

Research Article



Synchronizing Environmental Education Research Trends: Promoting Sustainable Practices and Enhancing Scientific Knowledge

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Abstract: This research explores the diversity of topics related to environmental education issues and students' environmental concerns regarding their behavior. The bibliometric method is a quantitative approach used to measure and investigate specific indicators within the literature published in a particular field. This method involves creating knowledge maps using extensive databases to identify patterns and trends. Using the keyword "environmental education" on Scopus from 2018 to 2023, 365 relevant documents were found. In the PRISMA flow diagram, the process started with 7550 traced documents, narrowing down to 2536 relevant documents through screening. From these, 776 related documents were chosen, and 573 relevant documents were recognized after the inclusion stage. Throughout, a total of 365 publications were included in the study. VOS viewer software was used to analyze data and generate bibliographic maps and networks. In the last five years, research on environmental education has experienced exciting fluctuations. Key sources like Sustainability Switzerland and the International Journal of Environmental Research and Public Health have played a significant role. Research by Bogner, F.X. stands out, reflecting high interest in environmental issues and education within the scientific community. Universities such as Universidad de Granada and Universiti Kebangsaan Malaysia contribute significantly. The United States leads in publications. Environmental education research remains crucial for sustainable practices and environmental literacy despite fluctuations. This data provides essential guidance for future research planning. This research not only underscores the increasing research emphasis on the educational ramifications of pandemics but also identifies specific areas that warrant more extensive exploration.

Keywords: Bibliometric; Environmental Education; Systematic Literature Review; PRISMA Flow; VOS viewer.

1. Introduction

Environmental concern involves a cognitive process that encourages students to analyze environmental issues to develop their competencies in this domain [1]–[3]. Environmental education aims to foster a better relationship between humans and the environment [4], [5]. Currently, the world is facing the era of global warming, necessitating continuous efforts to improve and enhance environmental conditions. Simultaneously, urgent measures are required to mitigate damages and pollution. Effectively addressing this problem demands solutions that identify and solve existing environmental challenges [6].

Environmental education is a conservation strategy fostering collaborative efforts among scientists, decision-makers, community members, and stakeholders. This approach facilitates productive collaborations, often locally, by recognizing and appreciating local knowledge, experiences, values, and practices within communities. Environmental education empowers diverse groups, including marginalized ones, to engage actively in research activities and conservation efforts [7]. Embracing various approaches, tools, and programs, environmental education aims to develop and strengthen attitudes, values, awareness, knowledge, and skills related to the environment. Its primary goal is to equip individuals to make informed and responsible decisions to conserve and protect the environment [8], [9].

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Environmental issues encompass ecological aspects, critical thinking, and understanding the intricate relationship between the environment and technology. Science and technology are interdependent and have significantly influenced the natural environment, making awareness of their interplay crucial in addressing current environmental challenges [10].

Given the increasing global attention to environmental issues, environmental education has emerged as an intriguing field of academic research [11]–[13]. Implementing environmental education requires educators to play a crucial role as instructors, who must overcome various challenges to convey its principles effectively. Educators play a vital role in raising community awareness and understanding of environmental issues and encouraging participation in conservation and environmental protection efforts [10], [14]. By doing so, implementing environmental education can achieve its intended goals. Therefore, the role of educators as instructors is pivotal in providing guidance and developing problem-solving skills for everyday life, addressing issues related to personal, cognitive, and emotional development.

The main objective of environmental education is to provide the community with teaching and learning about the natural functions of the environment, with a particular emphasis on how humans can manage their behavior and ecosystems [15]–[17]. Beyond meeting the expectations of the economic sector, acknowledge that ensuring the sustainability of education requires identifying and fulfilling the expectations of educational students as well [18], [19].

Zsóka et al. argue that environmentally sustainable-based environmental education focuses on three key aspects: knowledge about the environment, attitudes toward the environment, and environmental skills [20]. Moyo et al. researched environmental education objectives among recent community members, considering their knowledge and awareness of the environment and adaptive solutions to promote environmentally friendly behaviors [21].

When fostered through education, environmental education underscores that knowledge, attitudes, and skills about the environment constitute the bedrock of environmental sustainability [20], [22]. It is mentioned that environmental education grounded in sustainability centers on environmental knowledge, attitudes toward the environment, and environmental skills. Environmental knowledge pertains to the recognition and comprehension of environmental issues along with their potential solutions [23]–[26]. A study on ecological education in Malaysia and identified the elements of environmental education in both formal and informal

environments where teaching and learning methods were implemented [27].

