Research Article

Researches of "Teaching and Learning on ESD" Over the Last Two Decades: Bibliometric Analysis

Duhita Savira Wardani*, Ari Widodo, Ernawulan Syaodih, and Muslim Muslim

Elementary Education, Universitas Pendidikan Indonesia, Jawa Barat, Indonesia

ORCID
Duhita Savira Wardani: https://orcid.org/0000-0003-1286-1687

Abstract.
This study aims to provide an overview of 'teaching and learning on ESD' research in terms of scientific production, preferred publication venues, most involved researchers and countries (including collaborations). Data collection was done by extracting articles from Scopus online database system. The output was exported in BibTex format and was converted to a data frame through a function in bibliometrix. The main findings point to a continuous increase in research output in the field 'teaching and learning on ESD' over the last two decades. Furthermore, they indicate a shift regarding the research foci. While formerly mainly papers on the ESD were published, recently, an increase in the relevancy of empirical studies on the 'teaching and learning on ESD' can be observed. However, this study only focused on articles published in scientific journals so that future studies can also consider other sources books or conference proceedings.

Keywords: teaching and learning, ESD, bibliometric analysis

Corresponding Author: Duhita Savira Wardani; email: duhita@upi.edu

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1. INTRODUCTION

Education for Sustainable Development (ESD) emphasizes the importance of education to respond to pressing environmental challenges, such as the increasing greenhouse effect, mass biodiversity loss and climate change caused by collective human behavior (1),(2). ESD recognizes the transformation required for individuals and societies to shift human behavior towards sustainability, so that Earth's ecosystems can recover before humans cause their own extinction (3). In this case, the UN has set a universal agenda, namely the 2030 Agenda, to achieve this transformation through partnerships with governments (4). ESD can also be seen as a roadmap for changing the world towards a more sustainable future by contributing to the achievement of the SDGs in the field of quality education, which aims to ensure that everyone has access to high-quality education, in order to become responsible global citizens and contribute to sustainable

development. In this context, ESD plays an important role in achieving these goals by providing a foundation for teachers and students to address the complex and diverse sustainability issues facing the world today. However, to effectively fulfill ESD's mission in achieving the SDGs, teachers need to first build their own capacity in terms of knowledge, skills, values and attitudes (5). On the contrary, as shown by (6), teachers struggle to bridge the gap between curriculum reform and practice in everyday life. Many schools and even universities around the world are actively participating in transformation and have included the UN's Sustainable Development Goals (SDGs) in education and curriculum to foster the involvement of the younger generation in playing an active role in caring for the problems of everyday life phenomena related to the context of the world order. Based on sustainable principles, in the national curriculum, the government has included sustainability issues from Basic Education to Higher Education with the main aim of fostering sustainable knowledge, skills, attitudes and values designed to form a more promising and better future for students (7),(8). In this regard, teachers are accepted as an important element of ESD to achieve quality and sustainable education (9),(10). Students with teacher guidance must be able to make decisions to create a balance between a healthy ecosystem, economic development and a social system that is equal for everyone (11). ESD adheres to a holistic approach and addresses the transformation of education systems to direct society towards sustainable development (12). To integrate sustainable development into existing education programs.

Recently, more attention has been paid to bibliometric and scientometric approaches to various fields of study since these methods are fruitful in helping to visualize the knowledge construction and core publications in emerging issues (14), (15), (16). A few researchers have applied network analysis to mapping in studies on teaching and learning on ESD (17), (18), (19), (20). However, these studies have relied mostly upon semantic network analysis of utterances by pupils or teachers. The bibliometric method with network mapping offers researchers many interesting results, such as the most productive articles, knowledge networks centring on citations and historical changes in topics of research (21). This study aims at using the bibliometric method to conduct a review of the literature on teaching and learning on ESD in international journals using the bibliometrix R-package and VOSViewer, with some resulting implications given for ESD research.

