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A Two-Decade Review of Teaching and Learning in Education for Sustainable Development

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ABSTRACT

This research seeks to present a comprehensive depiction of scholarly developments in the field of teaching and learning within Education for Sustainable Development (ESD) by examining patterns of scientific productivity, dominant publication outlets, as well as the most active authors, countries, and their collaborative networks. Data were obtained through the extraction of relevant articles from the Scopus online database in November 2023. A total of 490 Scopus-indexed publications produced over a twenty-year period (2003–2023) were identified and selected for bibliometric analysis. The retrieved records were exported in BibTeX format and subsequently transformed into a data frame using functions available in the bibliometrix package. The results reveal a steady and notable growth in research output related to teaching and learning on ESD throughout the past two decades. In addition, the analysis highlights a shift in research emphasis: earlier studies tended to focus more broadly on ESD discourse, whereas more recent publications demonstrate increasing attention toward empirical investigations specifically addressing teaching and learning practices within the ESD context. Unlike existing ESD bibliometric studies that emphasize general thematic development, this review uniquely foregrounds the evolution of teaching and learning research within ESD. The fundamental finding reveals a clear longitudinal shift from conceptual discourse toward empirically driven pedagogical research, indicating the maturation of ESD as an evidence-based educational field.

INTRODUCTION

Education for Sustainable Development (ESD) underscores the central role of education in addressing escalating global environmental challenges, including the intensification of the greenhouse effect, the widespread loss of biodiversity, and the accelerating impacts of climate change, phenomena largely driven by accumulated human activities behavior (Gilead et al., 2022; IPBES, 2019). ESD acknowledges that a profound behavioral and societal transformation is required to steer humanity toward sustainable pathways, ensuring that the Earth's ecosystems can regenerate before environmental degradation reaches an irreversible threshold that threatens human survival itself (Stouthart & Bayram, 2023). In response to this urgency, the United Nations has articulated a universal framework, the 2030 Agenda, which calls for coordinated global action through partnerships with governments and institutions worldwide (United Nations, 2015). As part of this agenda, the UN introduced the 17 Sustainable Development Goals (SDGs), which integrate and balance economic, social, and environmental dimensions of sustainability. The SDGs function as a shared global blueprint that guides countries and organizations in shaping a more equitable, resilient, and prosperous future grounded in the principles of sustainability, human rights, and social justice.

Within this broader framework, ESD is conceptualized as an essential pathway for advancing the SDGs, particularly in terms of promoting quality education. The intention is not solely to expand access to education but also to cultivate informed, responsible

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global citizens capable of contributing meaningfully to sustainable development. Education, therefore, is positioned both as an end in itself and as a strategic tool for achieving the full spectrum of SDGs. In this regard, ESD equips both teachers and learners with the foundational competencies needed to confront the interlinked and increasingly complex sustainability challenges of the contemporary world. Nevertheless, to deliver ESD effectively, educators must first develop the requisite knowledge, values, skills, and dispositions that enable them to translate sustainability principles into classroom practice (Brown, 2008). However, as highlighted by Abdurrahman et al. (2023), many teachers continue to experience difficulty bridging the gap between curriculum reforms and their everyday pedagogical implementation. Strengthening teacher capacity thus becomes a critical prerequisite for enabling educators across disciplines to competently address issues such as climate change, biodiversity degradation, and other sustainability concerns central to the SDGs.

Around the world, numerous schools and higher education institutions have begun integrating the SDGs into their curricula to cultivate young generations who are aware of and motivated to respond to real-world socio-environmental problems. In line with national educational policies inspired by sustainable development principles, governments have incorporated topics such as renewable energy, environmental stewardship, and climate change into the curriculum, ranging from primary education to university-level instruction. These initiatives aim to nurture sustainability-oriented knowledge, skills, values, and attitudes necessary for empowering students to contribute to a more promising future (Sadler, 2004; Zeidler & Nichols, 2009). Within this context, teachers are widely regarded as key agents in delivering high-quality ESD and ensuring the integration of sustainability perspectives across subjects education (Sweeney, 2017; Strachan, 2012). With appropriate guidance, students are expected to develop the capacity to make informed decisions that strike a balance between ecological health, economic progress, and social equity (Cebrián et al., 2020). ESD adopts a holistic and transformative approach to reorient education systems toward sustainable development (UNESCO, 2014). Consequently, reconfiguring educational programs is essential for equipping new generations with the competencies necessary to build a sustainable society (UNESCO, 2014).