Elaborating on the viewpoints [27], [28] and [29], they have delineated the connection between ecological and outdoor education. This connection is pivotal in molding students' positive conduct, fostering an appreciation for environmental development, shaping attitudes toward science, promoting ecological behavior, and fostering a robust bond with the natural world. These environmental education approaches allow students to observe, experience, and engage with the elements in their surroundings. This empowers them to explore and understand their connection with the natural world.

Additional advantages of outdoor education have been pinpointed [30]. These encompass cultivating students' intellectual, physical, moral, and social dimensions connected to the natural surroundings within green schools dedicated to outdoor learning. Furthermore, [28] and [20] reported a new vision of the impact of ecological schools; according to their opinions, these types of green schools facilitate student engagement and creativity by enhancing field-based learning compared to indoor learning, allowing students to develop environmental knowledge, skills, and attitudes.

An alternate viewpoint on environmental education is upheld [31]. Their research discoveries showcase a positive correlation among three components of ecological education: environmental knowledge, ecological values, and ecological behaviors. Conversely, [32] and [33] advocate for a fresh perspective on ecological education within environmental education, considering the influence of the new generation immersed in Facebook and the effects of computer-based gaming trends. They recommend incorporating simulation games into environmental re-education, utilizing educational activities that involve students in ecological simulations. This approach aims to assist them in addressing real-life challenges and implementing solutions.

Ardoïn et al. [34] suggest employing digital photography and journal writing to assess field-based environmental education programs. This method aims to nurture the evolution of students' environmental attitudes and behaviors. [35] advocates and encourages environmental education research directly applicable to engineering, chemistry, and materials fields to enhance the industrial domain and ensure sustainable education for emerging green markets. The application of virtual reality and its potential impact on environmental education can also stimulate ethical attitudes among students, a topic currently being researched concerning the effects of environmental education [36]–[39].

Literature reviews and bibliometric studies in environmental education enable field research on both

local and global scales to identify prevailing trends and barriers that need to be addressed in education. According to [40], bibliometric studies should be conducted to analyze the dynamics and trends related to knowledge and education renewal. Bibliometric studies allow us to understand the research patterns in a field by identifying key elements. A relevant bibliographic analysis using environmental education keywords can reveal diverse perspectives in relatively high thematic clusters [41]. Studies showing interest in environmental education gain broad and diverse insights by analyzing bibliometric data. Based on these descriptions, researchers aim to explore the diversity of topics related to environmental education issues and students' environmental concerns regarding their behavior. After realizing the abundance of scientific data related to the terms and concepts they are researching and considering the arguments of Donthu et al. [42] and Sandnes [43], this study will conduct a bibliometric analysis of the relevant data using a VOS viewer as a supporting tool.

2. Material and Methods

2.1. Research Approach

Bibliometric analysis is a quantitative methodology employed to gauge and scrutinize specific indicators within the literature published in a particular field. It involves generating knowledge maps using extensive databases to discern patterns and trends [44]–[46]. This method enables researchers to summarize publication information, including the distribution of papers over time, authors, institutions, journals, and academic disciplines, and collaborations among authors and institutions. The analysis involves co-citation analysis [47], [48], co-authorship analysis [49], [50], and co-word analysis [51], [52].

The evolution of visual analytics tools like Cite Space [53], CitNetExplorer [54], [55], Gephi [56], Pajek [57], [58], and VOS Viewer [59] has streamlined the examination, creation, and representation of bibliometric networks, enhancing their analysis and visualization. By employing these tools, researchers can identify clusters of keywords, research trends, main research themes, and promising

directions for future studies within a specific field. Bibliometric analysis provides a holistic and comprehensive perspective by reviewing and analyzing a significant amount of relevant literature. This method is precious for understanding the research landscape and facilitating evidence-based decision-making in academic and scientific contexts.

2.2. Source of Information

Based on the arguments presented by [60] and [61], the scientific data used for this research was gathered from the Elsevier Scopus database. Introduced by Elsevier in 2004, this database currently holds an impressive collection of over 77.8 million records dating back to 1969. It encompasses more than 23,000 peer-reviewed journals, 294 trade publications, over 852 book series, and records of more than 120,000 scientific events worldwide [62]. Hence, it can be inferred that Scopus offers one of the most comprehensive perspectives on the current state of global research.

