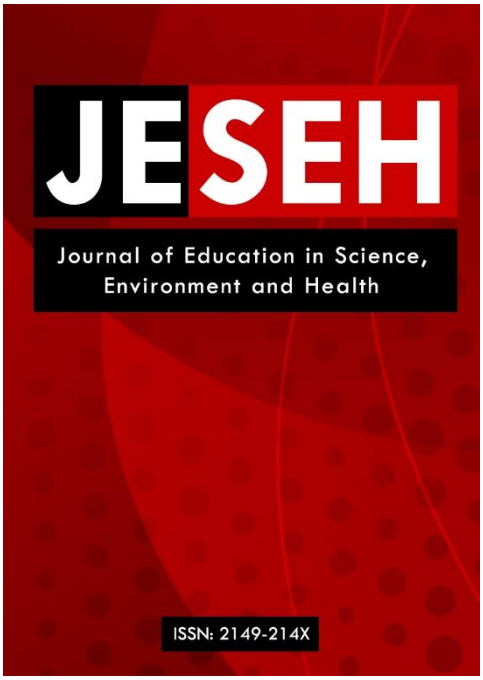

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Bibliometric Analysis of Studies on Artificial Intelligence in Environmental and Health Education

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Abstract

While the use of artificial intelligence in education is a prominent area of research, it has also become a collaborative application for educational institutions. These institutions are working to develop AI-based systems to enhance existing educational frameworks. Accordingly, this study conducts a bibliometric analysis of research on artificial intelligence in environmental and health education published between 2020 and 2024 (the past five years), using the Web of Science database. VOSviewer software was employed for the analysis. A search of the Web of Science database using these criteria yielded 640 studies. An examination of the publication distribution by year reveals a notable concentration of publications in 2024. In terms of country-specific contributions, the leading contributors were China, the United States, and England. The most prolific authors in the field were identified as Ai Koyanagi, Brendon Stubbs, and Joseph Firth. In terms of document and citation numbers within journals, the "Journal of Medical Internet Research" emerged as the most prominent. The most frequently cited keywords included "Artificial Intelligence," "Health Education," followed by "Machine Learning," "COVID-19," and "ChatGPT." These findings offer valuable insights into recent advancements in artificial intelligence research within the fields of environmental and health education. This study is anticipated to help researchers identify key trends and offer guidance for future investigations in the field.

Introduction

Global environmental issues such as climate change, biodiversity loss, fossil fuel use, ozone layer depletion, water scarcity, waste management, and environmental pollution make it imperative to increase individuals' environmental awareness and enhance their ecological literacy skills for a sustainable future (Fang&Yang , 2024; Yang & Xiu, 2023). As global environmental problems continue to escalate, comprehensive measures are required to mitigate the effects of climate change and prepare societies for a sustainable future. In light of the economic losses, workforce, and time losses resulting from health issues caused by environmental problems, environmental health services are gaining importance (Remoundou& Koundouri, 2009, Sarmiento et al., 2023). According to the World Health Organization (WHO), environmental health is a discipline that encompasses all aspects of human health, determined not only by physical environmental factors but also by chemical, biological, social, and psychosocial factors (López-Alcarria et al., 2014; Smith, 2013).

Environmental health involves practices aimed at protecting the elements that constitute the environment in ways that safeguard human health, as well as rectifying or reducing harmful conditions that pose a threat to human health. Given the effects of environmental changes on human health, the integration of environmental education and health education to raise environmental awareness should be considered a fundamental necessity for individuals to maintain a healthy life (Boris, 2010). Health education involves the creation of learning opportunities that aim to improve health literacy, enhance knowledge, and develop life skills through communication. Its broad objective is not only to increase awareness of personal health behaviors but also to foster the skills necessary to address the social, economic, and environmental determinants of health and to promote actions for improving health outcomes. This is especially important when examining the content of environmental education, as the two fields significantly overlap and share themes related to individual and community health (Bauman & Karel, 2013; WHO,2013).

Environmental education, aimed at raising awareness about environmental issues, increasing sensitivity, and fostering positive behaviors towards nature, provides individuals and communities with the information needed to understand the causes and consequences of environmental problems (Ozel & Yiğit, 2023). Therefore, the connection between health education and environmental education becomes evident, as both work together to

address the broader determinants of health and empower individuals to take action for a healthier environment (Boris, 2010).

Unlike traditional forms of education, environmental education is a holistic and lifelong learning process aimed at raising individuals who investigate and identify environmental problems, participate in problem-solving processes, take effective action to improve the environment, and are aware of their responsibilities (Ural & Dadli, 2020; Samosa et al., 2022; Stelljes& Allen-Gil, 2009). However, conventional environmental education approaches have been criticized for their inability to effectively influence students' attitudes and behaviors toward sustainability. The use of digital technologies, such as artificial intelligence (AI), has the potential to overcome the shortcomings of traditional education systems, leading to a historic transformation (Cao & Jian, 2024; Kamalov et al., 2023; Krstić et al., 2022; Wang et al., 2024).

