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# Trends and Networks in Education for Sustainable Development (ESD): A Bibliometric Analysis using Vosviewer

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## ABSTRACT

The incorporation of sustainable development in educational institutions through a variety of strategies and tactics is essential to raise public awareness of the concerns surrounding sustainable development. We refer to this process as education for sustainable development. The findings were visualized using VOSviewer software to show the research areas of concern associated with ESD employing density, network, and density visualization. This study also utilized the Publish or Perish tool in searching literature studies and filtering data from national and international publications in Google Scholar spanning the years 2019–2024. The results show that, despite a reduction in research from 2021–2022, ESD is an emerging trend today. In addition, the density visualization map identifies regions that need more research, especially those from the years 2019–2020 and 2022–2024 especially those with less vivid hues. The key themes from earlier studies were found using the bibliometric approach, which offered insightful information for further exploration in the area of ESD and associated domains.

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## 1. INTRODUCTION

To increase public knowledge on the issues surrounding sustainable development, sustainable development incorporation in the academic sector through several strategies and tactics is necessary. This process is known as education for sustainable development (ESD). This idea has been defined by many researchers as the process of giving students the skills, information, and dispositions needed to make wise choices and live responsible lives that protect the social, economic, and environmental well-being of both the current and future generations (Nousheen *et al*., 2020). Sustainable Development Goals (SDGs) acknowledge the importance of ESD under Goal 4.7. ESD is essential in achieving the SDGs as it empowers individuals to adapt their behaviors and advocate for social, political, and economic transformations. Through ESD, people can attain specific behavioral, socioemotional, and cognitive learning outcomes that assist them in addressing the challenges associated with each SDG (Kioupi & Voulvoulis, 2019).

Furthermore, studies are focusing on ESD conducted in the past years. Several studies show how the integration and application of ESD in the academic sector can provide a constructive impact on student learning outcomes, such as sustainability consciousness and action competence. According to the study conducted by Ssossé *et al*. (2021), the researcher exposed that ESD shows positive effects on students, including improved environmental problem-solving abilities, a re-evaluation of preconceptions, heightened environmental sensitivity, a greater tendency to identify environmental problems as individual concerns, and a relatively sustained adoption of the new, beneficial behaviors. Other research held by several researchers such as Wahyuni *et al*. (2023) and Novianti *et al*. (2023) mainly discussed the development of learning materials tailored to ESD. Although there was a bibliometric study related to ESD steered by Kusumaningrum *et al*. (2023), however, the data was then collected using the Scopus database and Web of Science. In this study, the researchers also stressed the research development on ESD in the previous years.

Additionally, it is indeed that academics have a great opening to advance their study on a particular topic through this concept. As a result, bibliometric analysis is required to identify thorough opportunities for investigating particular themes in any field of study. One tool that may be used to carry out a bibliometric study is through VOSviewer software. This Java-based program allows the creation, visualization, and analysis of bibliometric maps (Bukar *et al*., 2023). Numerous types of bibliometric network data can be analyzed by VOSviewer, including relationships between journal citations and publications, the frequency with which researchers use a particular keyword, associations between scientific terminology, collaborative relationships between researchers, and overlay visualizations that display the number of studies published in a given year (Nandiyanto & Al Husaeni, 2021).

However, following a thorough review of the literature, the researcher discovered that no bibliometric study had focused primarily on research trends in the field of ESD. This finding was made using the mapping analysis feature of the software, which includes network, overlay, and density visualization, along with the Publish or Perish and Mandeley software to filter data from the Google Scholar search engine and VOSviewer software program to highlight the current research topic trends. Due to this, this manuscript aims to conduct a bibliometric analysis focused on the domain of ESD to identify trends in development, highlight hotspots, and assess the topic's current applicability. Subsequent scholars will be able to identify areas that require additional investigation. In addition, this study also aims to aid as a helpful guide for academics to decide on or engage in research initiatives, principally in the field of education.

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This research employed a bibliometric analysis to investigate the developing field of this notion. The introduction, methodology, findings and discussions, and conclusion are the four sections that make up the paper. The necessity of academic research is emphasized in the introduction, along with the significance of incorporating sustainable development into the classroom. The methodology section describes the descriptive quantitative and bibliometric approaches used to gather data from national and international publications. The analysis used software tools, such as VOSviewer 1.60.20, and reference managers, such as Publish or Perish 8.9 and Mendeley, to determine and display trends from a dataset that covered the years 2019 to 2024. The conclusions and debates center on the advancement of research as well as contemporary educational trends, with a special emphasis on sustainable development. The conclusion lists the major discoveries and makes recommendations.

## 2. METHODS

A descriptive quantitative and bibliometric approach was employed in this research. The researcher gathered data from a selection of worldwide and national publications in numerous countries published between 2019 to 2024 in Google Scholar. The data was then collected on the 26$^{th}$ of January 2024. The literature study was conducted using Publish or Perish software version 8.9 and Mendeley program in filtering the data gathered. The researcher also excluded those studies written in languages other than English. The information was saved as a *.ris* file format, compatible with VOSviewer processing tool 1.6.20. The resources were carefully sorted to include relevant research related to ESD. The researcher carefully chose the Google Scholar database and used the keyword "ESD" as required in the title and keyword section; 896 matching data were retrieved. After filtering the data, 63 relevant journals were identified. The researcher then used the VOSviewer program to process and generate visualization data and conduct trend analysis, creating the bibliometric maps. After a careful review of each gathered manuscript, the data is categorized into network, overlay, and density visualization maps. Unrelated terms were excluded and those papers written only in English were included in the VOSviewer mapping interface.

## 3. RESULTS AND DISCUSSION

### 3.1. Education for Sustainable Development Research Development (2019-2024)

**Figure 1** shows how research on "ESD" changed between 2019 and 2024. The result indicates that there was a research development in 2020 with 15 publications, more than the total of 12 articles in 2019. The literature review conducted by the researcher revealed that 2020 has the largest number of publications. Only 11 publications were made in the years 2021–2022, it was a significant decline from the previous year (2021-2022). Fortunately, in 2023 there was a slight increase, with 13 publications overall. The graphic also demonstrates that this year 2024 had the release of just one publication related to ESD.