2. METHODOLOGY

This science mapping study of the literature used bibliometric methods to review research of teaching and learning on ESD. Research reviews grounded in bibliometric methods do not examine the substantive findings of studies. Rather, their value extends from the capability to document and synthesize broad trends that describe the landscape, composition and intellectual structure of a knowledge base. Thus, science mapping offers insights into patterns of knowledge accumulation that would be di_cult to 'see' using traditional methods of research review (22),(23). Data collection was done by extracting many articles from Scopus (www.scopus.com) online database system on November 2023. This system retrieves the enriched metadata of the literature on diverse topics indexed in Scopus. To gather the referential information from the system, this study selected 'teaching AND learning AND ESD' as the topic, 'article' as the document type, 'English' as the language and 'education' as the subject category, which resulted in 490 articles indexed in Scopus being selected for 2 decades, 2003-2023. The output was exported in BibTex format and was converted to a data frame through a function in bibliometrix. Table 1 provide an overview of the data used for our bibliometric analysis.

TABLE 1: Overview of the Data Extracted from Scopus Databases and Used for the Bibliometric Analysis.

Rubric	Summary
Main information about data	
Timespan	2003:2023
Number of Sources	224
Number of Documents	490
Annual Growth Rate %	16,44
Document Average Age	4,58
Average citations per documents	11,17
Authors	
Number of Authors	1379 94
Authors of single-authored documents	
Authors Collaboration	
Number of Single-authored documents	97
Co-Authors per Documents	2,98
International co-authorships %	20,82

Source: processed primary data

3. RESULTS AND DISCUSSIONS

3.1. Development of the Scientific Output on `Teaching Learning in ESD' Research

The number of publications of teaching and learning on ESD research increased from 5 in 2003 to more than 80 researches in 2023 with an annual growth rate of about 6.9% (cf. Figure 1).

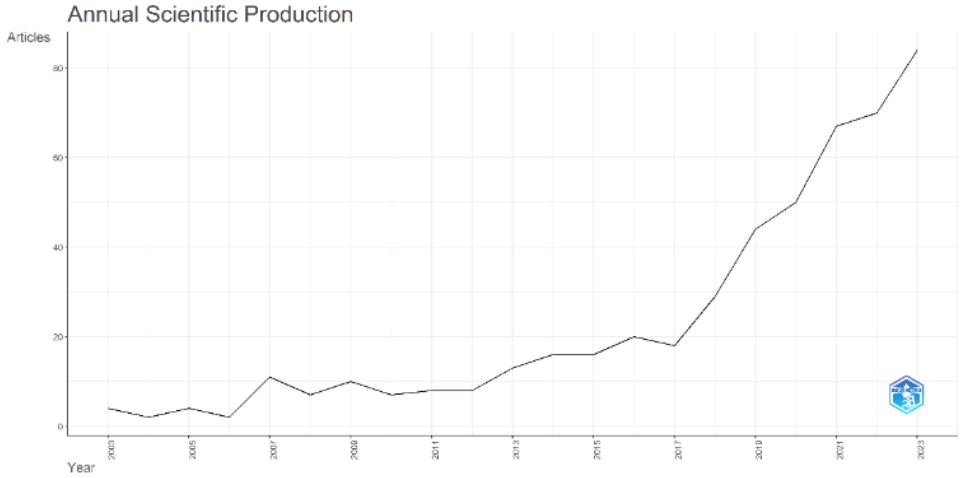

Figure 1: Annual number of Articles on Teaching and Learning in ESD Research Published in Scopus Indexed Journals from 2003 to 2023.

On average, each of the published articles was cited 11.17 times in total. The average number of citations per year for each publication was around 1.85. Figure 2 shows the average article citations per year. Out of 1379 authors included in the collection, 1305 published at least one article on teaching and learning in ESD research between 2003 and 2023 documented in Scopus. Furthermore, 68 authors published at least two, 5 authors published at least three, and 1 author published five or more articles. In the next section, we will focus on the latter, namely the most active authors (and countries) publishing articles on teaching and learning on ESD.

3.2. Most Active Authors and Countries Publishing Articles on Teaching Learning in ESD Research

Furthermore, Table 2 lists the ten most productive authors in the teaching and learning on ESD research area in terms of articles published between 2003 and 2023.

While some of the most productive authors have consistently contributed to the field with publications over the last two decades, others published all their work within

Table 2: Most Productive Authors Including Number of Published Articles On Teaching and Learning on ESD Research.

