

Education For Sustainable Development in Preservice Teacher Program: A Bibliometric Study

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Keyword

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Abstract

As the earth's condition gets worse due to many environmental and social challenges, sustainable development is a solution that must be carried out by all parties, including all actors in the education sector. Sustainability education or education for sustainable development is essential to enhance sustainable development. Teachers are role models for students to have knowledge and awareness of sustainability. As the younger generation, students will become citizens who carry out the future business and country's development, so they should act and behave according to sustainability principles. Thus, the role of teachers is significant in forming a young generation that possesses a high knowledge and awareness of sustainability, which determines their sustainability behavior in the future. Therefore, sustainability education for prospective teachers is very crucial. This study aims to provide a comprehensive overview of research trends regarding sustainability education for preservice teachers using bibliometric analysis by utilizing the VOS viewer and analysis features provided by Scopus. The articles used are on sustainability education for preservice teachers published in the Scopus database from 1998 to 2024. The study results show that many areas still need further study that scholars can use to research in this field.

INTRODUCTION

Climate change is one of the most critical global concerns and will continue to be so in the years ahead (Kuthe et al., 2019). However, this is not only because the global climate has changed, but it has also led to environmental and social problems. Climate change, global warming, destruction of natural resources, deforestation, high levels of water and air pollution, high carbon emissions, shortages of food, and other dangers to our world's future are now facing our lives (Grosseck, Laurent, Tîru & Bran, 2019). There is no sign of the slowing pace. Then, according to Gray (2013), if we all still implement our lifestyle as we do now, humanity will need approximately three planets. He also implied that even under very optimistic assumptions, humanity's ways of managing this planet do not appear sustainable or likely to become so.

To solve such sustainability challenges, Kuthe et al. (2019) proposed that all facets of society must immediately address this issue. Therefore, the world requires more sustainable civilizations, lifestyles, and economies (Grosseck, Laurent, Tîru & Bran, 2019). Young generations play an essential part in addressing such sustainability challenges. In the future, it will be their turn to become leaders, managers, and employees, and so they will be responsible for making ethical and sustainable decisions (Swaim et al., 2014). Therefore, educating young people who are open to global difficulties and prepared to solve today's pressing issues is critical. As many practitioners consider education central to sustainable development (Hazelton and Haigh, 2010), young generations must have a sustainable education. Education for sustainable development

(ESD) plays a vital role in developing a society's capacity to address sustainability problems (Brandt et al., 2019).

The lack of sustainability knowledge and awareness among youngsters is a serious problem. The young generation will be the future citizens who should have an awareness of sustainable development and be able to contribute to maintaining the existence of the planet and society in the long term. Studies have indicated that the public lacks knowledge of sustainable development and its goals (Chen et al., 2022). Previous studies showed that young generations in several parts of the world possess low sustainability awareness and knowledge. As such, Ebaid (2022) found that approximately 88% of the Saudi Arabian student respondents have expressed a low familiarity with the term sustainable development (Ebaid, 2022). Moreover, Aikowe & Mazancova, 2023 reported that Nigerian students performed poorly on the sustainability literacy test, implying a low level of sustainable knowledge and awareness. On the contrary, with the presence of sustainability-focused aspects in the college curriculum, implying a focus on sustainability education, Suganya et al. (2024) found a high awareness of sustainable development among the surveyed students, such as a strong propensity toward responsible trash disposal, and an eco-friendly product preference.

Since sustainability knowledge and awareness are the antecedents of people's behavior toward sustainability (Pradeep & Pradeep, 2023), it is imperative to strengthen students' knowledge and awareness regarding sustainable development (Alvarez-Risco, 2021). Formal and informal education can increase students' sustainability awareness (Aliman et al., 2019). Pertaining to formal education, since teachers act as role models for their students (Cheung 2020), teachers play a vital role in imparting a sustainable development curriculum and developing skills and action competencies to attain sustainability goals (Ferguson, Rooft & Cook, 2021).

Previous studies found that universities are essential in promoting public understanding and sustainability awareness (Agustina, Meyliana & Hanny, 2023). Educational institutions must support initiatives to protect the natural and sociocultural environment, including the development of soft skills and competencies in students from middle and high schools to universities since people build their value systems based on their experiences and culture (Piscitelli & D'Uggento, 2022). Since the essential role of teachers in delivering sustainability knowledge to young generations, universities need to focus on developing sustainability teacher competencies through sustainability programs and curricula in teacher education.

Recognizing the significance of education for Sustainable Development, the urgency of refocusing teacher education has increased (Soysal, 2016). Teacher sustainability education is essential for developing the sustainable competencies of teachers (Suh et al., 2020). Wang & Shih (2022) stated that the implementation of education has an impact on a country's development and prosperity, and cultivating high-quality instructors is a critical component of an effective education system. Their study showed that the quality of the teachers frequently determines the quality of education, and professional development for teachers is intimately related to teaching effectiveness and student learning results.

The academic production on "education for sustainability" has been expanding in recent years, which reflects the attention this subject has received (Côrtes & Rodrigues, 2016). Similarly, the scholarly publication regarding sustainability in teacher training education shows an increasing trend. In this sense, Ocaña-Fernández & Fuster-Guillén (2021) said that because of the increased number of scientific publications, literature reviews in the form of review articles have become increasingly important. They also stated that the proliferation of publications in various formats has resulted in a wealth of information, making it impossible for researchers and professionals to read or review all published information for various reasons, including limited access to various journals, a lack of time, and sometimes high costs. Then, they suggested that review articles are a viable solution for professionals to stay current on a subject's latest knowledge and trends.