Given the significance of sustainable development in the field of education and the findings presented in **Figure 1** regarding the theme's research developments, this study indicates that more research concentrating on related disciplines is imperative, particularly to fill in the gaps identified by the studies released in 2021-2022. The top 20 most referenced articles from 20 different journals were also ranked by the researcher (see **Table 1**). These articles, which are listed in **Table 1**, satisfy the research requirements. The findings show that, of the 20 selected articles, a research study by Castellanos & Queiruga-Dios from 2022 has received the greatest number of citations—76—among them. The research study by Didham & Ofei-Manu (2020) with sixty citations comes next. Nevertheless, with just 7 citations, a single paper had the fewest citations overall according to this ranking.

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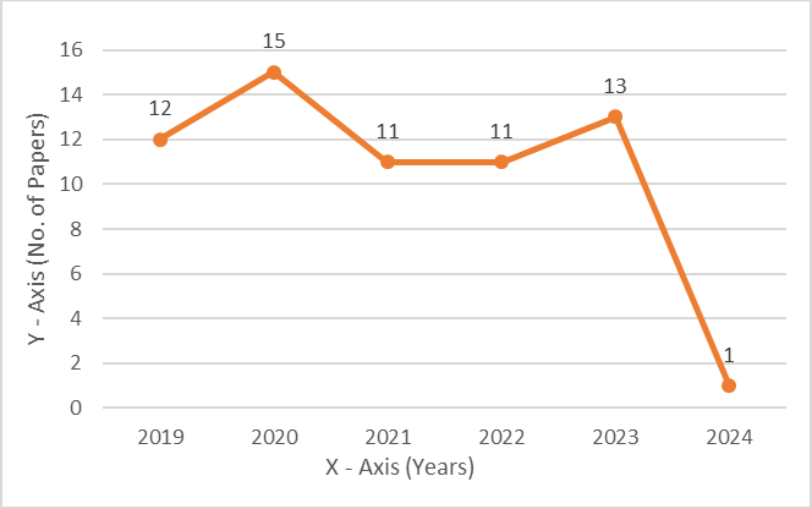


**Figure 1.** Research development on ESD (2019-2024).

**Table 1** additionally demonstrates which published studies on ESD in 2019 received the greatest citations from academics. According to that table, ESD was the subject of nine published publications, the most cited of which had an average of 148 citations. These papers gathered by the researcher primarily examined the self-efficacy and awareness of ESD among pre-service teachers, the competency development related to ESD, the significance of green technology, environmental education, and the integration of ESD into primary school design and technology courses, as well as its frameworks, and, finally, the directions that ESD is heading in the present and in the years to come.

**Table 1.** ESD most cited publications.

| Rank | Authors | Title | Cites | Year |
|---|---|---|---|---|
| 1 | ( Acosta Castellanos & Queiruga-Dios, 2022) | From environmental education to education for sustainable development in higher education: a systematic review | 76 | 2022 |
| 2 | (Didham & Ofei-Manu, 2020) | Adaptive capacity as an educational goal to advance policy for integrating DRR into quality education for sustainable development | 60 | 2020 |
| 3 | (Pegalajar-Palomino *et al.*, 2021) | What does education for sustainable development offer in initial teacher training? A systematic review | 43 | 2021 |
| 4 | (Maidou *et al.*, 2019) | Knowledge, Perceptions and Attitudes on Education for Sustainable Development of Pre-Service Early Childhood Teachers in Greece | 43 | 2019 |
| 5 | (Schank & Rieckmann, 2019) | Socio-economically Substantiated Education for Sustainable Development: Development of Competencies and Value Orientations Between Individual Responsibility and Structural Transformation | 43 | 2019 |
| 6 | (Malandrakis *et al.*, 2019) | An education for sustainable development self-efficacy scale for primary pre-service teachers: Construction and validation | 40 | 2019 |
| 7 | (Gómez-Zermeño, 2020) | Massive open online courses as a digital learning strategy of education for sustainable development | 37 | 2020 |
| 8 | (Tomas *et al.*, 2020) | Education for sustainable development in the senior Earth and Environmental Science syllabus in Queensland, Australia | 17 | 2020 |

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**Table 1 (Continue).** ESD most cited publications.

| Rank | Authors | Title | Cites | Year |
|---|---|---|---|---|
| 9 | (Jasmi *et al*., 2019) | Importance of green technology, Education for Sustainable Development (ESD) and environmental education for students and society | 15 | 2019 |
| 10 | (Oe *et al*., 2022) | A Qualitative Assessment of Community Learning Initiatives for Environmental Awareness and Behaviour Change: Applying UNESCO Education for Sustainable Development (ESD) Framework | 14 | 2022 |
| 11 | (Tetiana & Malolitneva, 2020) | Conceptual and legal framework for promotion of education for sustainable development: Case study for Ukraine | 13 | 2020 |
| 12 | (Ferguson *et al*., 2022) | Education for sustainable development (ESD) infusion into curricula: influences on students' understandings of sustainable development and ESD | 11 | 2022 |
| 13 | (Rosman *et al*., 2019) | The integration of Education for Sustainable Development (ESD) in design and technology subject: through teacher's perspective | 11 | 2019 |
| 14 | (Tekbiyik & Celik, 2019) | Education for sustainable development in primary school: improvement of students' ecocriticism skills | 11 | 2019 |
| 15 | (Sepetis *et al*., 2020) | Education for the sustainable development and corporate social responsibility in higher education institutions (HEIs): Evidence from Greece | 10 | 2020 |
| 16 | (Sulphey, 2019) | The present and future of education for sustainable development: a fact sheet | 10 | 2019 |
| 17 | (Androshchuk *et al*., 2020) | Building the Content of Teacher Training in the Context of Education for Sustainable Development | 9 | 2020 |
| 18 | (Satrianawati & Fu, 2019) | Education for sustainable development (ESD) in Indonesia: A Conceptual framework | 9 | 2019 |
| 19 | (Jodoin & Singer, 2019) | A Framework for Integrating Education for Sustainable Development in the English as a Foreign Language Classroom in Japan: An Appeal to the Language Teaching Community | 9 | 2019 |
| 20 | (Sung & Choi, 2022) | The Challenging and Transformative Implications of Education for Sustainable Development: A Case Study in South Korea | 7 | 2022 |