In recent years, bibliometric and scientometric methods have gained prominence across diverse academic fields due to their ability to systematically map knowledge structures and identify influential publications within emerging research domains (Garfield, 2004; Aria & Cuccurullo, 2017; Cobo et al., 2012). Several studies have employed network analysis to explore patterns in research on teaching and learning within the context of ESD (Hallinger & Chatpinyakoop, 2019; Wright & Pullen, 2007; Yang & Xiu, 2023; Hallinger & Nguyen, 2020). However, much of this existing research has focused primarily on semantic network analyses of classroom discourse, often overlooking broader trends within the international scholarly landscape. Bibliometric approaches that incorporate network mapping offer additional insights, such as identifying prolific authors, uncovering citation-based knowledge networks, and tracing the historical evolution of key research themes (Jho, 2018). Moreover, the development of advanced visualization tools, such as bibliometrix and VOSviewer, has made such analyses increasingly accessible and methodologically robust. Accordingly, this study addresses a conceptual gap by foregrounding teaching and learning as the central lens of analysis within ESD scholarship, a methodological gap by integrating bibliometrix-based

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performance analysis with VOSviewer network visualization, and an empirical gap by providing a longitudinal, global-scale mapping of the field from 2003 to 2023. By filling these gaps, the study aims to offer a more holistic and systematic understanding of how teaching and learning research in ESD has developed, thereby informing future empirical inquiry and theory building in sustainability education.

Against this backdrop, the present study employs a bibliometric approach to systematically review international publications on teaching and learning related to ESD. Using the bibliometrix R-package and VOSviewer, this research aims to map the intellectual structure of the field, identify major contributors and thematic trends, and offer implications for future ESD scholarship.

RESEARCH METHOD

This study employs a science-mapping approach grounded in bibliometric techniques to systematically review the body of research on teaching and learning related to Education for Sustainable Development (ESD). Unlike traditional literature reviews, bibliometric analyses do not focus on interpreting or critiquing the substantive outcomes of individual studies. Instead, their primary contribution lies in their ability to capture, quantify, and synthesize large-scale patterns that characterize the evolution, structure, and intellectual dynamics of a research field. By visualizing interconnections among publications, authors, and thematic clusters, science mapping provides a macro-level perspective on knowledge development that is often inaccessible through qualitative review methods alone (White & McCain, 1998; Zupic & Čater, 2015). Consequently, this methodological approach offers a rigorous foundation for understanding how scholarly attention to ESD teaching and learning has grown, diversified, and shifted over time.

Data collection was conducted by retrieving relevant publications from the Scopus online database (www.scopus.com) in November 2023. Scopus was chosen due to its extensive indexing coverage, enriched bibliographic metadata, and its broad representation of peer-reviewed international journals across disciplines. To ensure precision and relevance, a set of predefined search parameters was applied. The search query consisted of the keywords “teaching AND learning AND ESD", while the document type was restricted to articles, the language to English, and the subject area to education. These criteria were selected to capture scholarly works directly focused on pedagogical dimensions of ESD, and to exclude non-academic or non-peer-reviewed materials. The search process resulted in the identification of 490 articles published over a span of two decades, from 2003 to 2023, thereby offering a sufficiently long temporal window to observe chronological trends and thematic shifts.

The bibliographic records obtained from Scopus were exported in BibTeX format, which is compatible with various bibliometric software environments. These records were subsequently imported into the bibliometrix R-package, where they were converted into a structured data frame suitable for quantitative analysis. The bibliometrix framework provides a comprehensive suite of functions for conducting performance analysis, scientific collaboration mapping, and thematic evolution tracking. In addition, complementary visualization tools such as VOSviewer may be used to generate network maps that illustrate co-authorship patterns, citation linkages, and keyword co-occurrence networks, thereby enhancing the interpretive richness of the analysis.

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An overview of the final dataset used in this bibliometric study, including the number of documents, time span, and key descriptive statistics, is summarized in Table 1.

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
Authors of single-authored documents	94
Authors Collaboration	
Number of Single-authored documents	97
Co-Authors per Documents	2,98
International co-authorships %	20,82

Bibliometric analysis is generally understood to encompass two principal methodological components: performance analysis and science mapping (Donthu et al., 2021). The present study incorporates both of these complementary approaches to obtain a comprehensive understanding of the research landscape on teaching and learning in ESD. Performance analysis seeks to evaluate the scientific productivity and impact of a particular field by employing indicators that reflect both quantitative dimensions, such as the total number of publications, and qualitative dimensions, including metrics like the average number of citations per article or journal prestige (Gutiérrez-Salcedo et al., 2018). This technique allows for an assessment not only of the overall contribution of the research community but also of the scholarly output of individual authors, institutions, and countries.