Based on the underlying background, the research question is: Is there still an opportunity to conduct research in sustainability education for the preservice teacher's area? Therefore, this study aims to provide a comprehensive trend of sustainable education in teacher training through a bibliometric method. The bibliometric method represents the research area's structure by partitioning items (documents, writers, journals, keywords, country, year and so on) into distinct categories. Then, visualization represents the resulting categorization (Zupic & Čater, 2015). Thus, through bibliometric study, one of the literature review methods, the study's result can contribute by providing new knowledge as a basis for future research. Snyder (2023) proposed that a literature review synthesizes findings from studies and identifies areas where more research is needed, providing the foundation for a conceptual model and informing policy and practice.

Sustainability was first introduced as a term of sustainable development by the UNWCED in the Brundtland Report as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (UNWCED, 1987). According to Gray (2013), understanding sustainability in Brundtland's view can lead us to explore the earth's physical condition (nature, ecosystem stability, resources, life) and the social equity concerns over relative access to planetary and natural resources. The concept of sustainable development has served as the benchmark and driving force behind most global initiatives to achieve social, economic, and environmental goals (Gericke et al., 2019), or triple bottom line. The sustainability initiative is also conducted in education, as education for sustainable development is argued to promote sustainable development (Bakhati, 2015).

Sustainability education and sustainable education, two terminologies used interchangeably (Dong et al., 2023), is a learning and teaching approach that prioritizes the earth's environmental, economic, and social sustainability (Tripon et al., 2023). Some researchers also refer to sustainability education as education for sustainable development (ESD) (Evans et al., 2017; Kalsoom & Khanam, 2017). ESD aims to assist students in acquiring the skills necessary to solve sustainability-related problems and engage in sustainable development while critically analyzing their behavior (Brundiens et al., 2021). Simultaneously, initiatives focused on preserving natural spaces and biodiversity can contribute to educational aims and enhance the environmental literacy of communities (Hansmann et al., 2012). Sustainable education fosters critical thinking among students regarding their environmental impact and encourages them to comprehend the potential consequences of their present actions on the future global landscape. It also cultivates the necessary skills to become effective guardians of the planet, ensuring the longevity of its resources (Tripon et al., 2023). Therefore, to help young generations prepare for the uncertainties of the future, they should be assisted in acquiring the necessary knowledge because an absence of knowledge or possessing the wrong knowledge may impede pro-sustainable development actions (Chen et al., 2022).

Zguir, Dubis & Koç (2022) proposed that in reshaping education systems to make young generations better acquainted with sustainable development and ESD, regulators and academics alike have been requiring continuous improvement of teaching and quality of teachers as a critical foundation of sustainable development education. They also stated that teacher quality is viewed as a driver of transformational change within the education system; teachers' readiness and preparedness are vital to ESD's success. Therefore, teachers are essential as ESD pedagogues in developing students' sustainability attitudes and behaviors (Kalsoom & Khanam, 2017).

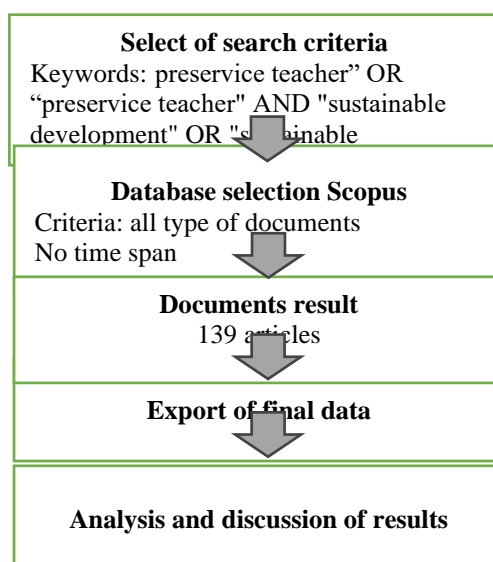
METHOD

Bibliometrics is considered a quantitative research method (Rodríguez-Ruiz, 2009), applying mathematics and statistical techniques in bibliographical studies and other types of written communication (Hazarika, Goswami & Das, 2003). Such a method is utilized in information science to describe patterns of publication within a particular

discipline or body of literature to identify the pattern of publication, the author's name, citations, and journal coverage with the expectation that such studies can give an insight into the dynamics of the field under consideration (Rodríguez-Ruiz, 2009). Bibliometric also refers to science mapping, which is based on the quantitative approach of bibliometric research methods and is increasingly utilized to map the structure and evolution of scientific subjects and fields of study (Zupic & Čater, 2015).

This research uses the Scopus database since Scopus provides high-quality publications. Moreover, Scopus has features that assist researchers in conducting analyses more easily. The first step is establishing search criteria or identifying keywords. Keywords used are preservice teacher, sustainable development and sustainable education. By using the boolean operator, the search step in the Scopus database is "preservice teacher" OR "preservice teacher" AND "sustainable development" OR "sustainable education" OR "education for sustainability." The search is done within the article title, abstract, and keyword fields, except for the sustainable development phrase in the title field, without a particular period.

