and other fields is very broad, both in terms of digital developments and in the field of social media (Abdullah, 2023; Sobirova et al., 2026).

The exponential growth of research has been documented in various forms of scientific work. According to a study by (Yuliani et al., 2024), the Scopus database on ecopedagogy is necessary to ensure successful implementation trends in education. There needs to be sufficient knowledge and understanding of the fundamental structures underlying ecopedagogy so that educators and students can be fully engaged in the learning process. A comprehensive understanding of these structures can also support the development of educational strategies that are more responsive to environmental challenges and sustainability issues. In this context, there is a need for evaluation in the field of education and the environment in schools based on data from 2013 to 2023. Such evaluations are important for identifying research trends, measuring educational progress, and determining areas that require further improvement. Furthermore, the findings from trend analyses can provide valuable guidance for policymakers and educators in designing more effective environmental education programs. This is in line with the research results of (Heidari-Shahreza, 2023) that school education is the main information provider in fostering environmental awareness and ecoliteracy among learners. Therefore, strengthening ecoliteracy through formal education remains a crucial strategy for preparing students to address current and future environmental challenges.

The data findings as illustrated in Figure 4 occurred based on statements (McCabe & Mueller-Langer, 2019) that there is a relationship that indirectly provides a link between the quantity of citations and the quantity of publications which is substantial and can be ascertained efficiently. In fact, there is a direct correlation between the number of citations and the number of publications, whereas citations decrease in direct proportion to the quantity of publications (Sahoo & Pandey, 2020), or it could be that the number of citations is quite large but it is a publication that is rarely published, of course the number of citations is influenced by the open access status of the article, open access to journal sources will be related to a higher number of citations, this is because it provides unlimited access to researchers or writers anywhere with no time limit and Access location required. Impactful open access publications also have large APCs but a large impact on citations does not always correspond to a high APC (Maddi & Sapinho, 2022).

Talking about online article publication is often directed at the relatively minimal APC. The frequency of article citations is measured using the impact factor which is used to assess the significance of a journal in a particular field, by including the impact factor as an indicator that journals with a high impact factor have a high APC too. This has been stated by (Triggle et al., 2022) that new methods in assessing the quality of scientific research are needed to increase publishing access to open access at a reasonable cost and solve the problem of impact factors and publication costs. In certain research fields, the focus has been shifted to countries, institutions and publishing journals which have collected volumes in terms of the number of publications and citations in certain fields. (Baminiwatta & Solangaarachchi, 2021).

The development of the number of publications and citations in publisher journals in certain fields can help researchers determine the appropriate scope for the content of the scientific articles to be published. Such as the focus of discussion on ecoliteracy in its application in the world of education which is starting to develop by integrating technology in learning such as learning video media from YouTube (Ninsiana et al., 2024). Using digital applications in augmented reality ecoliteracy can support teachers in displaying media in the form of area maps, AR animations, material explanations, practice questions and instructions for use. (Safitri et al., 2024). Ecoliteracy can also collaborate in the way the media works both in the editorial room in text and in newspaper reporting (Maimunah & Fahrimal, 2023).

Based on data from mapping results in countries with a level of collaboration in fields that have mutually beneficial interests. In this case, the implementation of ecoliteracy in education is a special concern between China and Australia and vice versa, having a frequency of 2 times the collaboration in writing scientific articles

on research results on the topic of ecoliteracy in education, followed by Greece to Cyprus having a frequency of 2 times the collaboration, and from Indonesia to Malaysia also have the same frequency on the same topic. These collaborative relationships indicate that ecoliteracy has become a shared research interest across different geographical regions and educational contexts. International collaboration enables researchers to exchange perspectives, methodologies, and best practices that can strengthen the implementation of ecoliteracy in education. Furthermore, such partnerships contribute to the development of broader research networks and enhance the dissemination of knowledge related to environmental literacy and sustainable education.

This study provides several important contributions and impacts. First, it offers a comprehensive bibliometric mapping that serves as a reference framework for researchers, educators, and policymakers in understanding the intellectual structure and development trajectory of ecoliteracy research. Second, the identification of dominant themes and emerging topics enables stakeholders to design more targeted and relevant educational interventions, particularly in integrating ecoliteracy into curricula across different educational levels. Third, the study highlights the importance of international collaboration and open-access dissemination in accelerating knowledge development and global engagement. More broadly, this research contributes to strengthening the role of education as a key driver of environmental sustainability by providing evidence-based insights into how ecoliteracy can be systematically developed within formal education systems. The findings also support the advancement of Low Carbon Education and sustainability-oriented pedagogy by emphasizing the need for interdisciplinary, technology-integrated, and context-sensitive learning approaches.