In recent years, the use of artificial intelligence technologies in education has become increasingly widespread, offering innovative solutions for learning processes. In education, artificial intelligence stands out through various applications, such as providing personalized learning experiences, conducting learning analytics, developing assessment systems, making learning interactive, experiential, and engaging, and offering data-driven feedback to students (Brečka et al., 2022; Holmes et al., 2019). Although the number of studies on the role of artificial intelligence in environmental and health education is steadily increasing, there is a need for a systematic evaluation to determine the general trends, key topics, and research gaps in this field. Bibliometric analysis is a method that provides a comprehensive overview of the literature by using mathematical and statistical techniques to analyze relevant research, examining scientific productivity, citation relationships, collaboration networks, prominent researchers, leading journals, countries, and research trends in a specific academic field (Arias-Chávez et al., 2022Genc & Kocak, 2024; Ulukok- Yıldırım, 2024; Geng et al., 2024; Lopera-Perez et al., 2021).

This study aims to examine academic research on environmental education and artificial intelligence through bibliometric analysis. Publications obtained from the Web of Science international database were analyzed using the VOSviewer program to investigate the distribution of publications over the years, the most productive countries, the most prolific and influential authors, the journals with the highest citation counts, and the distribution of key terms. The findings reveal the current state of AI usage in environmental and health education and highlight trends in literature, providing valuable guidance for future research in the field.

Method

Bibliometric analysis is a quantitative method for examining large-scale scientific literature obtained from various databases, processing the data, and mapping it (Hallinger & Kovacevic, 2019; Kılıcaslan et al., 2025). It also analyzes the general structure and development of scientific works by using various statistical techniques to measure criteria such as the number of articles, collaborations between authors, distribution of publications in journals, and citation counts (Ulukok -Yıldırım, 2024). A well-conducted bibliometric analysis can establish a strong foundation for the innovative and meaningful progression of a research field. It allows researchers to gain a comprehensive overview of the field, identify gaps in knowledge, generate new research ideas, and position their planned contributions effectively within the existing literature (Genc & Kocak, 2024). In this study, bibliometric analysis based on scientific mapping techniques has been used to examine international articles published on the use of artificial intelligence in environmental and health education in journals indexed in the WoS database and to identify the current state of the field.

Purpose and Limitations of the Study

In line with the objectives of the research, it was proposed to conduct a bibliometric analysis that encompasses both a descriptive examination of publications within a specified timeframe and the development of bibliometric maps, adhering to the established guidelines recognized within the scientific community for such studies. This research aims to provide a comprehensive analysis of studies published between 2020 and 2024 in the field of environmental and health education with a focus on artificial intelligence, examining factors such as year, author, citation, journal, country, and keywords, and exploring the relationships among these variables. The study is limited by the decision to use data from the past five years, sourced from the WoS database, the choice of VOSviewer software for bibliometric analysis, and the focus on specific headings for network mapping within the analysis.

Data Collection Process

Bibliometric mapping serves as a spatial representation of the relationships between disciplines, fields, individual publications, or authors. Bibliometric studies enable the identification of trends within a specific domain by quantifying various aspects of research and evaluating the outcomes. Such analyses facilitate the tracking of studies, researchers, institutions, and the scientific progression associated with a given scientific topic (Small, 1999; Martí-Parreño et al., 2016; Kasemodel et al., 2016; Kaban, 2023). So this study employed the bibliometric mapping method to analyze articles on artificial intelligence in environmental and health education across various variables. In this study, the Web of Science (WoS) database was utilized to gather data. Relevant studies were identified through WoS's advanced search query and filtering options. Web of Science (WoS) is a bibliographic database that allows us to download bibliometric data and provides access to various databases (SCI-E, SSCI, A&HCI, etc.) and citation data (Falagas et al., 2008). Figure 1 presents the search codes used in the database. Given that artificial intelligence is rapidly developing, this review focuses solely on research published from 2020 to 2024. On February 18, 2025, a total of 640 studies were retrieved from the WoS database based on the search criteria presented in Figure 1.

