



Mapping on Education for Sustainable Development in Science Education Research

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Abstract. Through bibliometric analysis, this research evaluates the most relevant themes related to Education for Sustainable Development (ESD). Data search used the keyword "Education for sustainable development in Science Learning" in the Scopus database. Visualize author, country, and keyword networks using VOSviewer. Analysis carried out on May 1, 2023, succeeded in detecting 777 documents from 2019 to 2023. Research results In the last four-year period (2019-2023), the number of publications regarding education for sustainable development has grown periodically. The United States is widely recognized as a leading country in terms of productivity in publishing educational documents related to sustainable development. Next, Spain, England, China, Germany, Indonesia, the Russian Federation, Italy, Poland, and Australia followed. The field of study under consideration is characterized by a list of the ten most prominent sources. These sources include Sustainability Switzerland, E3s Web Of Conferences, etc. Keyword analysis shows that recent research on Education for Sustainable Development mainly focuses on topics related to sustainable development goals, students, ESD, curriculum, educational computing, learning systems, implementation science, and human factors

Keywords: bibliometric analysis, science education, education for sustainable development

1 Introduction

The concept of ESD includes a holistic educational approach, which includes educational content, learning outcomes, pedagogy, and learning environment [1–3]. Sustainable development is defined as ensuring that development efficiently fulfills present demands while leaving chances for future generations to meet their requirements [4], [5]. This paradigm emphasizes the importance of implementing educational programs to maintain global survival [6], [7].

ESD encompasses a wide range of educational efforts that seek to foster personal and social values in students, enabling them to acquire essential competencies necessary for the sustainable preservation of life and the environment. The initial stage of

the sustainable development process involves community, economic, and regional development as key components [8], [9]. ESD is a strategic approach that can be used to effectively achieve the Sustainable Development Goals (SDGs) through educational initiatives. Education is obligated to develop appropriate values and competencies to facilitate sustainable development and equip individuals to face and overcome the complexities of the 21st century effectively. ESD not only promotes the integration of sustainable development principles and SDGs into educational practices and programs but also ensures that educational practices and programs are integrated into every effort that advances sustainable development and the SDGs [10], [11].

Within the framework of this bibliometric investigation, a systematic search was carried out to obtain a comprehensive understanding of the body of knowledge related to ESD. In ESD, the aim is to examine the origins of publications, countries, authors, and topics that receive the most citations. This study presents significant findings related to recent advances in research focused on ESD. This research will analyze data related to the number of publications, top ten authors, top ten sources, and keywords on the topic of ESD.

2 Method

This study uses bibliometric analysis [12]. The investigation was conducted using the Scopus database, using the keyword ESD. The search results were carried out on May 1, 2023, and produced a total of 2,492 documents. The identification process occurs at this stage. Next, a limitation was carried out to obtain 777 documents covering the 2019-2023* period. Sources available for this research include 617 articles, 150 conference papers, five book chapters, and five books. VOSviewer software is used to facilitate the export and import of relevant documents. The stages carried out in this research are shown in Figure 1.

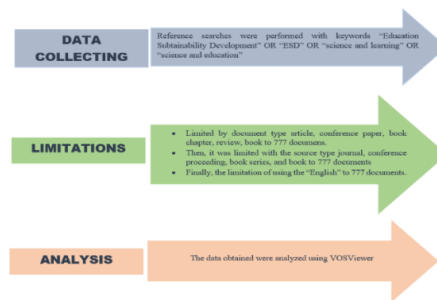


Fig. 1. Stages of bibliometric analysis of ESD.

3 Result and Discussion

Number of ESD Publications

Figure 2. displays the annual number of publications for the last five years (2019-2023*).

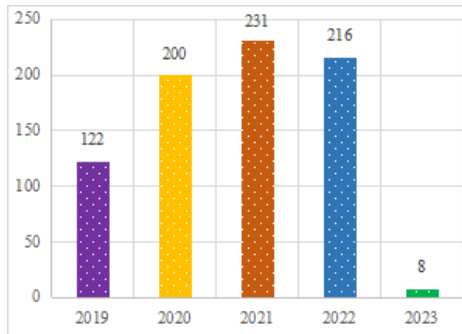


Fig. 2. Documents per Year about ESD.