Diagram 1.
Research method



The selected articles from the search step in the Scopus database are then analyzed using VOS viewer version 1 .6.18 from Leiden University, The Netherlands and the analysis tool provided by Scopus. VOS viewer assists the author in conducting co-occurrence analysis and provides visualization, while analysis from Scopus provides many features such as publication tren by year, country, author, etc. Following Abad-

Segura et al. (2020) work, this study applies the same procedure depicted in Diagram 1. After the search step, the documents are exported in the CSV format file so the VOS viewer can read and run it.

RESULTS AND DISCUSSION

Table 1.

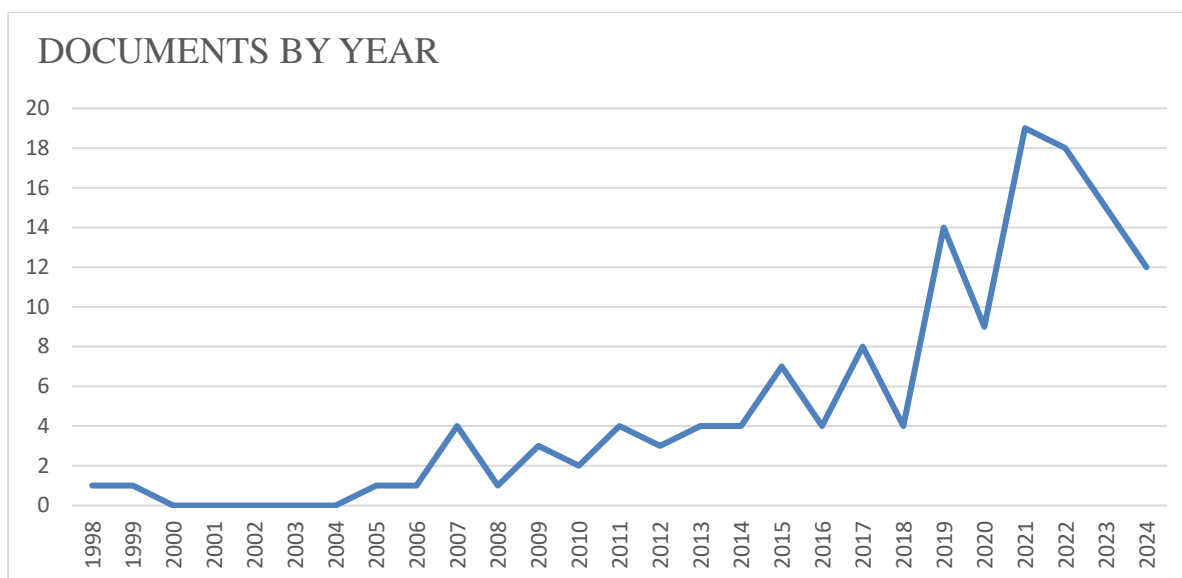
Number of documents published per year			
Year	Documents	Year	Documents
1998	1	2012	3
1999	1	2013	4
2000	0	2014	4
2001	0	2015	7
2002	0	2016	4
2003	0	2017	8
2004	0	2018	4
2005	1	2019	14
2006	1	2020	9
2007	4	2021	19
2008	1	2022	18
2009	3	2023	15
2010	2	2024	12
2011	4	TOTAL	139

Source: author, 2024

The search resulting 139 documents. The next step is screening the title to remove irrelevant documents with the topic being researched. However, since the keywords and boolean operator utilization are adequate, all articles are relevant to the topic. Then, there is no article deleted. Table 1 shows that the first publication concerning the topic was published in 1998, but from 2000 until 2004, there was no publication in such an issue.

Figure 1.

Number of documents published per year



Source: author, 2024

In 2005, Scopus' publication on the topic was started again, with an increasing trend. The publication trend by the year can be seen in Figure 1. The most publications are in 2021, with 19 documents and in 2022, with 18 articles. There is a declining trend in 2024 because when this research is conducted, it is still in the mid-year of 2024.