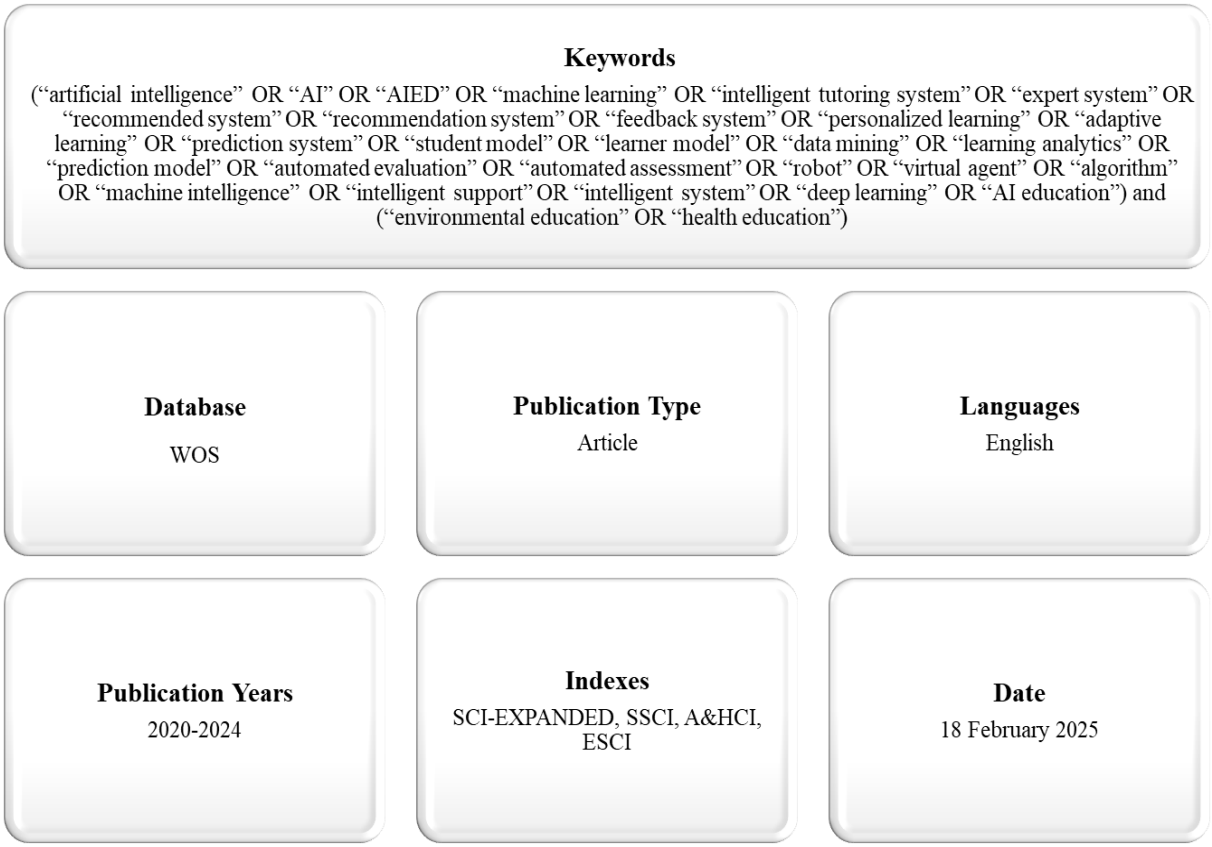

Figure 1. Article Selection Process

Data Analysis

Bibliometric software tools are required to analyze the data obtained from WoS. These tools are used for performance analysis and scientific mapping. VOSviewer is a software tool with excellent visualization capabilities that can perform big data analyses for scientific mapping (Moral-Munoz et al., 2020). VOSviewer supports large databases such as WoS and Scopus. In addition, the VOSviewer program can visualize and present analyses such as co-citation analysis, co-authorship analysis, bibliographic coupling analysis, keyword analysis, and citation analysis using bibliometric mapping methods according to the content of the data. In this study, 640 artificial intelligence-related environmental and health education research articles published in WoS up to February 2025 were analyzed using bibliometric analysis and bibliometric mapping techniques under headings such as year, country, journal, citation, co-citation, and keywords. The data downloaded from WoS were visualized using the bibliometric software tool VOSviewer (version 1.6.20), providing a descriptive and quantitative presentation of the current state. Prior to each analysis, the relevant data were thoroughly examined, and necessary data cleaning procedures were carried out, such as correcting author, journal, and institution names written in different languages and characters or creating 'thesaurus files' for identical or similar words.

Findings

Figure 2 displays the distribution of articles retrieved from the WoS database, highlighting the number of publications from 2020 to 2024. The data reveals noticeable variations in the volume of scholarly work across this period. This temporal analysis offers valuable insights into the evolving trends and dynamics of research activity over the specified years.