Scopus provides users with a wealth of bibliometric analysis acceleration features and global coverage [63], [64]. These features include multi-criteria filters that enable the segmentation of the worldwide dataset based on various criteria, such as journal names, document types, publication years, author names, author affiliations, citation counts, and more. This capability enhances the usability of Scopus for conducting sophisticated and refined bibliometric analyses. Researchers can leverage these functionalities to gain valuable insights and information relevant to their research inquiries.

2.3. Research Approach

Our research focused on the keyword "Environmental Education" and thoroughly searched the titles, abstracts, and document keywords within the Scopus database. Our search was explicitly confined to documents published between 2018 and 2023, using the query "TITLE-ABS-KEY (environmental AND education) AND PUBYEAR > 2017 AND PUBYEAR < 2024." Subsequently, we sorted the results by relevance. This meticulous search process yielded 365 documents that precisely matched our research criteria.

Table 1. Proprieties and Procedures for Searching

Keywords for Search	Search Within	Research Database	Period	Fundamental Query String	Number of Documents
Environmental Education	Title, Abstract, Keywords	Scopus	2018 to 2023	TITLE-ABS-KEY (environmental AND education) AND PUBYEAR > 2017 AND PUBYEAR < 2024	365

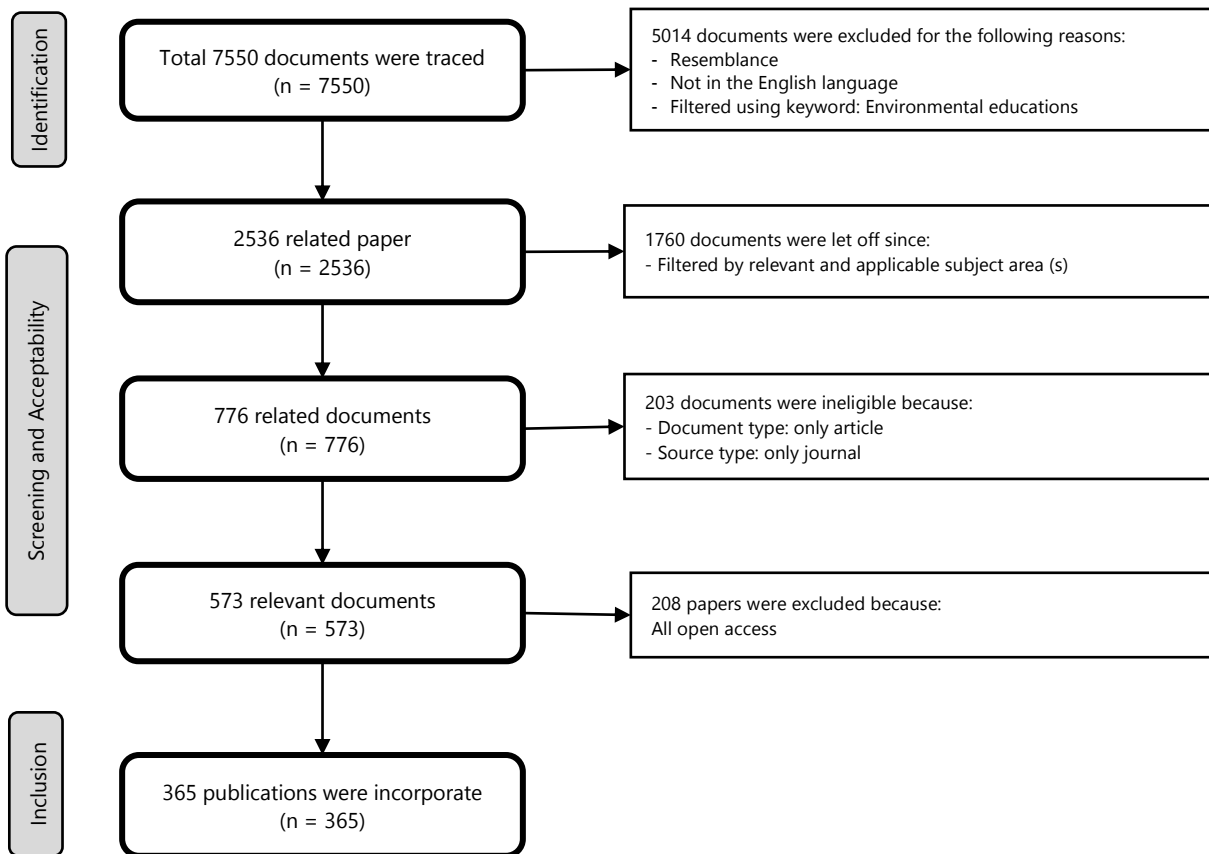


Figure 1. PRISMA Flow Diagram.