### 3.2. Education for Sustainable Development Research Topic Visualization

When presenting the data in the VOSviewer software application, the minimum number of occurrences in this research was in two terms. As a result, 62 threshold items were discovered. The visualization mapping study of the research on ESD revealed eight groups. The following are these clusters:

**(i)** **Cluster 1**: There are 11 items including competence, decade, development, higher education, knowledge, opportunity, skill, sustainable future, systematic review, training, and value (see **Figure 2**). However, there are no conducted studies that showed a direct relationship between the term “ESD” to the key term “decade” under cluster one.

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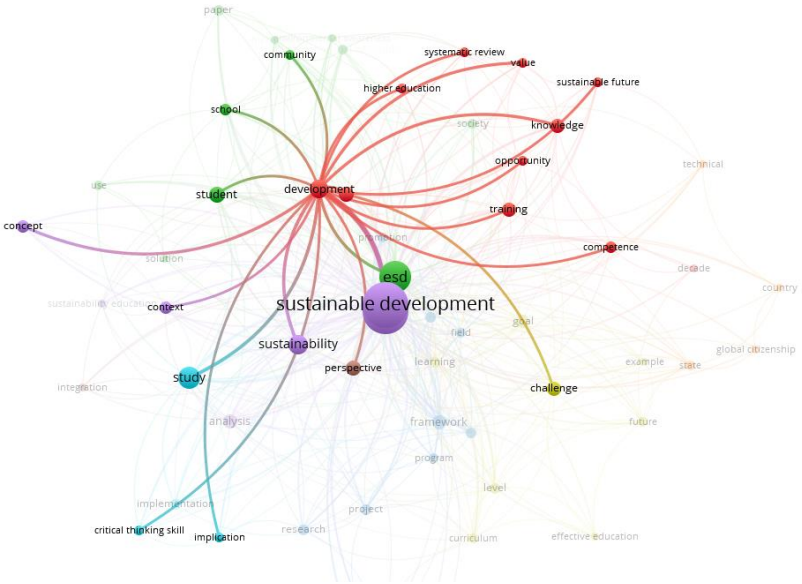


**Figure 2.** Research topics under cluster 1.

**(ii)** **Cluster 2***:* There are 11 items including the following: community, environmental awareness, environmental education, ESD, importance, paper, school, society, solution, student, and use (see **Figure 3**).

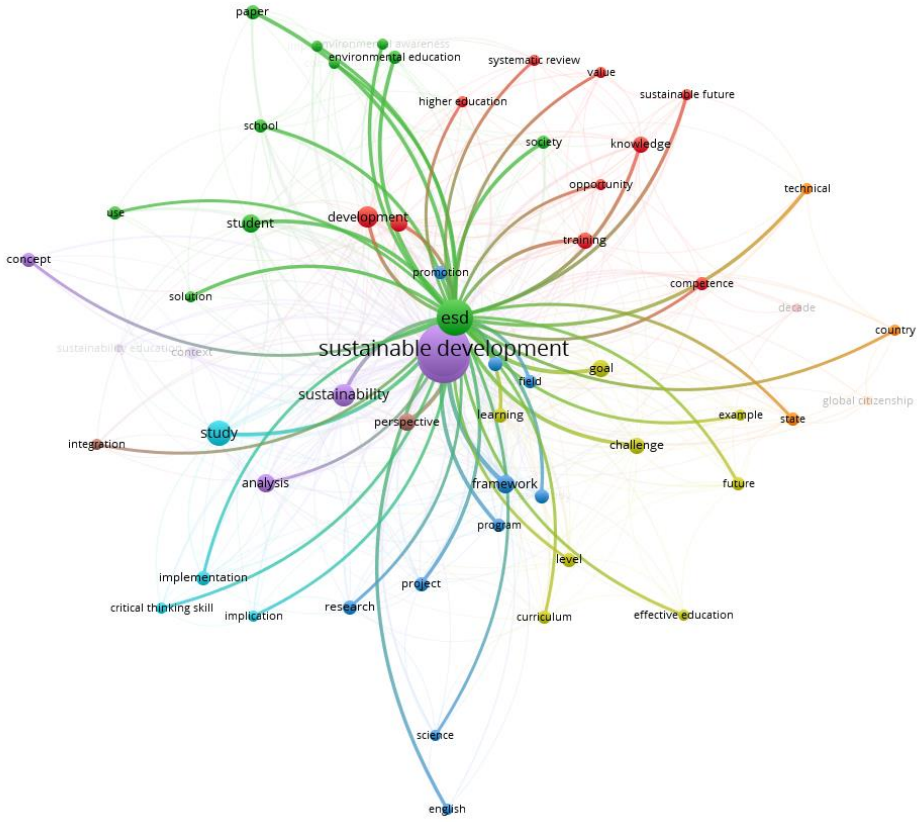


**Figure 3.** Research topics under cluster 2.

**(iii)** **Cluster 3**: There are 10 items depicted in this cluster and these are: approach, case study, English, field, framework, program, project, promotion, research, and science (see **Figure 4**).