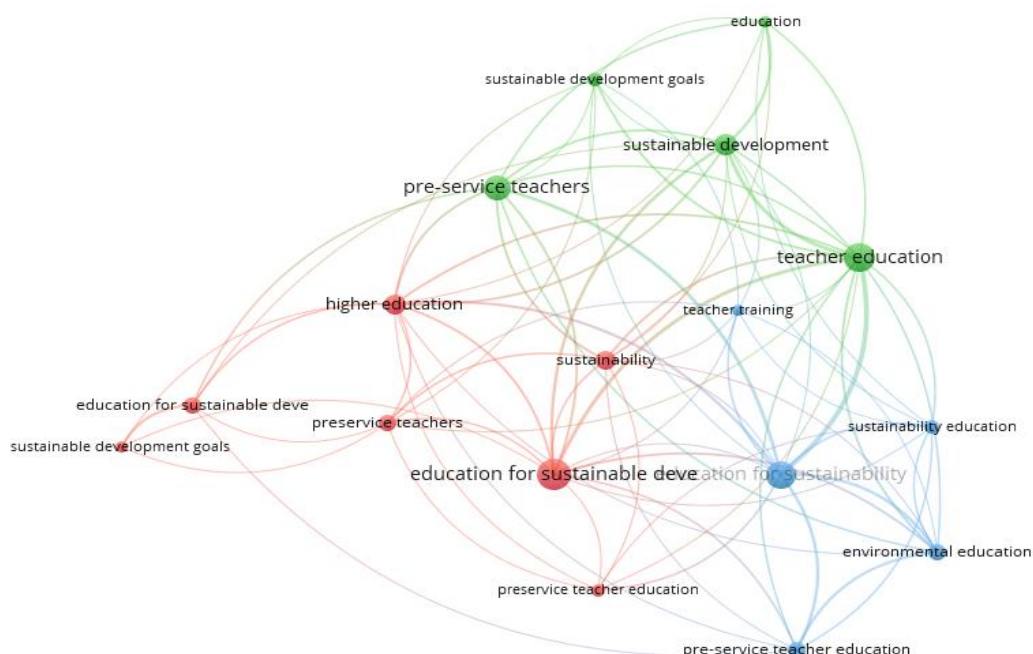
Table 2.
 Most used keywords

Keyword	Occurrences	Total Link Strength
education	5	12
education for sustainability	26	42
education for sustainable development	33	32
education for sustainable development (esd)	9	11
environmental education	10	24
higher education	14	26
preservice teacher education	9	18
preservice teachers	21	27
preservice teacher education	6	8
preservice teachers	10	12
sustainability	13	17
sustainability education	7	13
sustainable development	16	30
sustainable development goals	7	10
sustainable development goals (sdgs)	5	7
teacher education	28	49
teacher training	5	10

Source: author, 2024

The author then conducted a visual analysis using a VOS viewer software. Of 139 articles, it contains a total of 368 keywords. Using the choice type of analysis and counting method feature provided by the software, the author types 5 to choose a minimum number of keyword occurrences, meaning that the software selects the minimum keyword to occur in an article five times. Table 2 shows the result. These keywords are phrases that express the object of study of the publications. Analyzing these terms provides information about the interests developed along this research line to be retrieved. The strong link presents the critical concept of teacher education with 49 link strengths and education for sustainability with 42 link strengths.

Figure 2.
Keyword co-occurrences

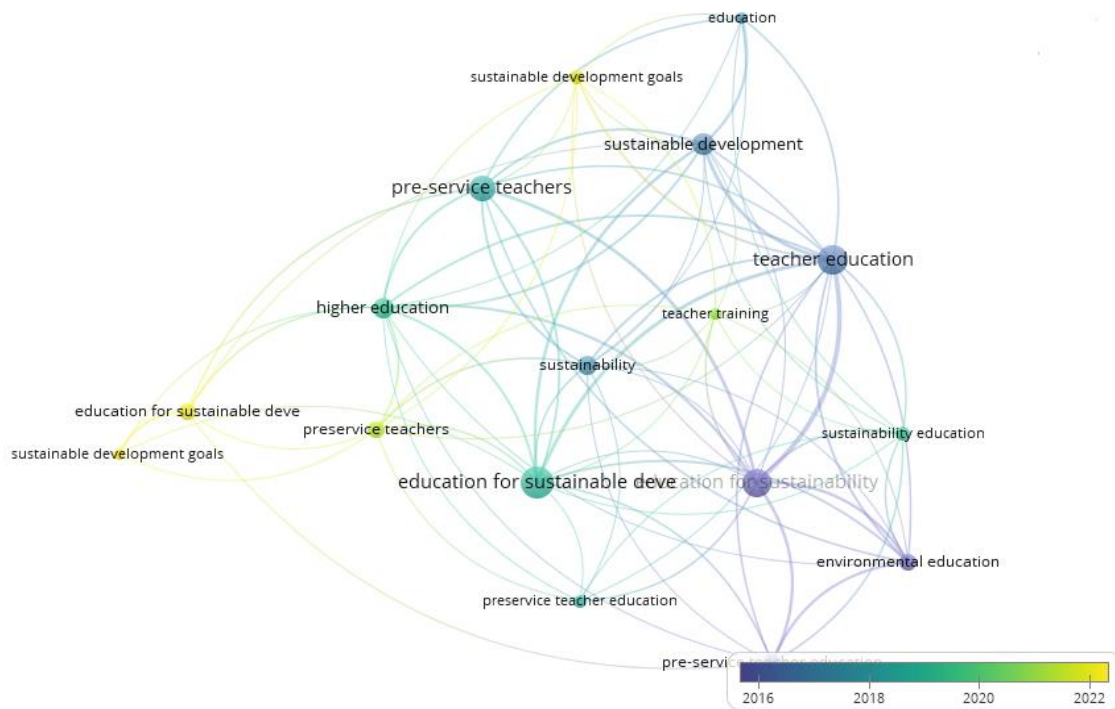


Source: author, 2024

Figure 2 depicts keyword co-occurrences-based network visualization using a VOS viewer or the primary terms utilized during the study period. From the figure, it can be seen that three main clusters are identified from the color of the lines and dots. The first cluster (red) represents the concepts of education for sustainable development, education for sustainable development (ESD), higher education, preservice teachers, preservice teacher education, sustainability and sustainable development goals. The second cluster, colored green, performs education, preservice teachers, sustainable development, sustainable development goals and teacher education conceptions. The last cluster, marked by blue, represents ideas of education for sustainable development, environmental education, pre-service teacher education, sustainability education and teacher training.

Figure 3.