The study has gathered 365 relevant publications, and their bibliographic information has been systematically presented in a table. Recognizing the importance of comprehensive bibliographic data for investigating research trends [65], the information from these selected documents has been exported in both CSV and RIS file formats to facilitate further exploration and analysis.

To assess and summarize the findings and trends in recent studies, several figures have been created using the bibliographic information from the literature published between 2018 and 2023. VOS viewer, a software tool for generating bibliographic maps and networks for data presentation, has been adopted for this purpose [55].

The study has developed broad thematic categories that establish links between blockchain and online learning, enhancing understanding of the relationship between these two fields. This approach provides valuable insights into the connections and intersections between blockchain technology and online education, contributing to a more comprehensive comprehension of the subject matter.

2.4. Research Approach

Bibliometric analysis is a statistical method that enables quantitative analysis of large scientific datasets, such as research papers, to provide insights into key research areas

related to a specific concept and predict future research topics [66]. While the consensus value of bibliometric analysis is unquestionable, a significant part of its value lies in the visual perception derived from the obtained results, as argued by Van Eck and Waltman [67]. Therefore, VOS viewer has been chosen as the supporting software for this research.

Initially crafted in 2010 by Nees Jan van Eck and Ludo Waltman at the Centre for Science and Technology Studies (CWTS) at Leiden University, the VOS viewer is a robust instrument for generating maps rooted in network data and navigating and examining those maps [68]. Its prowess extends to extrapolating and constructing networks involving scientific publications and journals, researchers and research organizations, countries, keywords, and terms. The elements within these networks can be linked through co-authorship, co-occurrence, citations, bibliographic coupling, or co-citation relationships.

The added value of the VOS viewer, as highlighted [67], extends beyond its ability to create various networks. It also stands out for its capacity to gather data from multiple scientific databases, including Scopus, and reference manager files like RIS, EndNote, and RefWorks. This versatility makes VOS viewer a valuable tool for conducting comprehensive bibliometric analyses and

gaining in-depth insights into complex scientific data.

3. Result and Discussion

Bibliometric analysis was employed in this research, wherein data was gathered from the Scopus database by querying the terms' environmental education across article titles, abstracts, and keywords. The search generated 7550 documents in the Scopus database spanning the research period from 2018 to 2023.

3.1. Documents by Years

In the past five years, research on environmental education has experienced exciting fluctuations. In 2018, the number of publications did not show significant growth. However, in 2019, there was an increase of 7.5%. The year 2020 saw a very high growth rate of 72.1%. The trend continued in 2021 with a growth rate of 9.46% and in 2022 with 11.11%. However, in 2023, there was a drastic decrease with a -58.89% annual growth rate. It is important to note that the data for 2023 only covers the period until July 2023.

Table 2. Documents by years (2018 – July 2023)

Years	Number of Publications	Annual Growth Rate (%)
2018	40	0.0%
2019	43	7.5%
2020	74	72.1%
2021	81	9.46%
2022	90	11.11%
2023	37	-58.89%

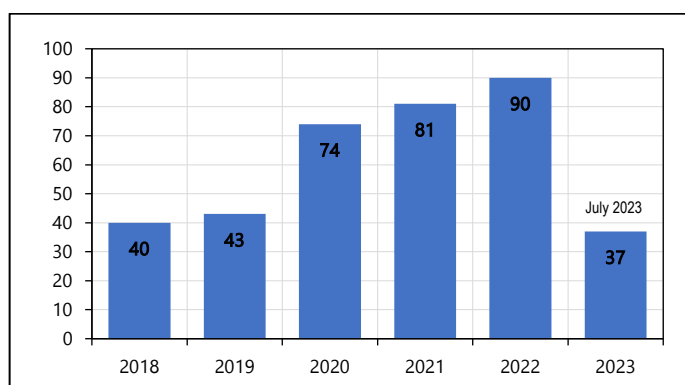


Figure 2. Documents by Years (2018 – July 2023).

3.2. Documents per Year by Sources

Several publication sources have significantly contributed to environmental education research in the last five years. Sustainability Switzerland is the top source with the most publications, totaling 122 documents.