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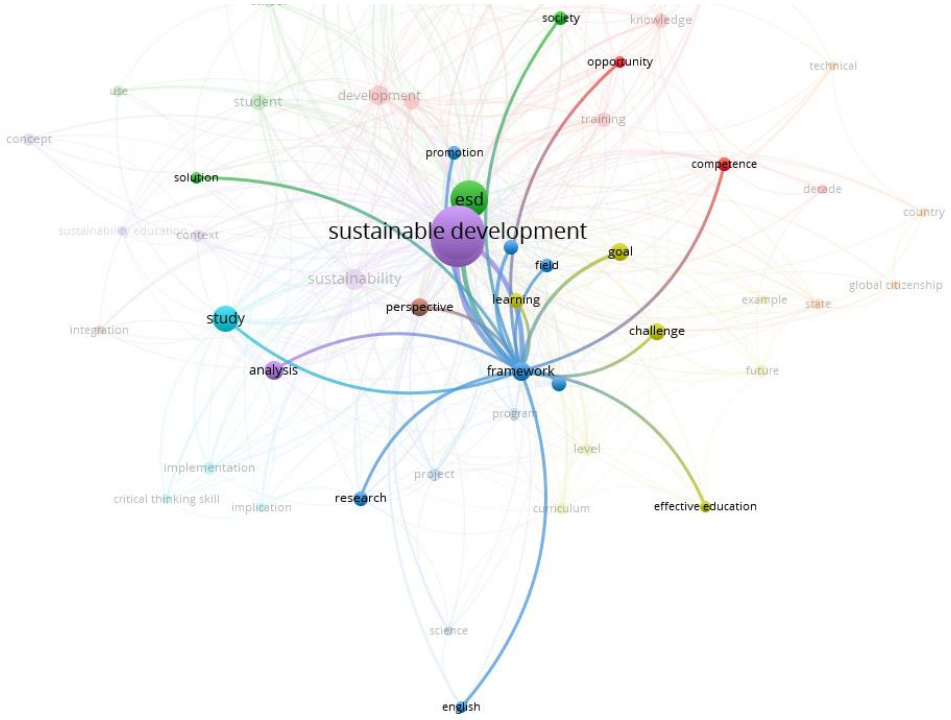


**Figure 4.** Research topics under cluster 3.

**(iv)** **Cluster 4**: There are 8 items depicted in this cluster and these are: challenge, curriculum, effective education, example, future, goal, learning, and level (see **Figure 5**).

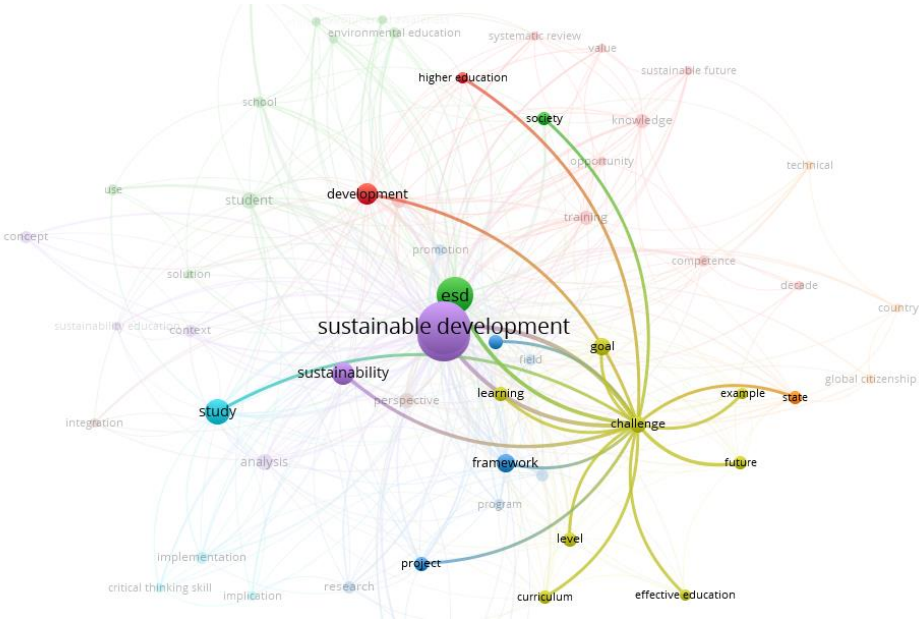


**Figure 5.** Research topics under cluster 4.

**(v)** **Cluster 5:** There are 7 items depicted in this cluster and these are: analysis, concept, context, education, sustainability, sustainability education, and sustainable development (see **Figure 6**). In this cluster, it shows that the majority of the topics have no studies showing a direct connection to Sustainable Development and Education, however, these research topics have an indirect connection through the key term sustainability.

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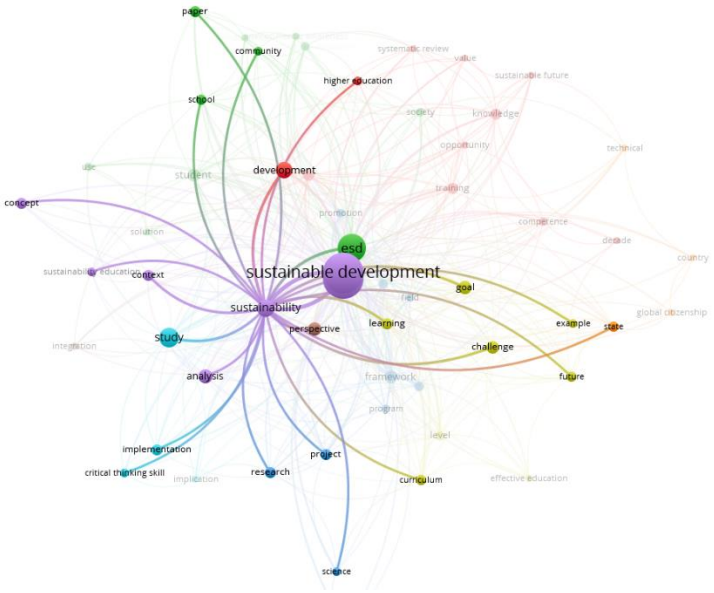


**Figure 6.** Research topics under cluster 5.

**(vi)** **Cluster 6:** There are 4 items in this cluster and these are: critical thinking skill, implementation, implication, and study (see **Figure 7**).