Overlay visualization of keywords



Source: author, 2024

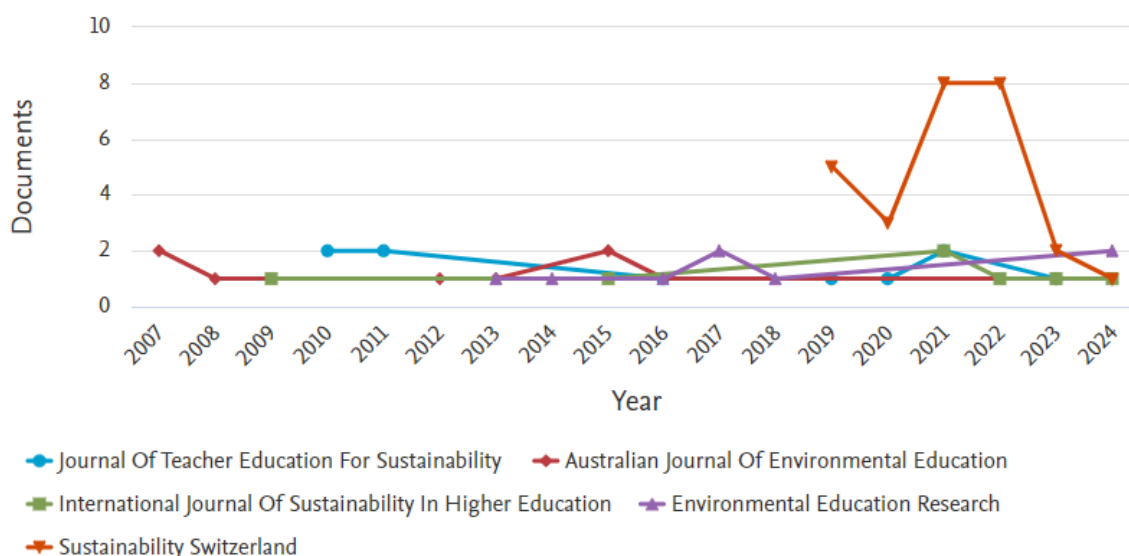
Figure 3 depicts the most used primary keywords in a given period. According to the color shown in the image, the main keywords that most often appear are in research conducted in the 2016-2018, 2018-2020 and 2020-2022 time frames. From 2016 to 2018, the keywords that most appeared were teacher education, education for sustainability, sustainable development, and pre-service teachers. In 2018-2020, keywords often occurred: education for sustainable development and preservice teachers, followed by smaller dots representing higher education and preservice teacher education keywords. The dots in the 2020-2022 time frame are smaller than in other periods, meaning the keywords rarely occur.

Figure 4.
Document source title

Documents per year by source

Compare the document counts for up to 10 sources.

[Compare sources and view CiteScore, SJR, and SNIP data](#)



Source: author, 2024

The topic of sustainability education in teacher education is often published in the Journal, as seen in Figure 4. In the period 2004-2024, the journals that most often publish these topics are the Journal of Teacher Education for Sustainability, the Australian Journal of Environmental Education, the International Journal of Sustainability in Higher Education, and Environmental Education Research and Sustainability Switzerland. Table 3 shows the ten document sources that published the most.

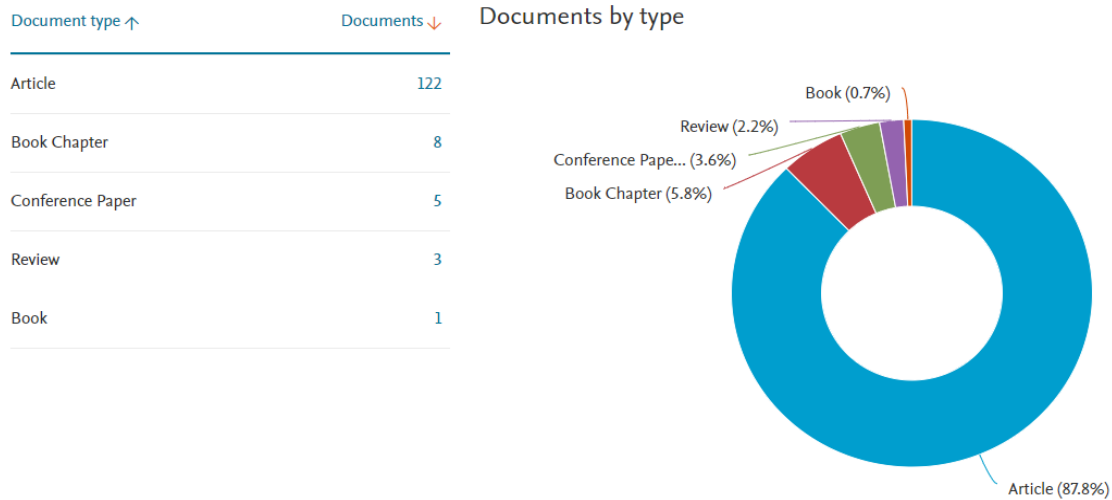
Table 3.
 Document source

Source	Documents
Sustainability Switzerland	27
Journal Of Teacher Education For Sustainability	10
Australian Journal Of Environmental Education	9
Environmental Education Research	8
International Journal Of Sustainability In Higher Education	7
Education Sciences	5
Australian Journal Of Teacher Education	4
International Research In Geographical And Environmental Education	3
Journal Of Cleaner Production	3
Ensenanza De Las Ciencias	2

Source: author, 2024

The sustainability in the preservice teacher field is mostly in article type (87,8%), as shown in Figure 5, followed by book chapter, conference paper, review and book format, respectively.