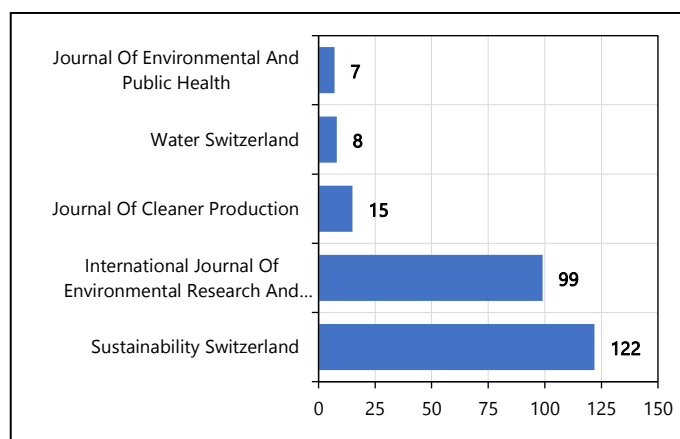


Figure 3. Documents per year by Sources.

The International Journal of Environmental Research and Public Health holds a strong position with 99 publications. Three other sources contributed to the research: the Journal of Cleaner Production with 15 documents, Water Switzerland with eight documents, and the Journal of Environmental and Public Health with seven documents. These data show that these publication sources are crucial in presenting research on environmental and sustainability issues in education.

3.3. Documents by Author

Research by Bogner, F.X. stands out with a significant contribution of 5 documents in research publications on environmental education, indicating this author's high interest in presenting research related to environmental issues and education. Additionally, there are nine other authors, each with three published documents. While their numbers may be fewer than Bogner, F.X., their contributions are still crucial in presenting research findings on environmental education.

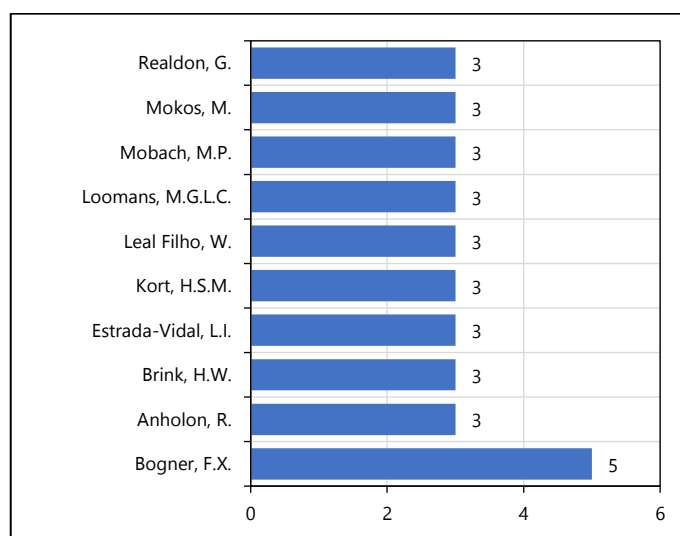


Figure 4. Documents by Author.

The diversity of authors in this field signifies the high interest and attention from the scientific community toward environmental education. This data serves as a crucial foundation for stakeholders in planning and directing future research efforts on environmental education. By acknowledging various authors' contributions and diverse perspectives, researchers, policymakers, and educators can comprehensively understand the field and identify potential areas for further exploration and collaboration. As environmental issues continue to be of global concern, ongoing research and publications in environmental education play a vital role in shaping sustainable practices and fostering environmental literacy among individuals and communities.

3.4. Documents by Affiliations

In research on environmental education, several colleges and universities are major contributors with significant numbers of publications.

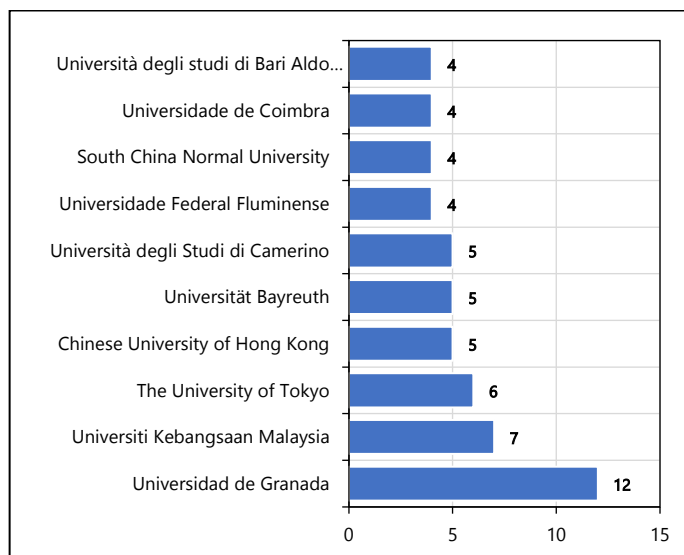


Figure 5. Documents by Affiliations.