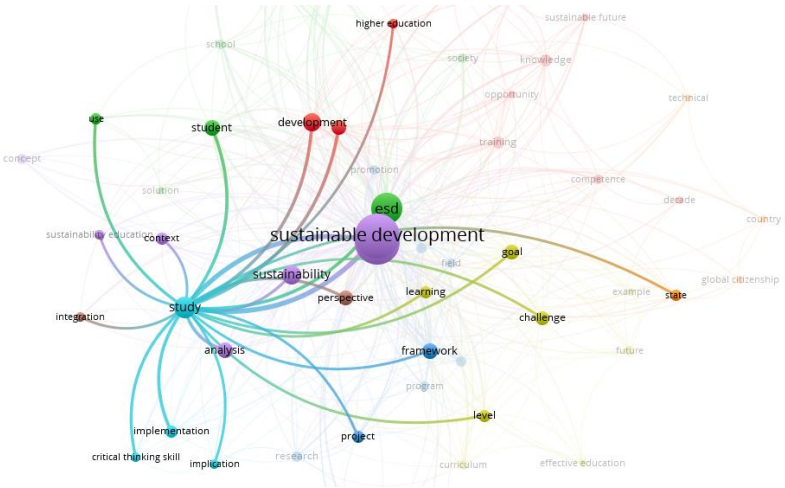


**Figure 7.** Research topics under cluster 6.

**(vii)** **Cluster 7**: There are also 4 items in this cluster and these are: country, global citizenship, state, and technical (see **Figure 8**). There are no studies conducted showing a direct relationship between the terms global citizenship and ESD.

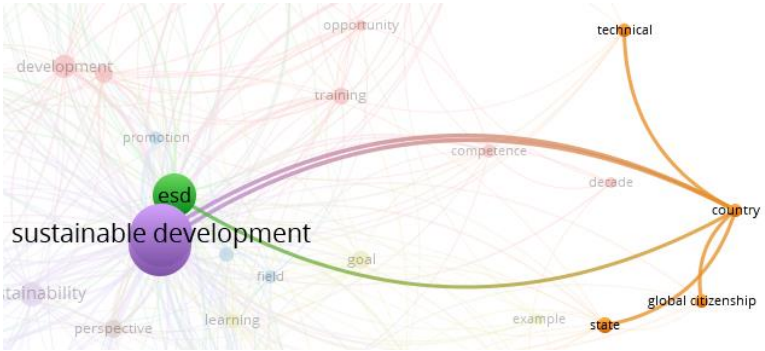


**Figure 8.** Research topics under cluster 7.

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**(viii) Cluster 8**: In this cluster, there are only 2 items which include integration and perspective (see **Figure 9**). One of the keywords shows a strong connection to “ESD”, ”education,” and “sustainable development”.

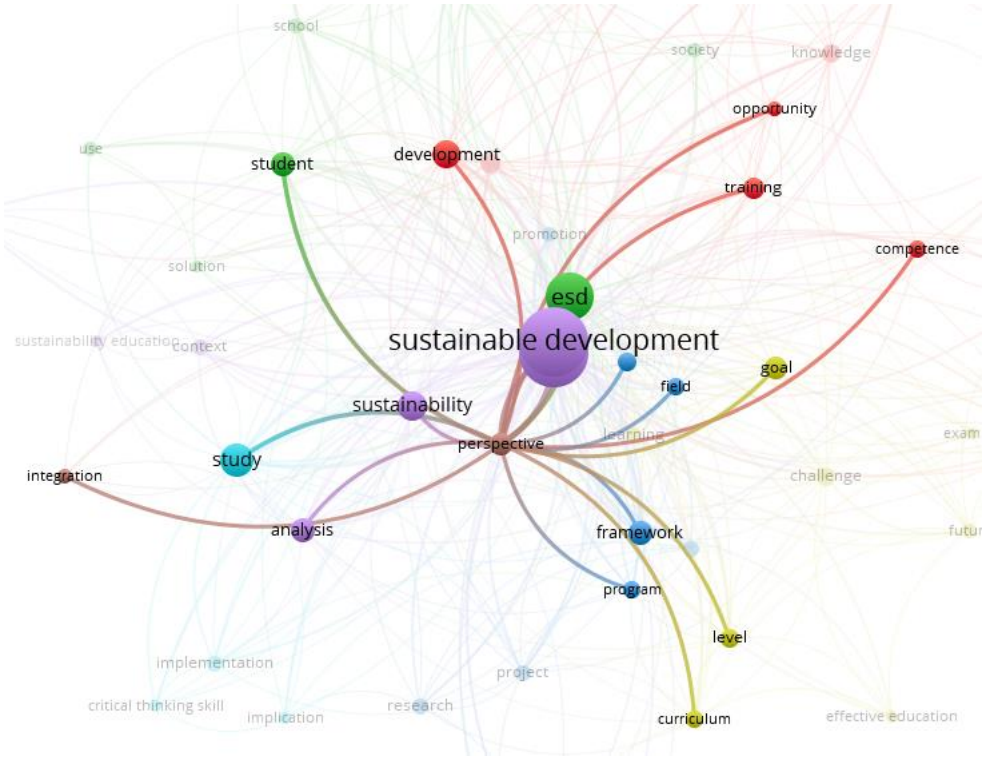


**Figure 9.** Research topics under cluster 8.

Additionally, the color red is associated with cluster 1, green color as second, royal blue shade as third, yellow shade as fourth, purple shade for the fifth cluster, light blue color for cluster 6, color orange for the seventh cluster, and brown with the eighth cluster.

### 3.3. Education for Sustainable Development Research Topic Network Visualization

Visualization Networks is one of the categories under which mapping is separated in this software. This category describes how keywords relate to one another on a map. The visualization network's strength of relationships is indicated by thick lines that connect sentences. **Figure 10** shows the association between the terms "education" and "sustainable development" on the VOSviewer application's Network Visualization map. **Figure 10** provides an example of every group in the examined topic areas. In cluster 1, the phrase "education for Sustainable Development" appears, as **Figure 10** shows. But it's written "ESD" instead. The terms "ESD" and "Sustainability Education" are evidence of how researchers used these keywords differently. clusters 2 and 5 also contain instances of it. Alternatively, the terms "education" and "sustainable development" are also examples of how researchers used the term separately in the research title or the keyword section.