Most Productive Authors	# Articles
1. Gericke N	3
2. Chaaban Y	2
3. Alsina	2
4. Du X	2
5. Gutierez SB	2
6. Li J	2
7. Liu H	2
8. Barth M	1
9. Barth M	1
10. Brandt JO	1

a shorter period of time, mainly after 2019. To provide an overview of the countries participating in the scientific debate on teaching and learning on ESD research, we investigated the corresponding authors' countries as well as the number of single and multiple country publications. From 65 countries collection, of the nine countries with the most publications on teaching and learning on ESD research, three are from Europe (Spain: 34 publications, United Kingdom: 20, Germany: 15) and three from Asia (China: 48, Korea: 12, Turkey: 12). The most publications analyzed were written by a corresponding author from the China. Thereby, the ratio of multiple country publications was 17%. China has the most significant percentage of multiple country publications (29,2%), followed by Germany (26,7%) and South Africa (23.1%). Figure 4 provides a graphical overview of the results for the ten most productive countries.

Table 3: Most Cited Manuscripts (Top Ten, Published Between 2003 and 2023) in the Field of Teaching and Learning on ESD research.

Corresponding Author	Publication Year	Journal	TC	TC/year
Cebrian G	2015	Sustainability	229	25.44
Svanström M	2008	Sustainability	223	13.94
Schlager MS	2003	Information Society	175	8.33
Zamora-Polo F	2019	Sustainability	115	23.00
Stevenson Rb	2007	Environmental education research	112	6.59
Chinn Pwu	2007	Research Science Teaching	110	6.47
Nolet V	2009	Research Science Teaching	98	6.53
Portillo J	2020	Sustainability	93	23.25
Ferreira JA	2007	Journal of Education for Teaching	84	4.94
Straková Z	2018	Sustainability	60	10.00

In terms of author performance, Gericke (h-index: 26, g-index: 35) produced the highest number of articles, followed by Chaaban (h-index: 9, g-index: 13), had the best performance in terms of authorship, meaning authorship of a document authored by more than one person. In general, authorships per article keep rising over time (21). The list of most-cited articles does not match the results of the most productive author list. Table 2 reveals that Gericke is the first author from the list of top productive authors. The idea of ESD effectiveness, implementaton of teaching ESD, teacher conceptual understanding on ESD, sustainability consciousness, action ceompetency on ESD (35, 36, 37, 38, 39) has become important in the field, and most articles about this were published after 2010. In contrast, Table 3 reveals that Cebrian is the first author from the list of top the most cited manuscript. Gisela Cebrián works as a Serra Hunter Fellow in the Department of Pedagogy at Universitat Rovira i Virgili, Spain. The most cited of her article is about competencies in ESD (40, 41, 42) that has become important in the field of Education of Sustainable Development.

As the number of publications on ESD teaching and learning increases, it is important to examine the factors that influence this growth. One of the main factors is the growing global awareness of environmental and sustainability issues, which encourages educational institutions to integrate ESD into their curricula (44). Research shows that sustainability-focused educational approaches can enhance students' understanding of the complex issues facing the world today (45). However, despite the positive trend in publications, there are challenges to be overcome. Many teachers still feel unprepared to teach ESD due to lack of training and resources. This suggests the need to improve teachers' capacity so that they can implement ESD effectively in the classroom (9). Research by Abdurrahman et al. (6) emphasizes the importance of ongoing training programs to improve teachers' competence in teaching sustainability issues. Thus, despite significant progress in research and publications on ESD teaching and learning, challenges in implementation in the field still need to be addressed. Further research is expected to explore more deeply the effective training methods for teachers and strategies to build stronger collaborations between researchers and educational institutions around the world.

4. CONCLUSION

The number of publications of 'teaching and learning on ESD' research increased from 5 in 2003 to more than 80 publications in 2023 with an annual growth rate of about 6.9%. It

provide hints for future development of the 'teaching and learning about ESD' research community in the world, because research on ESD is already spread evenly across countries in this world. The most productive country of publication about 'teaching and learning on ESD' is China, although the most productive author is Gericke from Sweden, Europe. Furthermore, the most relevant sources in terms of the number of published articles on 'teaching and learning on ESD' research is Sustainability in Switzerland. However, this study only focused on articles published in scientific journals so that future studies can also consider other sources, e.g., books or conference proceedings.

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