## Conclusion

The results of this research have significant implications for providing valuable information. The study shows that over the past two decades, ecoliteracy has experienced rapid development in formal education. From Scopus data, starting in 2017, five documents have appeared. This could be due to the growing concern about the threat of climate change, as well as efforts to realize sustainable development goals (SDGs) globally. The main contributors over the two decades based on sources are the journal Sustainability (Switzerland) and the Eurasian Journal of Mathematics, Science, and Technology. Meanwhile, the countries that are active in collaborating on research on ecoliteracy in formal education are China and Australia. The level of cooperation between Greece and Cyprus is also quite high. Followed by cooperation between Southeast Asian countries, Indonesia and Malaysia. The evolution and development that has developed has seen an increase in the number of publications over the years, even though the citation rate is quite high. One reason behind this may be that newly published documents take time to create an H-Impax impact. The theme of ecoliteracy began to emerge and develop rapidly in formal education from 2019 to 2023. Researchers believe that ecoliteracy research in formal education will experience an increase from year to year, involving both early childhood, elementary school, and university students in the future as a form of deep awareness of the importance of the existence of the surrounding natural environment. Despite its contributions, this study also highlights several avenues for future research. First, future studies should expand the scope beyond Scopus-indexed open-access journals to include other databases such as Web of Science or Dimensions to provide a more comprehensive global perspective. Second, there is a need for more empirical and longitudinal studies that examine the effectiveness of ecoliteracy interventions in improving students' environmental behavior and competencies. Third, future research should explore the integration of emerging technologies, such as artificial intelligence, virtual reality, and data-driven learning in enhancing ecoliteracy education. Additionally, cross-cultural comparative studies are recommended to better understand how ecoliteracy is implemented in different socio-educational contexts. Finally, further research is needed to explore the linkage between ecoliteracy and Low Carbon Education as well as its contribution to achieving long-term sustainability goals.

## References

- Abdullah, K. H. (2023). Eco-literacy and social media: A bibliometric review. *Journal of Scientometric Research*, 12(3), 631–640.
- Aikowe, L. D., & Mazancova, J. (2022). Pro-environmental awareness of university students – assessment through sustainability literacy test. *International Journal of Sustainability in Higher Education*, 24(3), 719–741.

- Ariyatun, A., Sudarmin, S., Wardani, S., Saptono, S., & Winarto, W. (2024). Bibliometric analysis of environmental literacy in sustainable development: A comprehensive review based on scopus data from 2013 to 2023. *International Journal of Educational Methodology*, 10(1), 179–195.
- Bamidele, S. (2026). Climate change, resource conflicts, and rural women's empowerment in Nigeria amid democratic erosion: A feminist political economy perspective. In *Women's Studies International Forum*. 115, 103270.
- Baminiwatta, A., & Solangaarachchi, I. (2021). Trends and developments in mindfulness research over 55 years: A bibliometric analysis of publications indexed in web of science. *Mindfulness*, 12(9), 2099–2116.
- Bello, S., Gatawa, M. I., & Mani, B. U. (2023). Enhancing university students' ecoliteracy through concept mapping instructional strategy. *British Journal of Education, Learning and Development Psychology*, 6(1), 49–62.
- Berman, N. (2021). Environmental education catalyzed by tourism: Ecoliteracy initiatives on the coast of Kenya. *Sustainability*, 13(15), 8501.
- Bond, M., Bedenlier, S., Marín, V. I., & Händel, M. (2021). Emergency remote teaching in higher education: Mapping the first global online semester. *International Journal of Educational Technology in Higher Education*, 18(1), 50.
- Capra, F. (1996). *The Web of Life: A New Scientific Understanding of Living Systems*. New York: Anchor Books.
- Carbonell-Alcocer, A., Romero-Luis, J., & Gertrudix, M. (2023). Metodologías y recursos educativos para fomentar la cultura ecológica y la concienciación climática en la escuela. *Revista de Investigación Educativa*, 41(1), 185–203.
- Cid, C. R., & Pouyat, R. V. (2013). Making ecology relevant to decision making: The human-centered, place-based approach. *Frontiers in Ecology and the Environment*, 11(8), 447–448.
- Dao, L. T., Tran, T., Van Le, H., Nguyen, G. N., & Trinh, T. P. T. (2023). A bibliometric analysis of research on Education 4.0 during the 2017–2021 period. *Education and Information Technologies*, 28(3), 2437–2453.
- Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. *Journal of Business Research*, 133, 285–296.
- Farooq, R. (2022). Knowledge management and performance: A bibliometric analysis based on Scopus and WOS data (1988–2021). *Journal of Knowledge Management*, 27(7), 1948–1991.
- Figueiredo, M., Dias, A., Neves, J., & Vicente, H. (2023). Assessment of literacy to biotechnological solutions for environmental sustainability in Portugal. *Sustainability*, 15(13), 10056.
- Gao, Y., Wong, S. L., Md. Khambari, M. N., & Noordin, N. (2022). A bibliometric analysis of online faculty professional development in higher education. *Research and Practice in Technology Enhanced Learning*, 17(1), 17.
- Goleman. (2012). *Ecoliterate how educators are cultivating emotional, social, and ecological intelligence*. Jossey Bass.
- Gunawan, M. R., & Setiadi, Y. (2023). Perbandingan pengelompokan pada wilayah berdasarkan tingkat kerusakan lingkungan di Indonesia. *Prosiding Seminar Pendidikan Matematika dan Matematika*, 8, 2721.
- Hakim, A., Efwindi, S., Damayanti, P., Syam, M., Mutmainah, O., & Norsaputra, A. (2023). Improving climate literacy of high school students through physics teaching materials based on STEM. *Jurnal Pendidikan IPA Indonesia*, 12(4), 526–537.
- Hannah, B., & Varuneshwaran, S. (2024). Ecoliteracy to achieve sustainable development goals. *An International Conference in Hybrid Mode- Climate Advocacy, Resilience and Ethics*, 12(1), 32–37.
- Heidari-Shahreza, M. A. (2023). Humour beyond human: Eco-humour as a pedagogical toolkit for environmental education. *Australian Journal of Environmental Education*, 39(4), 550–562.
- Hudha, M. N., Hamidah, I., Permanasari, A., & Abdullah, A. G. (2023). Trends of environmental literacy research: A systematic review of the literature. *AIP Conference Proceedings*, 2646(1), 030017.
- Husamah, H., Suwono, H., Nur, H., & Dharmawan, A. (2022). Sustainable development research in eurasia journal of mathematics, science and technology education: A systematic literature review. *Eurasia Journal of Mathematics, Science and Technology Education*, 18(5), em2103.