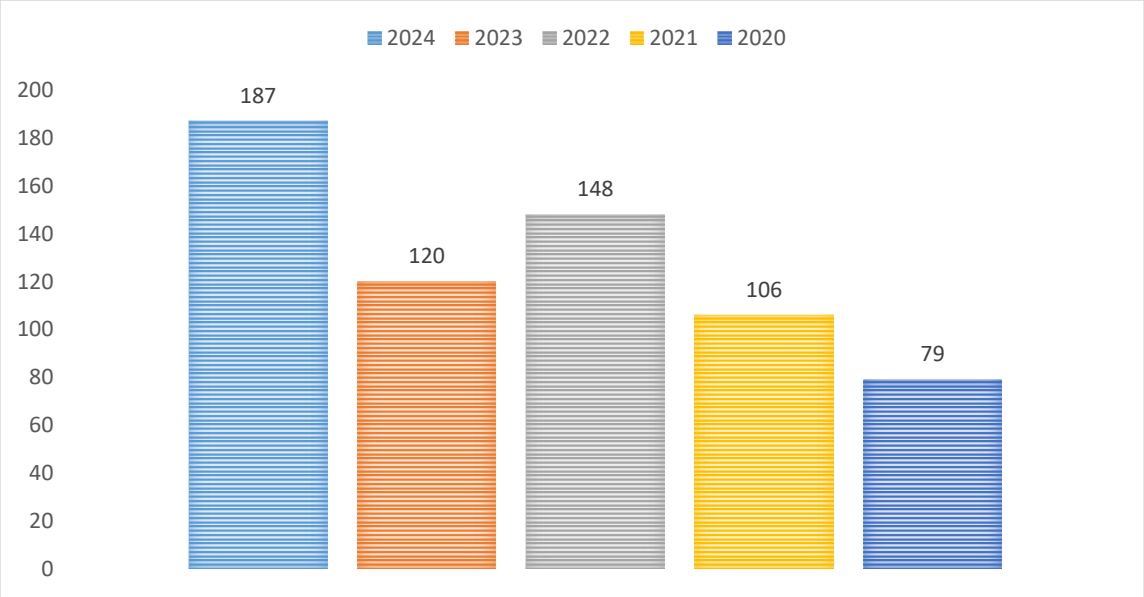

Figure 2. Distribution of publications by year

As shown in Figure 2, while research on AI in environmental and health education has increased between 2020 and 2022, there was a decline in 2023. However, it is seen that studies in this field increased again in 2024 and the number of publications reached its peak.

Table 1 and Figure 3 present the geographical distribution of publications. To identify the most productive countries in scientific research, a threshold was set, requiring at least 10 publications and a minimum of one citation. This criterion ensures the inclusion of countries with a substantial impact on scholarly output, providing a more comprehensive understanding of global research dynamics.

Table 1. Top ten contributed countries

Rank	Country/Region	Number of publications	Citation	TLS
1	China	232	1064	4
2	USA	124	1252	16
3	England	72	1041	18
4	Australia	38	477	0
5	Spain	30	493	12
6	Taiwan	28	154	10
7	India	22	278	0
8	France	21	345	12
9	Canada	21	308	1
10	Saudi Arabia	16	187	0

An analysis was performed using 23 observation units, revealing relationships between them. Seven clusters, 31 links, and a total link strength of 51 were identified. The countries with the highest number of citations are the USA (1,252 citations), China (1,064 citations), and the UK (1,041 citations). In terms of publication volume, the ranking is as follows: China (232 publications), the USA (124 publications), and the UK (72 publications).

A citation network map was created based on the criteria of a minimum of three publications and at least one citation to identify citation networks among authors. The resulting table and map are presented in Table 2 and Figure 4.