According to Figure 2, the number of documents related to ESD has been analyzed over five years using the Scopus database. According to data, the number of documents from 2019 to 2021 increased. Although there is a decrease in 2022, the number of publications is still relatively large. According to projections made by researchers, the number of document publications is expected to increase in 2023. This is in line with research on critical thinking skills [13], STEM [14], etc., which also experiences an increase in publications every year.

Top Countries in the Field of ESD

Visualizing about productive countries in ESD, as shown in Figure 3.

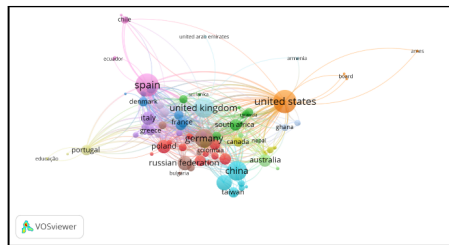


Fig. 3. Documents per Year about ESD.

Figure 3 shows that the US has the highest productivity level in publishing ESD-related documents, specifically a total of 100 documents. Spain achieved the second highest position, then the United Kingdom took third place. Many researchers from the US who researched ESD include Wissinger [15], Lopesko [16], Skowronek [17], etc.

Top Authors in the Field of ESD

Figure 4 reveals the large number of documents and citations for the ten most influential authors in ESD.

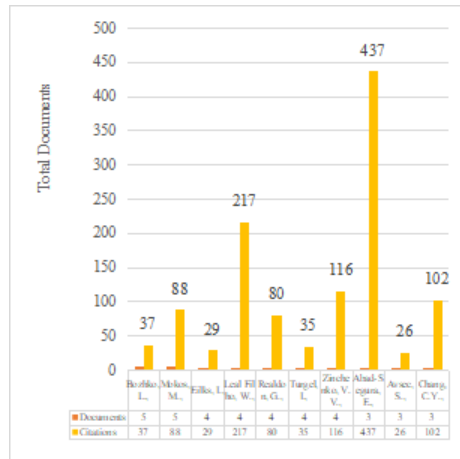


Fig. 4. 10 Influential authors based on total documents and citations.

Figure 4, it can be seen that the highest number of citations was obtained by Abad-Segura E., from the University of Almeria, Spain. This study analyzed the main trends in global research on the sustainable management of Digital Transformation (DT) in Higher Education (HE) (period 1986-2019) [18]. This was followed by Leal Filho W., who had the second-highest number of citations from Hamburg University, Hamburg, Germany. This research is about The implementation of sustainable development in HE [19].

The third most citations are from the author Zinchenko VV, from the Institute of Higher Education of the National Academy of Educational Sciences of Ukraine. This study about Sustainable community development has an impact on national models as well as global development paradigms [20]. Bozhko L., [21–23] and Mokos M. [24], have the most published documents.

ESD Top Sources

Below are ten sources from journals and proceedings that publish many articles about ESD, shown in Figure 5.

Figure 5 illustrates that the main origins of most articles are in scientific journals with quartile 1. Sustainability Switzerland is listed as a journal with quartile 1, which has published 208 articles on ESD. Many researchers who published their ESD articles in Sustainability Switzerland include Abad-Segura [18], Zamora-Polo [25], Sonetti [26], etc.

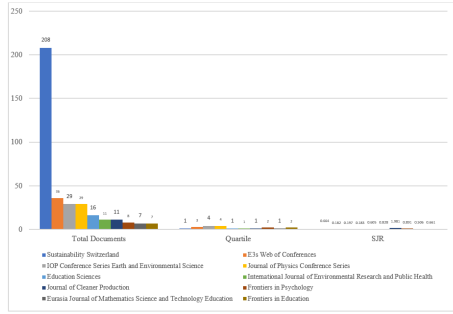


Fig. 5. Source of publication of ESD.