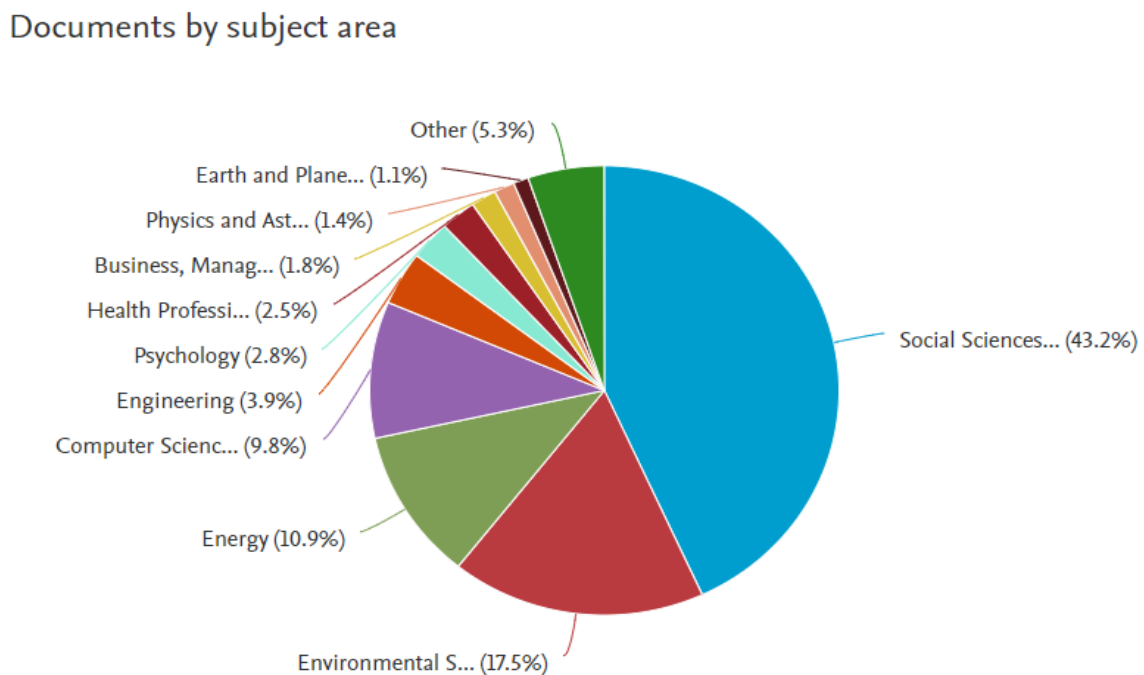
Figure 5.
 Document Type



Source: author, 2024

The areas most discussed in publications are social sciences, environmental science, energy, computer science, and engineering, with more than ten publications, as shown in Figure 6.

Figure 6.
 Publication by subject area.



Source: author, 2024

Table 4 shows that the fields that only have five or fewer publications are Business, Management and Accounting, Physics and Astronomy, Earth and Planetary Sciences, Multidisciplinary, Agricultural and Biological Sciences, Arts and Humanities, Economics, Econometrics and Finance, Mathematics, Medicine, Biochemistry, Genetics and Molecular Biology and Chemistry. From 1998-2024, only five or fewer academic articles were published in sustainability education for preservice teachers for the subject areas. It

means that such areas are under research, and there are many opportunities to conduct research and publish it.

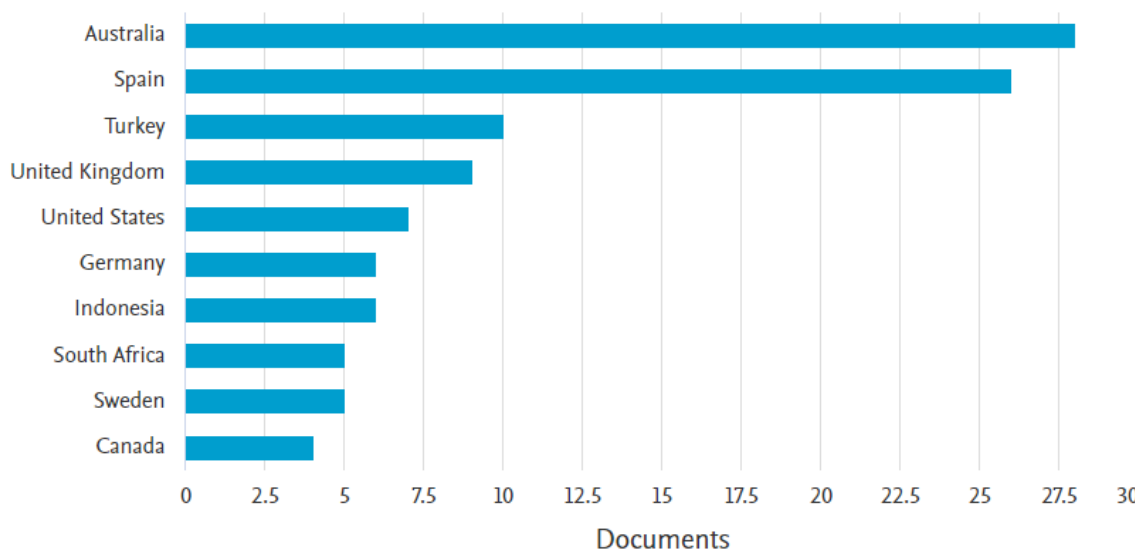
Table 4.
 Publication by subject area

Subject area	Documents
Social Sciences	123
Environmental Science	50
Energy	31
Computer Science	28
Engineering	11
Psychology	8
Health Professions	7
Business, Management and Accounting	5
Physics and Astronomy	4
Earth and Planetary Sciences	3
Multidisciplinary	3
Agricultural and Biological Sciences	2
Arts and Humanities	2
Economics, Econometrics and Finance	2
Mathematics	2
Medicine	2
Biochemistry, Genetics and Molecular Biology	1
Chemistry	1

Source: author, 2024

The country or territory of the articles is varied across the globe. Research is often conducted in Australia, followed by Spain, Turkey and the United Kingdom. The number of articles published per country is presented in Table 5. If we consider Turkey a European country, Indonesia is the Asian country that is most frequently researched on this topic. However, from 1998 to 2024 or 26 years, only six publications can be considered very low. Thus, research and publication in the Indonesian context for such a subject are still widely open.