Universidad de Granada has the highest number of publications, with 12 documents. Additionally, there are several other universities, such as Universiti Kebangsaan Malaysia, The University of Tokyo, the Chinese University of Hong Kong, Universität Bayreuth, Università degli Studi

di Camerino, and others, each with 5-7 published documents. These universities are essential in presenting research on environmental issues and education.

3.5. Documents by Country

The United States has the highest number of publications in environmental education research, with 62 documents.

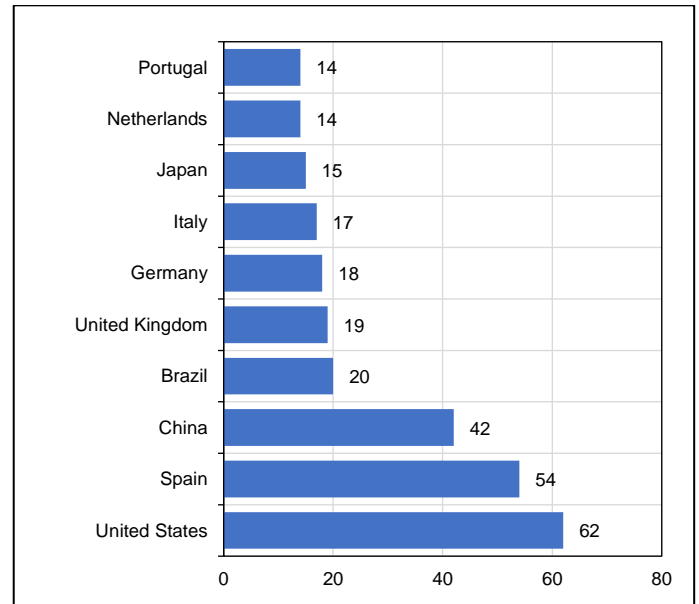


Figure 6. Documents by Country

Spain and China follow closely with 54 and 42 documents, respectively. Brazil, the United Kingdom, Germany, Italy, and Japan contribute significantly, with 20 to 15 documents each. Furthermore, the Netherlands and Portugal both have 14 published documents. These countries show their active participation and interest in contributing to the knowledge and understanding of environmental education issues.

3.6. Trends in Research Subjects Based on Occurrence.

The three cluster groups are the red, green, and blue groups. The red area consists of topics related to case studies, China, Impact, Pandemic, Study, Sustainable development, and University students.

Table 3. The occurrences of Article Subjects Trend.

Cluster 1 (Red)		Cluster 2 (Green)		Cluster 3 (Blue)	
Term	Occurrences	Term	Occurrences	Term	Occurrences
Study	32	Analysis	16	Effect	20
Case study	16	Perception	16	Attitude	15
Impact	26	Influence	10	Knowledge	17
China	11	College student	13	Environmental Education	34

Cluster 1 (Red)		Cluster 2 (Green)		Cluster 3 (Blue)	
Term	Occurrences	Term	Occurrences	Term	Occurrences
University student	20	Sustainability	23		
Sustainable Development	15				
Pandemic	12				