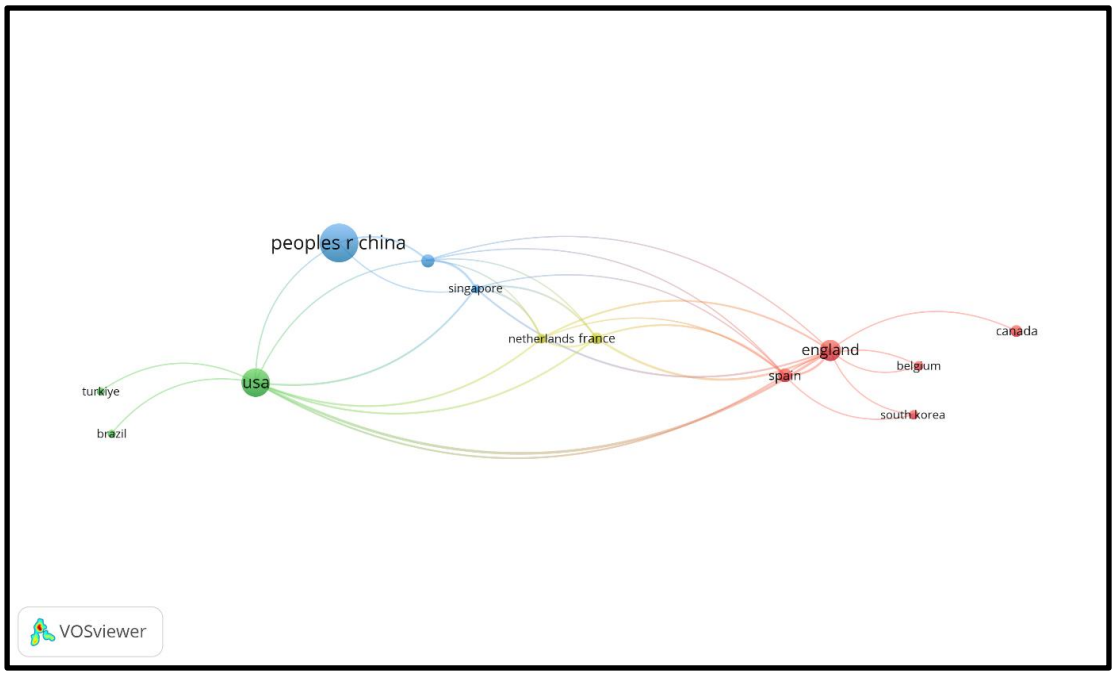

Figure 3. Network diagram of countries

Table 2. Top ten contributed researchers

Rank	Author	Number of publications	Citation	TLS
1	A. Koyanagi	13	308	8
2	B. Stubbs	12	308	8
3	J. Firth	8	252	0
4	J. I. Shin	4	181	4
5	F. Hu	6	123	0
6	J. Y. Bernard.	5	114	20
7	D. Vancampfort	9	110	4
8	Lee Smith	5	92	4
9	R. Shi	5	90	0
10	B. Heude	5	83	20

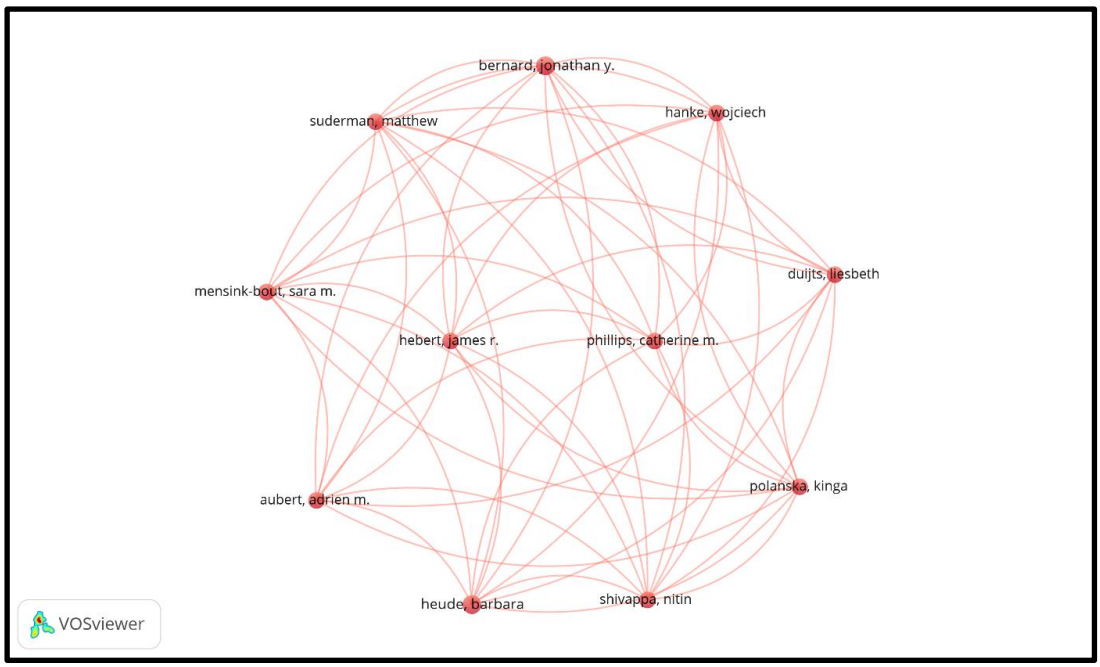

Figure 4. Author citation network

In an analysis conducted on 29 interconnected units, one cluster, 55 link, and total link strength of 110 were identified. The most cited authors are Ai Koyanagi and Brendon Stubbs with 308 citations and Joseph Firth with 252 citations. Additionally, 'co-citation' was chosen as the analysis type, with 'cited authors' designated as the analysis unit within the VOSviewer software (Table 3). A threshold value of 24 was applied to reduce clutter in the data visualization. The resulting map is presented in Figure 5.