Main Publications and Research Interests Based on Keywords

Figure 6 displays the results of the co-occurrence analysis, specifically highlighting the key publications and research interests derived from the authors’ chosen keywords. The ESD keywords identified in Figure 6 have been categorized into three groups. The initial cluster is visually marked in red, with the prominent keyword being sustainable development goals, which also serves as the main focal point. The initial cluster denoted in red shows the correlation between sustainable development goals, students, ESD, and curriculum. The SDGs concept refers to global goals addressing various social, economic, and environmental challenges. The SDGs’ main principle is to ensure inclusivity and equality, not allowing individuals or groups to be marginalized or excluded from the development process. The ability of the SDGs to address two fundamental questions is critical. First, procedural justice relates to the level of inclusivity in the overall development process, particularly ensuring marginalized groups’ active involvement. Second, substantive justice concerns the effectiveness of policies and plans in overcoming related problems and providing satisfactory solutions [27–29]. SDGs include the integration of three fundamental pillars: environment, economy, and social environment. Ideally, reorientation efforts in education should be based on the context of local and national sustainability goals. To increase the alignment of education with local and national contexts, it is very important to consider reorienting educational practices [30–32].

The prominent term in cluster 2 is educational computing. The integration of educational technology has significantly impacted traditional teaching roles, leading to new responsibilities for educators, including resource management and learning management. The use of information and communication technology in the education sector can produce several benefits, such as improving the quality of learning by improving the delivery of teaching and learning materials, encouraging educators’ professional growth through continuous development opportunities, etc [33]. Information and communication technology can accelerate the achievement of the 4th SDGs, especially in improving educational standards [34], [35].

In cluster 3, sentences are symbolized in blue, especially those related to humans, which link the concepts of ESD and SDGs. To address education challenges in In-

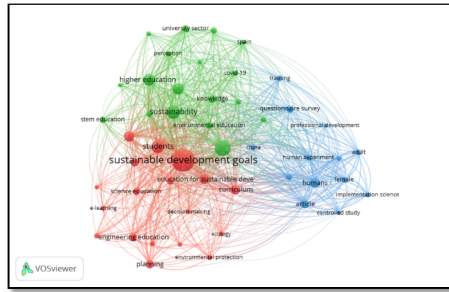


Fig. 6. ESD Network Visualization based on Co-occurrence Analysis

Indonesia effectively and in line with SDG goals and strategies, Indonesia must prioritize certain aspects in implementing its education system. The goals outlined in Global Goal 4 relate to providing comprehensive, equitable, and inclusive education and facilitating lifelong learning opportunities for all individuals [36], [37]. Various regions have made various efforts to achieve the SDGs strategy to improve the quality of education in Indonesia [38–41] especially target 4. These targets include (1) building and improving safe educational facilities for children; (2) improving the quality of teachers and educational resources that support the teaching and learning process; (3) expanding special education services; and (4) prioritizing and strengthening character education. The results of overlay visualization about the ESD topic are shown in Figure 7.

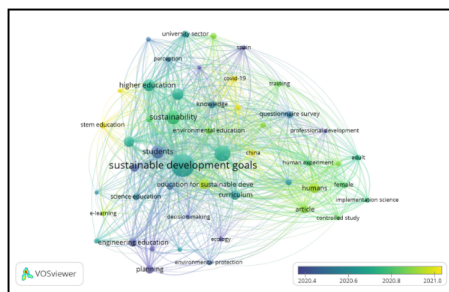


Fig. 7. Overlay Visualization of ESD based on Co-occurrence analysis

According to Figure 7, there has been a significant emphasis on ESD and articles in STEM education over the past two years. Apart from that, it is also closely related to higher education and Covid-19. Martín-Sánchez [42] researched the implementation of Service Learning methodology as an ESD strategy in general science courses. Apart from that, Vilmala [43] discusses Prospective science teacher students' perspectives on STEM education related to ESD. These two research results link ESD and STEM in higher education.