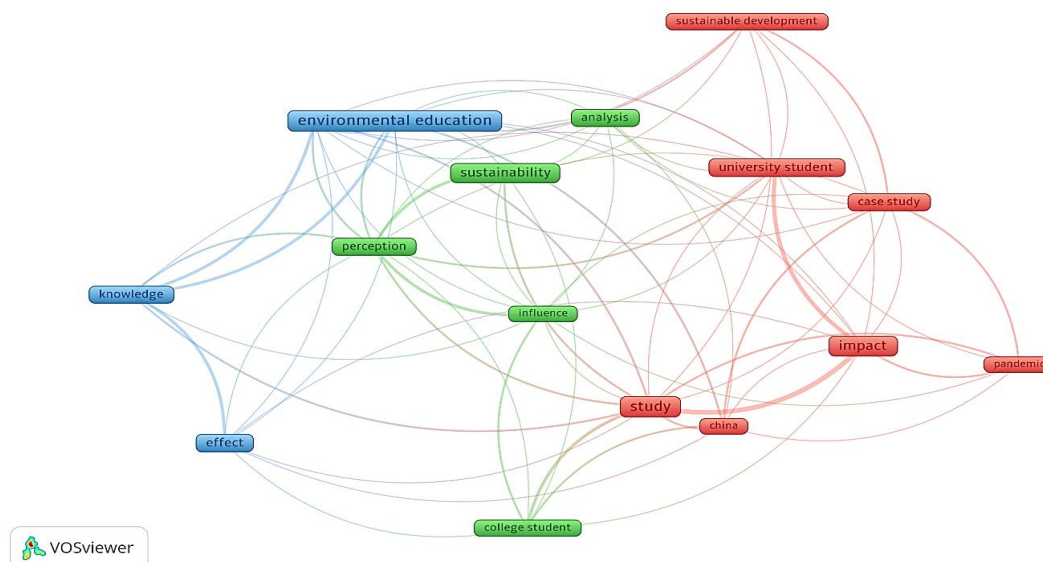


Figure 7. Network Visualization (Subject Trends Visualization)

The dominance of the red cluster is study and impact. The green area comprises topics related to Analysis, College students, Influence, Perception, and Sustainability. The domination of the green cluster is Sustainability, Perception, and analysis. The blue area consists of Attitude, Effect, Environmental Education, and Knowledge. The domination of the blue cluster is Environmental education and Effect.

3.7. Trends in Subject Research Articles Based on Time

The distribution of subject trends based on time can be seen from the visualization of Figure 8. The yellow indicates the current time, and the blue indicates the last time the subject of this article was written. From the figure, it appears that in 2018 – 2023, the subject trend discussed a lot about influence and pandemics.

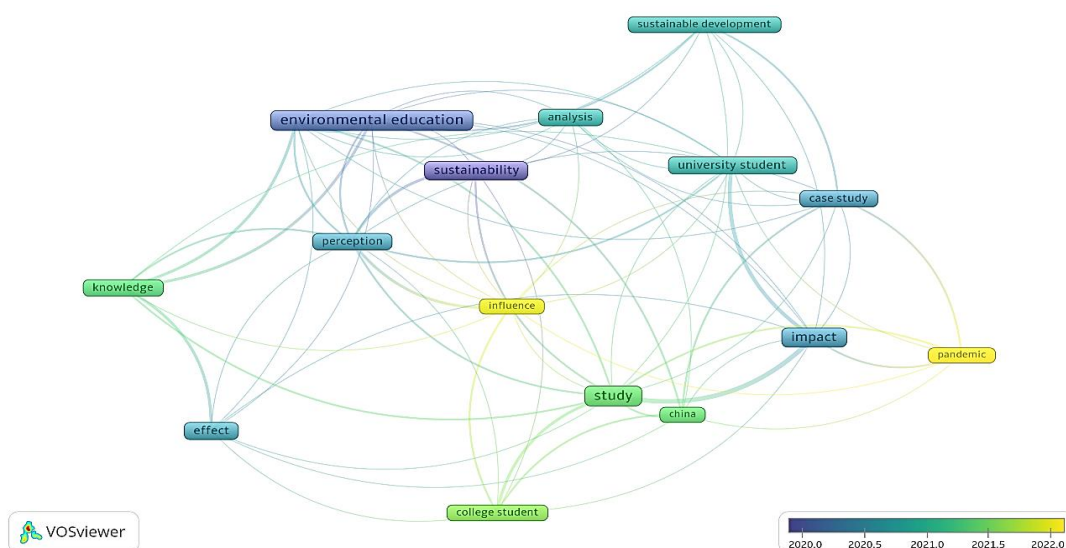


Figure 8. Trends in Subject Research Articles Based on Time

Past time (blue): In the past period, highlighted in blue, the subject of articles related to influence and pandemics may have received less attention or research. This could be due to several reasons, such as the issues that dominated attention at the time or the lack of awareness about the importance of the impact and the pandemic in the educational context.

Current time (yellow): The most recent period, highlighted in yellow, has seen increased attention and research on the influence of pandemics in the educational context. A brighter yellow indicates that this topic has been the research focus recently, particularly between 2018 and 2023. Combining the subjects "influence" and "pandemic": From the visualization, it can be seen that the two subjects, namely "influence" and "pandemic," have an increasing

trend in the current period. This suggests that greater attention has been paid to these two topics in the educational context over the last few years.