Table 3. Ranking of the most influential researchers by co-citation

Rank	Author	Co-Citation	TLS
1	WHO	104	86
2	B. Stubbs	26	146
3	D. Vancampfort	25	152
4	J. Zhang	19	31
5	A. Bandura	18	2
6	X. B. Qu	17	38
7	Y. Yang	17	26
8	OpenAI	17	20
9	Y. Liu	17	13
10	J. Y. Ma	16	16

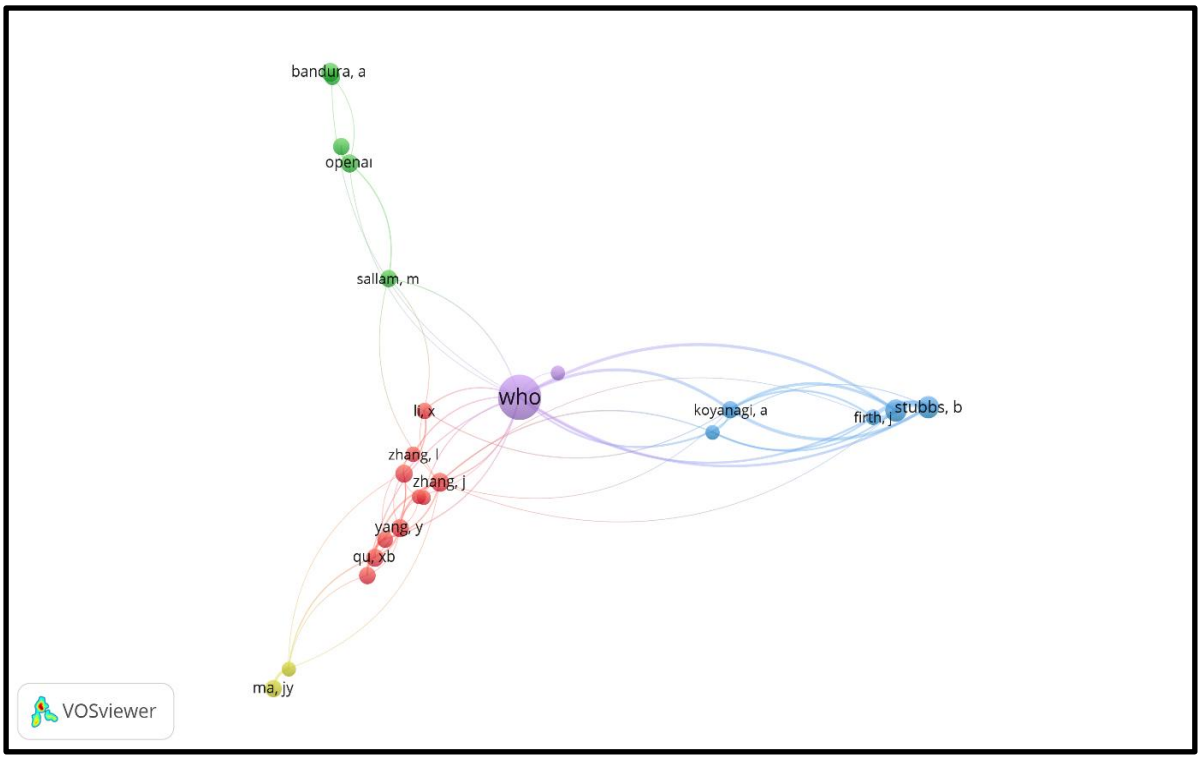

Figure 5. Co-author citation network

When the map in Figure 5 is examined, it is seen that there are five different colored clusters related to the common referenced authors. WHO is in the center of the names in the purple cluster, at the center of the red cluster is J. Zhang, at the center of the blue cluster is B. Stubbs, at the center of the yellow cluster is J. Y. Ma and at the center of the green cluster is OpenAI. G-J.

Journals with a minimum of five publications were included in the analysis. A citation analysis was performed to identify the most influential publications in the field. The results revealed that 22 out of 392 journals published ten or more studies on the topic. Table 4 presents the top ten most influential journals.

According to the findings in Table 4, the journals "Journal of Medical Internet Research" journal is in first place with 10 articles and 177 citations. "JMIR Medical Education" ranks second with 7 publications and 86 citations. It is followed by the "International Journal of Environmental Research and Public Health" with 12 articles and 78 citations. As can be seen from the Table 4, the TLS values of the journals are zero, so there is no connection between the journals.

Table 4. The most influential journals

Rank	Journals	Number of publications	Citation	TLS
1	Journal of Medical Internet Research	10	177	0
2	JMIR Medical Education	7	86	0
3	International Journal of Environmental Research and Public Health	12	78	0
4	Frontiers In Psychology	15	73	0
5	BMC Public Health	10	68	0
6	JMIR Formative Research	10	66	0
7	Applied Sciences-Basel	5	59	0
8	Health Education & Behavior	5	48	0
9	Sustainability	6	40	0
10	Scientific Reports	8	34	0