4 Conclusion

Over the last four years (2019-2023), there has been consistent growth in the quantity of publications related to ESD. The majority of influential writers in the field of ESD come from Europe. The United States is widely recognized as the leading country in productivity, publishing ESD articles. Most sources that publish articles about ESD come from journals with quartile 1. Keyword analysis shows that recent research on ESD mainly focuses on topics related to SDGs, students, curriculum, educational computing, learning systems, implementation science, and human factors.

References

1. S. Nurlailah, G. Hamdu, *Ideas Journal of Education, Social, and Culture* **7**, 309 (2021)
2. E. Sinakou, V. Donche, J. Boeve-de Pauw, P. Petegem, *Sustainability* **11**, 5994 (2019). DOI 10.3390/su11215994
3. Q. Ssosse, J. Wagner, C. Hopper, *Sustainability* **13**, 2854 (2021). DOI 10.3390/su13052854
4. H. Ghany, *Madaniyah* **8**, 186 (2018)
5. J. Mensah, *Cogent Social Sciences* **5**, 1653531 (2019). DOI 10.1080/23311886.2019.1653531
6. T. Setyaningrum, G. Gunansyah, *Jurnal Penelitian Pendidikan Guru Sekolah Dasar* **8** (2020)
7. H. Koprina, *Environmental Education Research* **18**, 699 (2012). DOI 10.1080/13504622.2011.634707
8. N. Nofriyandi, D. Andrian, L. Effendi, F. Firdaus, R. Ariawan, R. Qudsi, M. Indriani, *Community Education Engagement Journal* **2**, 21 (2021)
9. M. Manioudis, A. Angelakis, *Sustainability* **15**, 7681 (2023). DOI 10.3390/su15107681
10. S. Purnamasari, F.A.F. Suhendi, N.L.N. Zulfah, *Jurnal Kajian Pendidikan IPA* **2**, 105 (2022)
11. S. Purnamasari, A.N. Hanifah, *JKPI Jurnal Kajian Pendidikan IPA* **1**, 53 (2021)
12. I. Zupic, T. Čater, *Organizational Research Methods* **18**, 429 (2015). DOI 10.1177/1094428114562629
13. M. Misbah, I. Hamidah, S. Sriyati, A. Samsudin, *Journal of Engineering Science and Technology* **17**, 118 (2022)
14. C.T. Ha, T.T.P. Thao, N.T. Trung, N. Dinh, T. Trung, *Eurasia Journal of Mathematics, Science and Technology Education* **16**, 1889 (2020). DOI 10.29333/ejmste/8659
15. J.E. Wissinger, A. Visa, B.B. Saha, S.A. Matlin, P.G. Mahaffy, K. Kümmerer, S. Cornell, *Journal of Chemical Education* **98**, 1061 (2021). DOI 10.1021/acs.jchemed.0c00841
16. E.I. Szczepankiewicz, J. Fazlagić, W. Loopesko, *Sustainability* **13**, 1241 (2021). DOI 10.3390/su13031241
17. M. Skowronek, M. Gilberti, R. M. and Petro, C. Sancomb, S. Maddern, J. Jankovic, *Energy AI* **7**, 100124 (2022). DOI 10.1016/j.egyai.2021.100124
18. E. Abad-Segura, M.D. González-Zamar, J. Infante-Moro, G. Ruipérez García, *Global Research Trends in Sustainability* **12**, 2107 (2020). DOI 10.3390/su12062107
19. W. Leal Filho, C. Skanavis, A. Kounani, L. Brandli, C. Shiel, A. Do Paco, K. Shula, *Journal of Cleaner Production* **235**, 678 (2019). DOI 10.1016/j.jclepro.2019.06.299
20. V.V. Zinchenko, V.V. Levkulych, V.Y. Svyscho, *IOP Conference Series: Earth and Environmental Science* **635**, 12001 (2021). DOI 10.1088/1755-1315/635/1/012001
21. I. Turgel, L. Bozhko, O. Bazhenov, *Environmental and Climate Technologies* **24**, 501 (2020). DOI 10.2478/rtuect-2020-0017
22. L. Bozhko, R. Sapanova, I. Shtykova, F. Wijayanti, in *E3S Web Conference*, vol. 208 (EDP Sciences, 2020), vol. 208. DOI 10.1051/e3sconf/202020801001