Furthermore, under cluster 1, there are 154 total link strengths and 29 total occurrences for the keyword "ESD." However, the word "sustainability education" which also represents the theme only has two total occurrences and a total link strength of 10. This suggests that not many studies have been done on this important term. Moreover, nearly every cluster is associated with the "ESD" term, as Figure 10 illustrates. This emphasizes how important it is for upcoming scholars to look into the relationships between these important words in more detail.

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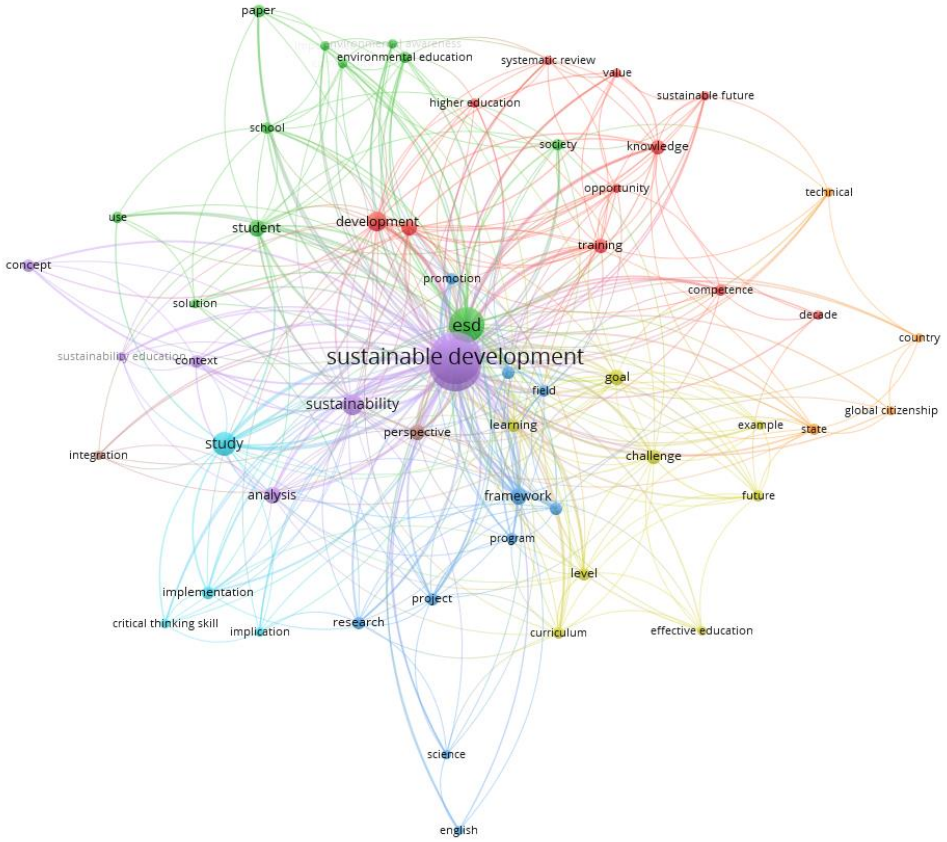


**Figure 10.** ESD research topic network visualization.

### 3.4. ESD Research Topic Overlay Visualization

Overlay mapping representation, which emphasizes a term's uniqueness within the research, is another feature provided by software. **Figure 11** shows a contemporary topic of research on ESD. Using the overlay visualization mapping, one may track a keyword's popularity over time. The overlay visualization mapping's various colors represent how frequently each term appears during a given period. The years 2019 through 2024 were employed in this analysis. The color of a keyword used in several studies which grows closer to a dark violet tone was finished nearly year 2019. Nevertheless, if a keyword's hue is approaching yellow, it signifies the investigation was completed within the last year.

Additionally, this figure demonstrates that the majority of research on several popular subjects, such as "education," "sustainable development," and "ESD," was completed in 2021. The theme "ESD" is associated with a limited number of studies that cover a wide range of topics. These include higher education, student development, training, challenges, states, programs, projects, frameworks, learning, implementation, opportunities, significance, value, environmental education, concepts, and sustainability education.

Moreover, this overlay also shows the popularity of the following keywords "education," "sustainable development," and "ESD". Concerning these keywords, "study," "sustainability," "development," "framework," and “student” are the other frequently searched terms. The image aptly illustrates the robust connections among "esd," education, sustainable development, and other related subjects. There is a strong relationship between "ESD," “education,” and “sustainable development” and key terms like "development," "student," "knowledge," “training,” “perspective,” "study," and "sustainability." The relationships between the phrases and the study dates are shown in **Figure 11** as overlay mapping.

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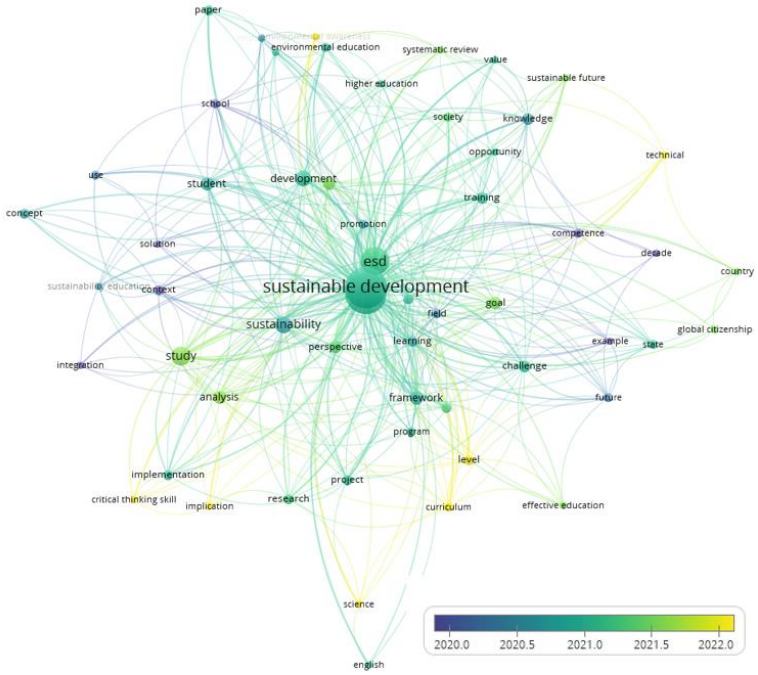