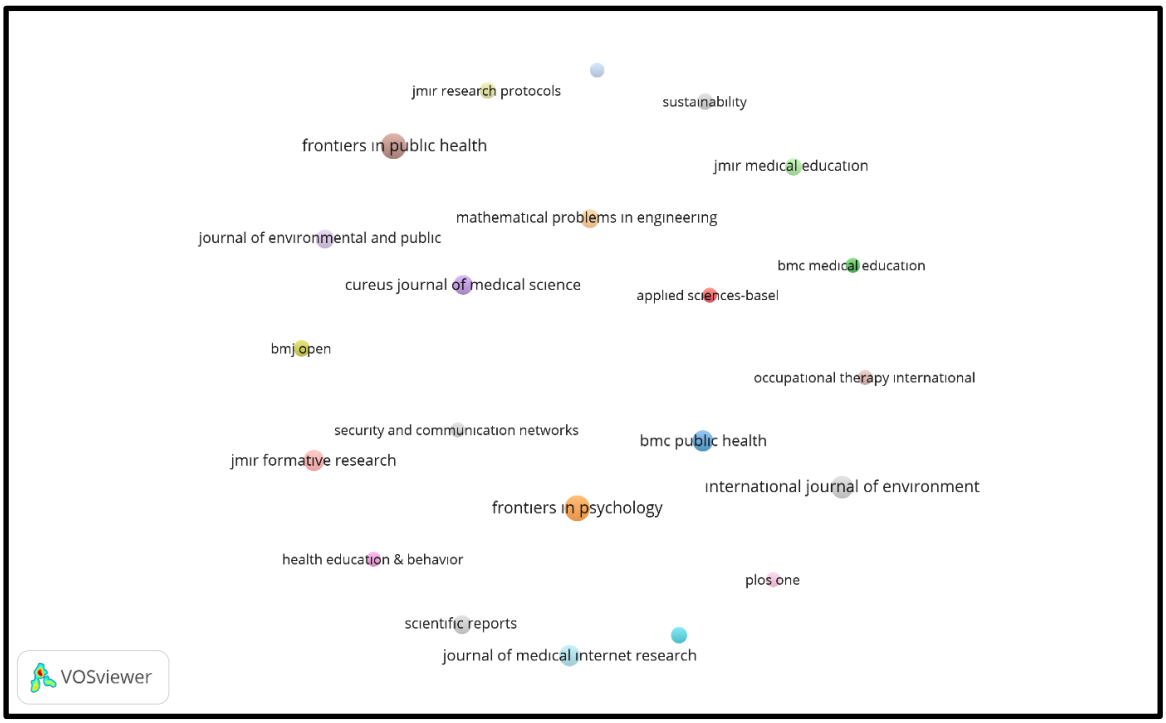

Figure 6. Journal network

A total of 2170 keywords were used across 640 publications related to AI in environmental and health education. The minimum threshold for keyword frequency in VOSviewer was set to 7. As a result of the analysis, 23 keywords, 5 clusters, 89 links, and a total link strength of 207 met the usage criteria. Table 5 presents the top ten most influential keywords.

Table 5. The most influential keywords

Rank	Keyword	Occurrences	TLS
1	Artificial Intelligence	85	84
2	Health Education	65	60
3	Machine Learning	33	26
4	Covid-19	25	22
5	ChatGPT	19	35
6	Mental Health	17	13
7	Deep Learning	16	10
8	Education	15	22
9	Health Literacy	14	9
10	Digital Health	13	20