23. M. Mokus, G. Realdon, I. Zubak Čižmek, *Sustainability* **12**, 10647 (2020). DOI 10.3390/su122410647
24. F. Zamora-Polo, J. Sánchez-Martín, *Sustainability* **11**, 4224 (2019). DOI 10.3390/su11154224
25. G. Sonetti, M. Brown, E. Naboni, *Sustainability* **11**, 254 (2019). DOI 10.3390/su11010254
26. R.A.R. Pangestu. Pengembangan modul digital pada pembelajaran matematika dengan pendekatan matematika realistik kelas viii di smp 18 padang. <http://repo.bunghatta.ac.id> (2021)
27. R.B. Swain, in *Handbook of Sustainable Science and Research* (Springer, 2018), p. 341. DOI 10.1007/978-3-319-63007-6
28. N. Eisenmenger, M. Pichler, N. Krenmayr, D. Noll, B. Plank, E. Schalmann, S. Gingrich, *Sustainability Science* **15**, 1101 (2020). DOI 10.1007/s11625-020-00877-5
29. M. Tareze, I. Astuti, *Visipena* **13**, 42 (2022)
30. S.M. Khoshnava, R. Rostami, R.M. Zin, D. Štreimikienė, A. Yousefpour, W. Strielkowski, A. Mardani, *Sustainability* **11**, 4615 (2019). DOI 10.3390/su11174615
31. M. Ranjbari, Z.S. Esfandabadi, M.C. Zanetti, S.D. Scagnelli, P.O. Siebers, M. Aghbashlo, M. Tabatabaei, *Journal of Cleaner Production* **297**, 126660 (2021). DOI 10.1016/j.jclepro.2021.126660
32. A.K. Makarigakis, B.E. Jimenez-Cisneros, *Water* **11**, 388 (2019). DOI 10.3390/w11020388
33. I.B. Sembiring, W. Hadi, I. Pramuniati, in *Proceedings of the National Seminar of LPPM Ummat* (2023), pp. 1082–1091
34. J. Wu, S. Guo, H. Huang, W. Liu, Y. Xiang, *IEEE Communications Surveys and Tutorials* **20**, 2389 (2018). DOI 10.1109/COMST.2018.2835653
35. J. Polinter, *Pendidikan Ilmu Politik FISIP* **5** (2019)
36. M. Martin, A. Godonoga, Sdg 4-policies for flexible learning pathways in higher education. Tech. rep., IIEP-UNESCO Working Papers (2020)
37. A. Muslim, *Adi Widya Jurnal Pendidikan Dasar* **6**, 170 (2021)
38. N. Rulandari, *Budapest International Research Critics Institute Humanit. Soc. Sci.* **4**, 2702 (2021)
39. M. Hannase, F. Arifah, S. Annas, in *IOP Conference Series: Earth and Environmental Science*, vol. 436 (2020), vol. 436, p. 12027
40. M. Odagiri, A.A. Cronin, A. Thomas, M.A. Kurniawan, M. Zainal, W. Setiabudi, P. Pronyk, *International Journal of Hygiene and Environmental Health* **230**, 113584 (2020). DOI 10.1016/j.ijheh.2020.113584
41. M. Odagiri, A.A. Cronin, A. Thomas, M.A. Kurniawan, M. Zainal, W. Setiabudi, P. Pronyk, *International Journal of Hygiene and Environmental Health* **230**, 113584 (2020). DOI 10.1016/j.ijheh.2020.113584
42. A. Martín-Sánchez, D. González-Gómez, J.S. Jeong, *Sustainability* **14**, 6965 (2022). DOI 10.3390/su14116965
43. B.K. Vilmala, I. Kaniawati, A. Suhandi, A. Permanasari, in *AIP Conference Proceedings*, vol. 2468 (2022), vol. 2468

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