- Ismawati, D., Fauziah, P. Y., H., Fuadi, D. S., & Suhardiman, S. (2024). Developing of eco-literacy learning model to enhance environmental caring character. *Journal of Ecohumanism*, 3(5), 1017–1027.
- Kim, G. W., Vaswani, R. T., Kang, W., Nam, M., & Lee, D. (2017). Enhancing ecoliteracy through traditional ecological knowledge in proverbs. *Sustainability*, 9(7), 1182.
- Kushairi, N., & Ahmi, A. (2021). Flipped classroom in the second decade of the millennia: A bibliometrics analysis with Lotka's law. *Education and Information Technologies*, 26(4), 4401–4431.
- Lázár, A. N., Nicholls, R. J., Hutton, C. W., Payo, A., Adams, H., Haque, A., Clarke, D., Salehin, M., Hunt, A., Allan, A., Adger, W. N., Rahman, M. M., & Smith, R. (2026). Relative importance of climate versus socio-environmental development changes to 2050 in rural coastal Bangladesh—a system analysis. *Regional Environmental Change*, 26(1), 38.
- Leal Filho, W., Balasubramanian, M., Abeldaño Zuñiga, R. A., & Sierra, J. (2023). The effects of climate change on children's education attainment. *Sustainability*, 15(7), 6320.
- Lin, M., Chen, Y., & Chen, R. (2021). Bibliometric analysis on Pythagorean fuzzy sets during 2013–2020. *International Journal of Intelligent Computing and Cybernetics*, 14(2), 104–121.
- Lubis, B. S., & Yus, A. (2024). Mapping knowledge and research trend on technology adoption in higher education: A bibliometric analysis. *Education and Information Technologies*, 29(18), 24415–24458.
- Maddi, A., & Sapinho, D. (2022). Article processing charges, altmetrics and citation impact: Is there an economic rationale? *Scientometrics*, 127(12), 7351–7368.
- Maimunah, S., & Fahrimal, Y. (2023). Implementasi ekoliterasi melalui rubrik pojok gambut pada situs berita online Basajan.net. *Jurnal Publish (Basic and Applied Research Publication on Communications)*, 2(2), 185–219.
- McCabe, M. J., & Mueller-Langer, F. (2019). *Does data disclosure increase citations? Empirical evidence from a natural experiment in leading economics journals* (SSRN Scholarly Paper No. 3329272). Social Science Research Network.
- Mohadab, M. E., Bouikhalene, B., & Safi, S. (2020). Bibliometric method for mapping the state of the art of scientific production in Covid-19. *Chaos, Solitons & Fractals*, 139, 110052.
- Murti, W., Rohman, F., Sapta Sari, M., & Ibrohim, I. (2025). Ecoliteracy competencies: A systematic literature review of domains, approaches, and impacts in education. *Eurasia Journal of Mathematics, Science and Technology Education*, 21(8), em2677.
- Ninsiana, W., Septiyana, L., & Suprihatin, Y. (2024). Introducing eco-literacy to early childhood students through digital learning. *Journal of Education and Learning*, 18(1), 89–96.
- Panieri, G., Poto, M. P., & Murray, E. M. (2024). *Emotional and ecological literacy for a more sustainable society*. Palgrave Macmillan.
- Rahma, A., Mardiatno, D., & Hizbaron, D. R. (2022). Ecoliteracy assessment using Q-methodology: Indonesian high school students' views on disaster and ecology. *Issues in Educational Research*, 32(2), 701–720.
- Rojas-Sánchez, M. A., Palos-Sánchez, P. R., & Folgado-Fernández, J. A. (2023). Systematic literature review and bibliometric analysis on virtual reality and education. *Education and Information Technologies*, 28(1), 155–192.
- Safitri, S., Juhadi, J., & Aji, A. (2024). Ecoliteracy learning design with augmented reality-based SETS approach for flood disaster education. *IJORE: International Journal of Recent Educational Research*, 5(3), 779–795.
- Sahoo, S., & Pandey, S. (2020). Evaluating research performance of coronavirus and COVID-19 pandemic using scientometric indicators. *Online Information Review*, 44(7), 1443–1461.
- Schimek, M. J. (2016). *How an experience in nature affects ecoliteracy of high school students* (Publication No. 4133) [Master's thesis, Hamline University]. DigitalCommons@Hamline.
- Sigit, D. V., Ristanto, R. H., Nurrismawati, A., Komala, R., Prastowo, P., & Katili, A. S. (2023). Ecoliteracy's contribution to creative thinking: A study of senior high school students. *Journal of Turkish Science Education*, 20(2), 356–368.