Impact of the pandemic on education: The increased focus on the pandemic, in particular, indicates that much research is interested in understanding the effects of the COVID-19 pandemic on the education system, including implementation of distance learning, use of technology, challenges and solutions in online learning, and psychological and social effects on students and teacher. Influence on education: More research on impact in educational contexts might cover topics such as the effect of teachers on student achievement, the effect of the learning environment, the influence of families, or the impact of educational policies on the education system.

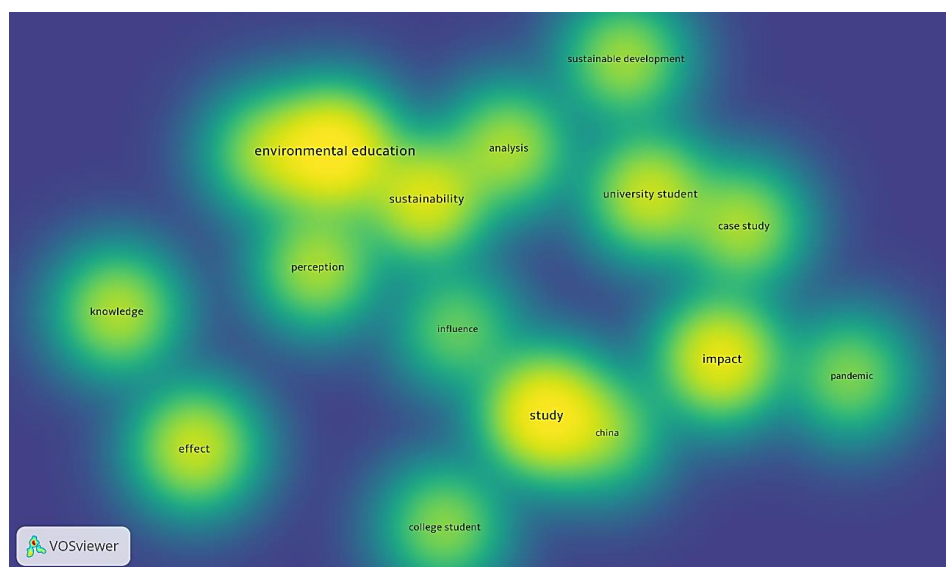


Figure 9. Density Visualization

Thus, the interpretation of the Figure 8 visualization shows that in recent years (2018-2023), there has been increased attention and research on the influence of pandemics in the educational context. This reflects the importance of understanding the impact of global events such as pandemics on educational systems and practices and the interrelationships of various factors influencing the learning process. The density visualization in the image illustrates the saturation level of the research topic. The dense area is indicated by the number of adjacent vertices and the color, which indicates the saturation level. For example, yellow surrounds environmental education, study, impact, sustainability, effect, and university students. This shows that these topics have been extensively researched. On the other hand, topics that are colored green, such as knowledge, perception, analysis, influence, China, college students, pandemics, and case studies, are noted as topics that are rarely researched.

The visualization presented in Figure 8 reveals a substantial surge in both attention and research focus on the impact of pandemics within the educational context over a specific period. This heightened interest underscores the critical importance of comprehending global events' repercussions on educational systems and practices, particularly pandemics. In recent years, the COVID-19 pandemic, serving as a prominent case in point, has compelled educational institutions across the globe to adapt to new and unprecedented challenges swiftly. These challenges encompassed a shift towards remote learning modalities, implementation of health and safety protocols, and a reevaluation of traditional teaching methods.

Furthermore, this visualization offers valuable insights into the extent to which different research topics have been explored and investigated. Dense areas in the visualization are prominently highlighted in yellow, symbolizing high research density and activity levels. These densely researched topics encompass

"environmental education," "studies," "impact," "sustainability," "effects," and "university students." The vivid yellow hue conveys that these specific subjects have garnered significant research attention and have been subjected to comprehensive and in-depth investigations throughout the specified timeframe.

In contrast, topics shaded in green within the visualization, such as "knowledge," "perception," "analysis," "influence," "China," "college students," "pandemics," and "case studies," denote areas that have received relatively little research attention within the context of education and its relationship to pandemic impacts. The predominant green coloring hints at unexplored research avenues, suggesting the existence of untapped opportunities for future investigations.

4. Conclusion

The density visualization in the image illustrates the saturation level of the research topic. The dense area is indicated by the number of adjacent vertices and the color, which indicates the saturation level. For example, yellow surrounds environmental education, study, impact, sustainability, effect, and university students. This shows that these topics have been extensively researched. On the other hand, topics that are colored green, such as knowledge, perception, analysis, influence, China, college students, pandemics, and case studies, are noted as topics that are rarely researched.

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