**Figure 11.** ESD research topic overlay visualization.

### 3.5. ESD Research Topic Overlay Visualization

Another sort of mapping that can be done using the VOSviewer program is called density visualization. The frequency of each term in the research will determine its category in this section. The Density Visualization for the research topic ESD is shown in **Figure 12**. Each topic's color designates how frequently a particular key term appears in the study. A lighter tint indicates a growing prevalence or usage of the term among scholars. On the other hand, if the hue is fainter or less vivid, it suggests that there has been less research done on that particular term from 2019 to 2023. Consequently, more research is needed on the subjects shown in **Figure 12** darker regions.

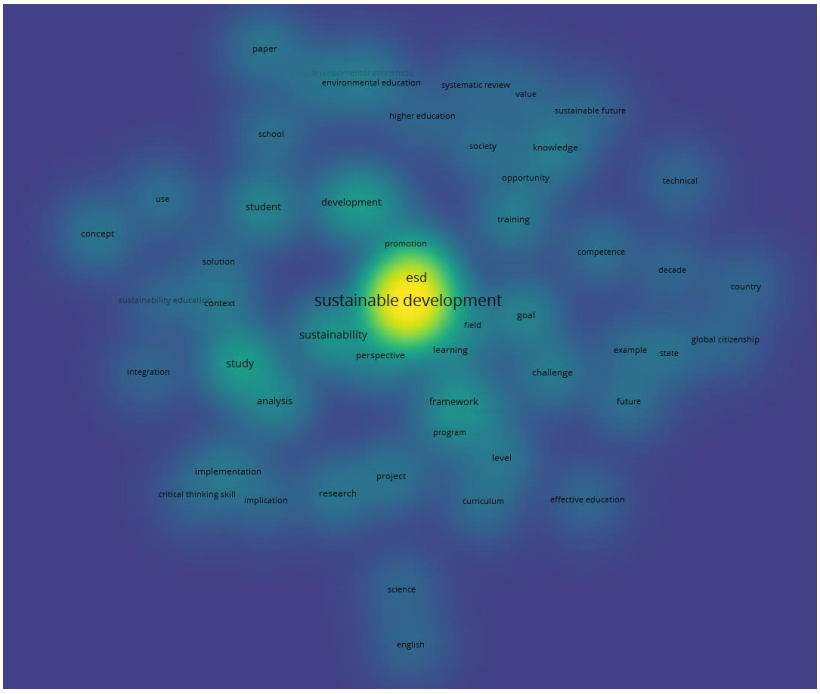


**Figure 12.** ESD research topic density visualization.

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Furthermore, **Figure 12** displays colored words with a notable diameter. These terms have something to do with ESD, and how often these terms are utilized in various papers. Figure 12 implies that the research topics "Sustainable Development", and the keyword "education" behind the terms "sustainable development" and "esd" were commonly used in earlier research investigations. The map shows yellow patterns, where a circle's diameter increases in proportion to how frequently a keyword appears. While the yellow hues merge or vanish into the blue expanse, it only indicates that the term occurs with decreasing regularity and it requires further research. The aforementioned discovery highlights the value of the bibliometric evaluation in highlighting current research, especially in terms of novelty, which can indicate areas requiring additional investigation.

### 3.6. Trends and Networks in ESD Research

The research landscape and current developments in ESD research are examined in this paper. It investigates the connections and trends between various topics linked to ESD through the use of bibliometric mapping analysis features such as the network, overlay, and Density visualization. The goal of this paper is to provide insights into the development, difficulties, and potential areas for further exploration in the multidisciplinary domain of ESD employing looking at research patterns in it. The visual representation of research themes from 2019 to 2024 highlights the significance of incorporating sustainable development into education. It also showcases the importance of continuing scholarly inquiry to foster sustainable development practices in the academic setting. This method provides an opportunity to uncover emerging trends and an in-depth review of the present condition of ESD Research (Donthu *et al*., 2021; Al Husaeni & Munir, 2023). Further, according to the data shown in **Figure 1**, there was a notable surge in research on ESD in 2020. However, there was also a subsequent downturn in the following years, especially in research that concentrated on other aspects of education and sustainable development. This fall asks the query of how ESD research was prioritized and supported during this particular time, considering the decline in 2020-2021 and 2024. Several researchers also have noticed the lack of empirical studies focusing on the development outcomes of the field and its effectiveness in the academic setting (Kioupi & Voulvoulis, 2019; Saqib *et al*., 2020). This can be attributed to the existing issues frequently observed from various ESD research, particularly the lack of precision regarding its position against consumer society (Acosta Castellanos & Queiruga-Dios, 2022).

Furthermore, the categorization of key terms using clusters was employed which can be viewed in **Figure 10** to determine the associated research topics involved in the domain of ESD. Research trends in this study were identified with the presence of clusters, nodes, and lines to determine their relationship, similarities, key concepts, and their connection in the research domain. Each node in this mapping has a size corresponding to how frequently the keyword it represents occurs. While the thickness of the connecting lines and the distance between the nodes determine the strength of co-occurrence between keyword pairs. As mentioned by Gao *et al*. (2021), keyword clusters are groups of related terms that appear frequently together and can be thought of as large areas for future research in each of the fields represented by the color of the nodes.