- Sobirova, M., Toliboeva, N., Tilovboyev, M., Soliyev, B., Djourayev, G., Sharipov, S., & Bayzakova, M. (2026). Developing interactive conservation education modules to enhance eco literacy and stewardship for local aquatic biodiversity. *International Journal of Aquatic Research and Environmental Studies*, 13-27
- Solarin, S. A. (2019). Convergence in CO2 emissions, carbon footprint and ecological footprint: Evidence from OECD countries. *Environmental Science and Pollution Research*, 26(6), 6167–6181.
- Song, Y., Cui, H., Zong, Y., & Yin, S. (2024). Effect of ecoliteracy on farmers' participation in pesticide packaging waste governance behavior in rural North China. *Scientific Reports*, 14(1), 23103.
- Tang, J., Vinayavekhin, S., Weeramongkolkul, M., Suksanon, C., Pattarapremcharoen, K., Thiawathittayanuphap, S., & Leelawat, N. (2022). Agent-based simulation and modeling of COVID-19 pandemic: A bibliometric analysis. *Journal of Disaster Research*, 17(1), 93–102.
- Triggle, C. R., MacDonald, R., Triggle, D. J., & Grierson, D. (2022). Requiem for impact factors and high publication charges. *Accountability in Research*, 29(3), 133–164.
- Usman, H., Wardhani, P. A., Tjakrawerdaja, W., Siregar, Y. E. Y., Bayu, G. W., Kamin, Y., & Fajarianto, O. (2024). Ecoliteracy-based on digital storytelling comic media for elementary school in Indonesia. *Library Progress International*, 44(3), 15833–15845.
- van de Wetering, J., Leijten, P., Spitzer, J., & Thomaes, S. (2022). Does environmental education benefit environmental outcomes in children and adolescents? A meta-analysis. *Journal of Environmental Psychology*, 81, 101782.
- van Eck, N. J., & Waltman, L. (2020). *VOSviewer manual 1.6.15*. Universiteit Leiden.
- Vioreza, N., Supriatna, N., & Abdul Hakam, K. (2022). Development of digital teaching materials based on Betawi local food to increase ecoliteracy in elementary school students. *Al Ibtida: Jurnal Pendidikan Guru MI*, 9(2), 402–416.
- Wang, D., & Jia, Q. (2023). Twenty years of research development on teachers' critical thinking: Current status and future implications—a bibliometric analysis of research articles collected in WOS. *Thinking Skills and Creativity*, 48, 101252.
- Yan, L., & Zhiping, W. (2023). Mapping the literature on academic publishing: A bibliometric analysis on WOS. *SAGE Open*, 13(1), 1–16.
- Yuliani, S., Maryani, E., Nurbayani, S., & Disman, D. (2024). Bibliometric analysis of mapping trend ecopedagogy research in education. *Proceedings of the 4th International Conference on Law, Economic, and Governance, ICOLEG 2023, 23-24 November 2023, Semarang, Indonesia*. EAI.