Figure 7.
 Documents by country or territory



Source: author, 2024

From Table 5 below, we can see many countries where studies in preservice teacher sustainability education are still seldom conducted. They are primarily Asian countries. Surprisingly, there are only two publications on such a topic in Finland, which is regarded as the country with the best education system (Kilag et al., 2023). So, opportunities to research and publish in countries where publications are rarely conducted on such a topic are still open. Moreover, opportunities for collaboration with scholars from countries with low publications are still wide open.

Table 5.

Documents by Country or Territory

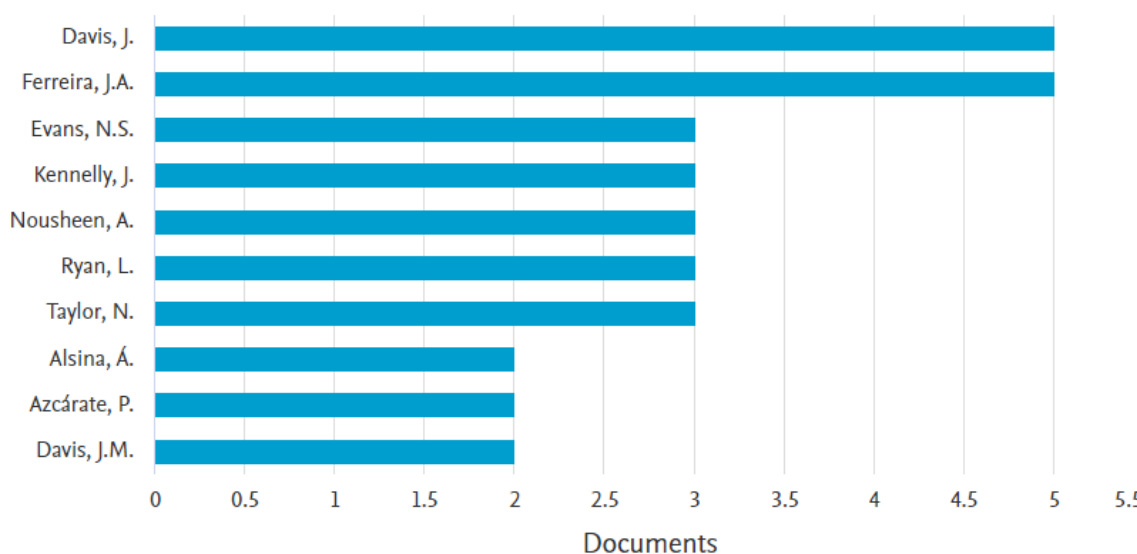
Country	Documents	Percentage	Country	Documents	Percentage
Australia	28	20%	Norway	2	1%
Spain	26	19%	Philippines	2	1%
Turkey	10	7%	Viet Nam	2	1%
United Kingdom	9	6%	Argentina	1	1%
United States	7	5%	Austria	1	1%
Germany	6	4%	Belgium	1	1%
Indonesia	6	4%	China	1	1%
South Africa	5	4%	Hong Kong	1	1%
Sweden	5	4%	Hungary	1	1%
Canada	4	3%	India	1	1%
Pakistan	4	3%	Jamaica	1	1%
Chile	3	2%	Lithuania	1	1%
Greece	3	2%	Malaysia	1	1%
South Korea	3	2%	Malta	1	1%
Switzerland	3	2%	Morocco	1	1%
Taiwan	3	2%	Netherlands	1	1%
Finland	2	1%	New Zealand	1	1%
France	2	1%	Poland	1	1%

Ireland	2	1%	Romania	1	1%
Israel	2	1%	Saudi Arabia	1	1%
Italy	2	1%	Slovenia	1	1%
Latvia	2	1%	Undefined	2	1%

Source: author, 2024

Figure 8 shows that Davis J.M from the Faculty of Education, Early Childhood, Queensland University of Technology, Brisbane, Australia and Ferreira J. A from Southern Cross University, Gold Coast, Queensland, Australia, produced the most significant number of articles. Moreover, the list of authors with many publications concerning the topic is then followed by Evans N. S from the College of Arts, Society and Education, Division of Tropical Environments, James Cook University, Cairns, Australia; Kennelly J from University of New England, United Kingdom; Nousheen A from National University of Modern Languages, Islamabad, Pakistan; Ryan L of Sustainability Education, Faculty of Arts and Business, University of the Sunshine Coast, Sippy Downs, QLD, Australia; and Taylor N from School of Education, University of New England, Armidale, Australia. So, when scholars are interested in sending an inquiry or discussing education for sustainability in the preservice teacher field, they know who to contact.

Figure 8.
 Documents by Author



Source: author, 2024

The most cited document (300 or above) is depicted in the following table (Table 6). The top three most cited articles are written by Evans et al. (2017), Nousheen et al. (2020) and Lee & Hwang (2022). The article by Evans et al. (2017) has 131 citations, making it the most cited document.