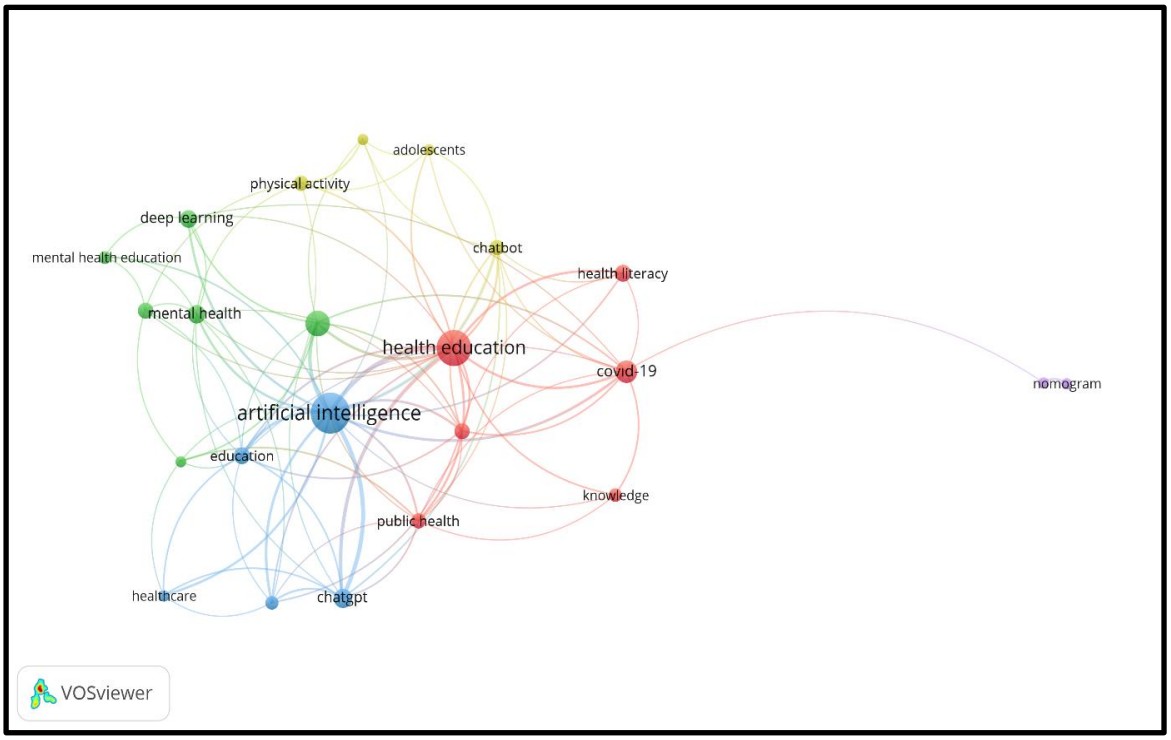

Figure 7. Keywords network

As shown in Figure 7, the first red cluster contains the words covıd-19, digital health, health education, health literacy, knowledge and public health. The second cluster, colored green, includes data mining, deep learning, machine learning, mental health, mental health education and social media. The words artificial intelligence, ChatGPT, education, healthcare and medical education are included in the blue cluster. The fourth cluster is yellow. The prominent keywords in this cluster are adolescents, chatbot, depression and physical activity. The last cluster is purple and contains nomogram and prediction model keywords. Artificial intelligence, health education, machine learning are the most frequently used keywords.

Conclusion and Discussion

The publications related to AI in environmental and health education were retrieved from the Web of Science (WoS) and analyzed in an objective and comprehensive manner. This study includes articles published in English, and it covers a total of 640 articles indexed in the WoS database on the topic of AI in environmental and health education from 2020 to 2024 (the past five years), which were subjected to bibliometric analysis.

The use of AI in environmental and health education has demonstrated steady growth over the past five years. From 2020 to February 2025, there was a significant increase in the number of related publications. In 2020, 79 publications were recorded, which rose to 106 in 2021, further increased to 148 in 2022, and then slightly declined to 120 in 2023. By 2024, the number of focused publications had reached 187. Despite this growth, the overall volume of publications remains limited, and the distribution of research outputs across different countries remains uneven. This disparity may be attributed to variations in resource allocation, technological development levels, and the availability of specialized training (Nahar, 2024).

China has been a leading contributor to the production of articles on artificial intelligence and has also ranked first in citation numbers, indicating the global influence and impact of its research. However, despite China ranking first in terms of article production, the United States surpassed China in citations. This suggests that although the United States produced fewer articles, its research may have had a more significant impact. While Taiwan surpasses countries such as India, France, Canada and Saudi Arabia in the number of articles, it is at the bottom in the number of citations.

Upon examining the distribution of journals with the highest number of publications on the subject, it was found that prominent journals related to the use of AI in education emerged as key contributors. The most published journals were Frontiers In Psychology and International Journal of Environmental Research and Public Health.

When the number of citations per article was examined, the journals Journal of Medical Internet Research, JMIR Medical Education and International Journal of Environmental Research and Public Health were found to be the most popular ones. When examining the authors of articles published on the use of artificial intelligence in environmental and health education, the number of citations and the number of publications were used to determine how much they contributed to the field. Individually, A. Koyanagi is the most cited author and has written the most articles.

Regarding the keywords defined by the authors, 'artificial intelligence' and 'health education' appeared at the top of the list, reflecting the central focus of the study. However, it was notable that terms such as 'ChatGPT' were present, indicating the influence of emerging technologies targeting end-users, and 'COVID-19,' suggesting research on the interaction between the pandemic and AI-mediated education. Additionally, terms like 'machine learning' and 'deep learning' highlighted the specific techniques and tools that have been extensively explored within this educational context. These key terms provide a comprehensive overview of the dominant themes and areas of interest concerning the relationship between AI and education. Mental health, health literacy and digital health keywords are also among the most frequently used keywords in health education studies.

From a theoretical perspective, this work not only addresses a gap in specialized literature but also lays a robust foundation for future research. The intersection of environmental education and health education presents both opportunities and challenges. An interdisciplinary approach, coupled with global collaboration, will be crucial to navigating this complex and evolving research domain. From a practical standpoint, there are several key managerial implications for educational institutions and leaders. Educational administrators should assess and adapt curricula to incorporate competency-based elements, reflecting the rapid advancements of artificial intelligence in education. Furthermore, it is essential for administrators to ensure that educators and staff are adequately equipped to integrate these technologies and stay abreast of technological advancements in the field.

Scientific Ethics Declaration

The authors declare that the scientific ethical and legal responsibility of this article published in JESEH journal belongs to the authors.

Conflict of Interest

The authors have no competing interests to declare that are relevant to the content of this article.

Funding Declaration

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