In this research, key terms such as sustainable development and education under cluster 5 were identified as the most frequently occurring research terms. This means that both of these key terms show the importance and relationship between one another. This is evident based on the number of published studies that revealed the necessity of embracing sustainable development practices in academic society (Violanda *et al*., 2023). Another

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frequently used keyword is "ESD". Several researchers showed curiosity in this field, ESD by expressing different abbreviated terms. Researchers like Alicamen (2023) mentioned that understanding sustainability is crucial for developing efficacious pedagogies that include ESD themes in diverse learning domains. This can also be attested based on the result shown in cluster 1, which consists of the following keywords: development, competence, training, knowledge, and higher education. However, challenges are being reported particularly on the limited number of studies being conducted focusing on ESD (Alicamen, 2023). As revealed from the study steered by Violanda *et al*. (2023), one of the issues encountered by several academic institutions is the lack of knowledge on sustainability. This can be attributed to the reported cases of scarcity of various information, concerning ESD, in the academic setting (Alicamen, 2023). Funa *et al*. (2022) stressed that several secondary teachers were having some challenges expressing their knowledge and attitude toward ESD due to a lack of opportunities and difficulty manifesting qualities into behavior.

Other keywords that are connected to "ESD" categorized under cluster 2 are environmental Education, environmental awareness, ESD, student, school, and community. These terminologies play a vital role in realizing the concept. According to Rogayan & Nebrida (2019), environmental education is a procedure that aims to generate a global population that is committed to solving existing environmental problems and reducing the wild development of new ones, and individuals that are fully knowledgeable and anxious about the environment as a whole and the issues that are associated with it. The researcher also added that the school should serve as the learning habitat of the students and mold them to become an environmental advocate. Punzalan *et al*. (2019) established that environmental education is emerging as an important approach that can be very helpful in mitigating and preventing environmental injustices in the schools or the community both present and in the future. Other researchers (Dolenc Orbanić & Kovač, 2021; Wilujeng *et al*., 2019) stressed that effective education with the presence of an ESD framework can help students build their knowledge, attitudes, values, and environmental awareness and equip them with the skills necessary to work together to take responsible environmental action and foster positive environmental behavior. This can also be seen under clusters 3 and 4 showing significant terms such as approach and effective education.

Cluster 5 also fits ESD. Several researchers used other terminologies or concepts like that of "sustainability education" to address several issues of "ESD" and to investigate its current state. As cited by Sinakou *et al*. (2018), the researcher highlighted that sustainability is a significant prerequisite for cultivating educators' ESD skills. However, Nousheen *et al*. (2020) exposed in the study that research scholars were not well-versed in the concepts of sustainability and ESD according to empirical data. This can be ascribed to many external causes, including inadequate incentives and collaboration, a crowded curriculum, problems with governance, and regulations that are not appropriate or that hinder institutional integration of sustainability education. In addition, several studies also revealed that there is a growing concern over the absence of ESD implementation as an area of study in various countries' higher education systems (Franco *et al*., 2019). However, according to the research led by Kalsoom & Qureshi (2019) concerning the application of the ESD concept in teacher education programs, they made it clear that international initiatives such as the call for the incorporation of Sustainable Development in the academic system do not necessarily influence other entity to fully implement the concept.

Moreover, an overlay visualization map is used in this paper to analyze the distinctiveness and popularity of key terms in research By looking at the number of occurrences of a particular keyword and year in which these research topics appear at a given time (Huang *et*

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*al*., 2020), the research topic is characterized by the node shape, and the average time of each important year determines the node's color. For instance, the article keyword used, such as "Sustainable Development," has a total of 65 occurrences in various research. Based on the shade of the node, these studies were published around the year 2021, similar to the term "Education," which occurred 64 times. The phrase "ESD," which stands for "ESD", is the most prevalent term after these terms, "education and sustainable development" appearing 30 times. It is noteworthy that these publications were released in the same year. For those key terms that have a high influence in the field, the node has a larger area. If the research has a multidisciplinary background or the research field has interdisciplinary attributes, the node connects to two or more nodes. Additionally, **Figure 11** reveals that the following keywords, such as "level," "curriculum," "implication," "technical," "science," "critical thinking skills," and "environmental awareness," were published in the recent year 2022. Based on its diameter shown in **Figure 11**, it shows that these important key terms have a limited number of published research focusing on the area of ESD. This encourages future scholars to explore this field. Several scholars expressed their awareness of ESD by tapping into the cognitive aspect. According to the study by Sobari *et al*. (2022), the ability to think critically is an essential skill for overcoming the difficulties of 21st-century living, considering the prevalent number of environmental issues.

Density visualization, on the other hand, portrays the regularity of research topics used by scholars in the field. The key terms "education" and "sustainable development" were repeatedly used in research based on the result of the researcher's analysis. This is evident in the number of published studies shown in **Table 1**. Various researchers debated the implications of both "education and sustainable development". It is argued that there is a complex and vital interaction between sustainable development and education to achieve continuing societal and environmental goals (Belke *et al*., 2020). Therefore, it is widely believed that education leads to progress. Funding education is believed to yield favorable results in various development-related areas, such as social advancement, economic expansion, and environmental preservation. Further study is needed for the research domains, as these topics depict limited influence in the research field. This is evident in the study conducted by Venezia & Pizzutilo (2022); Venezia and Pizzutilo stated that there is a lack of studies on the efficacy and several factors causing the scarcity on the availability of information and instructional material designed for ESD.

## 4. CONCLUSION

Examining the literature on ESD using Bibliometric tools is the goal of this study. The term "ESD" was used to gather data, and the inclusion of this topic in the title, abstract, and keyword parts of the publications was taken into account. Only 63 papers out of 896 were determined to be extremely pertinent to the topic. The data was visually represented using maps, such as overlay, network, and density maps, using VOSviewer software. The results show that, despite a reduction in research from 2021–2022, ESD is indeed relevant nowadays, especially in examining its effectiveness in the academic setting. The analysis also shows that the number of research articles that have been lately examined by different experts that center on ESD is just 7. These topics include level, curriculum, implication, technical, science, critical thinking skills, and environmental awareness. In addition, the density visualization map identifies regions that need more exploration, especially those research topics from clusters 1, 3, 4, 6, 7, and 8. These research topics have less vivid hues based on the figure shown above. It means that these emerging research topics are applicable to be used for future research. The key themes from earlier studies were found using bibliometric tools,

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which offered insightful information for further investigation in the area of ESD and associated domains.

## 5. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirmed that the paper was free of plagiarism.

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