Table 6.
 Most cited document

Cited	Authors	Year	Title of article
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131	Evans N.S.; Stevenson R.B.; Lasen M.; Ferreira J.-A.; Davis J.	2017	Approaches to embedding sustainability in teacher education: A synthesis of the literature
119	Nousheen A.; Yousuf Zai S.A.; Waseem M.; Khan S.A.	2020	Education for sustainable development (ESD): Effects of sustainability education on pre-service teachers' attitude towards sustainable development (SD)
109	Lee H.J.; Hwang Y.	2022	Technology-Enhanced Education through VR-Making and Metaverse-Linking to Foster Teacher Readiness and Sustainable Learning
94	Ferreira J.-A.; Ryan L.; Tilbury D.	2007	Mainstreaming education for sustainable development in initial teacher education in Australia: A review of existing professional development models
66	Jeronen E.; Palmberg I.; Yli-Panula E.	2017	Teaching methods in biology education and sustainability education including outdoor education for promoting sustainability—a literature review
54	Stir J.	2006	Restructuring teacher education for sustainability: student involvement through a "strengths model"
51	Dyment J.E.; Davis J.M.; Nailon D.; Emery S.; Getenet S.; McCrea N.; Hill A.	2014	The impact of professional development on early childhood educators' confidence, understanding and knowledge of education for sustainability
50	García-González E.; Jiménez-Fontana R.; Azcárate P.	2020	Education for sustainability and the sustainable development goals: Pre-service teachers' perceptions and knowledge
49	Tomas L.; Girgenti S.; Jackson C.	2017	Pre-service teachers' attitudes toward education for sustainability and its relevance to their learning: implications for pedagogical practice
48	Cebrián G.; Pubill M.J.	2014	Professional competencies in education for sustainability: An exploratory study of student teachers' views; [Competencias profesionales en educación para la sostenibilidad: Un estudio exploratorio de la visión de futuros maestros]
46	Effeney G.; Davis J.	2013	Education for sustainability: A case study of pre-service primary teachers' knowledge and efficacy
44	Merritt E.; Hale A.; Archambault L.	2019	Changes in pre-service teachers' values, sense of agency, motivation and consumption practices: A case study of an education for sustainability course
39	Alsina Á.; Mulà I.	2019	Advancing towards a transformational professional competence model through reflective learning and sustainability: The case of mathematics teacher education
35	Manasia L.; Ianos M.G.; Chicioreanu T.D.	2020	Pre-service teacher preparedness for fostering education for sustainable development: An empirical analysis of central dimensions of teaching readiness
34	Sureda-Negre J.; Oliver-Trobat M.; Catalan-Fernández A.; Comas-Forgas R.	2014	Environmental education for sustainability in the curriculum of primary teacher training in Spain
34	Andersson K.	2017	Starting the pluralistic tradition of teaching? Effects of education for sustainable development (ESD) on pre-service teachers' views on teaching about sustainable development

32	Karpudewan M.; Ismail Z.H.; Mohamed N.	2009	The integration of green chemistry experiments with sustainable development concepts in pre-service teachers' Curriculum: Experiences from Malaysia
32	O'Gorman L.; Davis J.	2013	Ecological footprinting: Its potential as a tool for change in preservice teacher education
31	Brandt J.-O.; Barth M.; Merritt E.; Hale A.	2021	A matter of connection: The 4 Cs of learning in pre-service teacher education for sustainability

Source: author, 2024

Articles with many citations mean attention. In other words, many scholars are interested in particular topics examined in such documents. Furthermore, such topics are hot or emerging fields of research. Thus, academics who intend to research can seek ideas from the area. Interestingly, several articles were written by a single author, which means there is an open opportunity for collaboration among scholars interested in sustainable education for preservice teachers.

CONCLUSION

This research intends to address a question regarding the trend and opportunity to conduct research in sustainability education for the preservice teacher's area. So, the aim is to provide a comprehensive view of sustainable education in teacher training from 1998-2024. The author conducts a bibliometric analysis of 139 articles from the Scopus database. The main elements contributing to the research issue have been recognized, including the number of writers, affiliation, countries, and source titles as the subject areas with which the articles are associated. The search criteria were determined without a particular time. The document search results show that the earliest publication was found in 1998. Although there is a lack of publications from 2001-2004, the publication trend from 2005-2024 shows a rising trend. Social Sciences and Environmental Science are the main subject areas that contribute to most publications. However, Business, Management and Accounting; Arts and Humanities and Economics, Econometrics and Finance, which are part of social science, only have a few publications, meaning there is still plenty of possible chance to conduct research.

Furthermore, research on education for sustainability in the preservice teacher context is primarily conducted in Australia (20%), Spain (19%) and Turkey (7%). Asian countries have received very little attention for research on such a theme. Thus, research in those territories will provide significant contributions.

This research has several limitations that can be used as the basis for further studies. Firstly, the keywords utilized in this study are described in the prior section of this paper, so further studies that employ different keywords referring to the same terms might result in different publications. Secondly, this study utilizes the VOS viewer and Scopus analysis feature, so future studies can employ other software that can provide extended analysis, such as biblioshiny and Atlas.ti. Thirdly, this research utilizes the Scopus database only, so the following research can employ other databases to capture more data and provide a more comprehensive trend. Lastly, this study only employs a quantitative bibliometric analysis. So, further study can be combined with other methods

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