Science mapping, in contrast, is designed to generate a spatial or network-based visualization of the intellectual structure within a research domain (Small, 1999). This method reveals how different topics, documents, or scholars are interconnected by analyzing relational patterns. Techniques frequently employed in science mapping include citation analysis (Moed, 2009), co-citation analysis and bibliographic coupling (Boyack & Klavans, 2010), co-word analysis (Assefa & Rorissa, 2013) or co-authorship analysis (Kumar, 2015). Through these tools, science mapping enables the monitoring of knowledge evolution, the identification of thematic clusters, and the detection of emerging research fronts within a scientific field (Cobo et al., 2011). In the context of this study, the combination of performance analysis and science mapping offers a holistic framework for capturing the development of ESD teaching and learning research over time. Beyond database indexing, additional measures were taken to address the scientific reliability of the source publications. These included the use of citation-based performance indicators to identify influential and well-established studies, cross-validation of thematic structures using both bibliometrix and VOSviewer to ensure analytical consistency, and reliance on journals with recognized peer-review standards

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in the fields of education and sustainability studies. By integrating performance analysis and science mapping techniques, this study provides a robust and multidimensional overview of the intellectual, social, and thematic structures of ESD research, thereby enhancing the validity and methodological transparency of the findings.

Despite its strengths, the methodology employed in this study carries several inherent limitations that should be taken into account when interpreting the results. **First,** the quantitative data reported, for example, publication counts by author, institution, or country, are solely based on the bibliographic records indexed in Scopus. These figures may therefore not represent the full global output, as any publications not captured by Scopus fall outside the scope of this analysis. This issue is particularly relevant for citation counts, since databases may not index every citation of a given article, potentially introducing discrepancies in the ranking of highly cited authors or influential papers. **Second,** bibliometric methods by design focus on published scholarly literature and thus cannot capture other forms of academic influence. Some researchers may contribute significantly through leadership in major projects, policy work, pedagogical innovation, or community engagement rather than through large quantities of journal publications. Such non-publication-based forms of scholarly impact are not reflected in bibliometric indicators and therefore remain outside the analytical frame of this study. **Third,** this investigation concentrates exclusively on peer-reviewed journal articles, thereby excluding other potentially valuable sources of knowledge such as books, book chapters, conference proceedings, and grey literature. Future studies may therefore wish to broaden the data sources to develop a more inclusive picture of the research landscape, particularly given that ESD scholarship often spans interdisciplinary and practice-oriented domains where non-journal outputs are common.

Overall, while these limitations do not diminish the analytical value of the present work, they underscore the importance of interpreting bibliometric findings in context and recognizing the scope and boundaries of the employed research design.

RESULTS AND DISCUSSION

Results

Development of the Scientific Output on Teaching and Learning in ESD Research

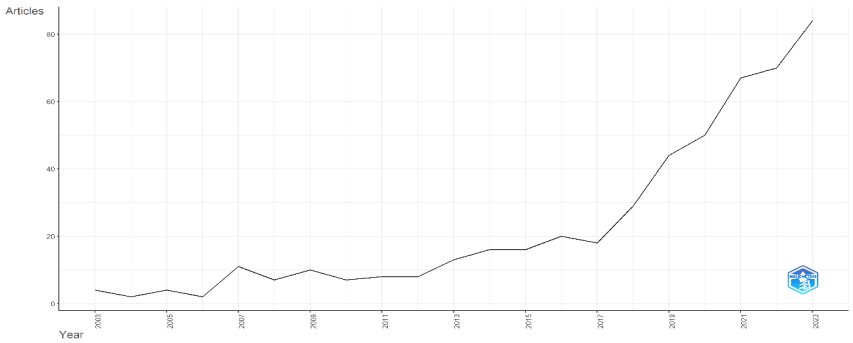

Figure 1. Annual number of articles on teaching and learning in esd research published in scopus indexed journals from 2003 to 2023

The scholarly output related to research on teaching and learning within the context of ESD has shown a marked upward trajectory over the past two decades. Beginning with only five publications in 2003, the field experienced substantial expansion, reaching over

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eighty published studies by 2023. This progression reflects an estimated annual growth rate of approximately 6.9%, indicating sustained and increasing academic interest in the topic throughout the examined period (see Figure 1). This steady rise also suggests a broadening recognition of the critical role that ESD-focused pedagogical research plays in advancing sustainable education frameworks globally.

Across the dataset, each article received an average of 11.17 citations, indicating a moderate level of academic impact within the field. When assessed on an annual basis, the publications demonstrated an average citation rate of approximately 1.85 citations per year, suggesting that research on teaching and learning in ESD has maintained a consistent presence within scholarly dialogue over time. A visual representation of the yearly citation trends is provided in Figure 2, which illustrates how citation patterns have evolved throughout the examined period.

From the 1,379 authors identified in the corpus, 1,305 individuals contributed at least one publication related to teaching and learning in ESD between 2003 and 2023, as indexed in Scopus. A closer examination of authorship productivity reveals that 68 authors produced two or more publications, five authors were responsible for at least three outputs, and notably one author authored five or more articles in this domain. These figures highlight a research landscape characterized by a broad base of occasional contributors, alongside a relatively small group of highly productive scholars who play a pivotal role in advancing the field. In the following section, attention will be directed toward this latter group of prolific authors, as well as the countries with the highest research output, to provide deeper insight into the leading contributors shaping the development of ESD-focused teaching and learning literature.

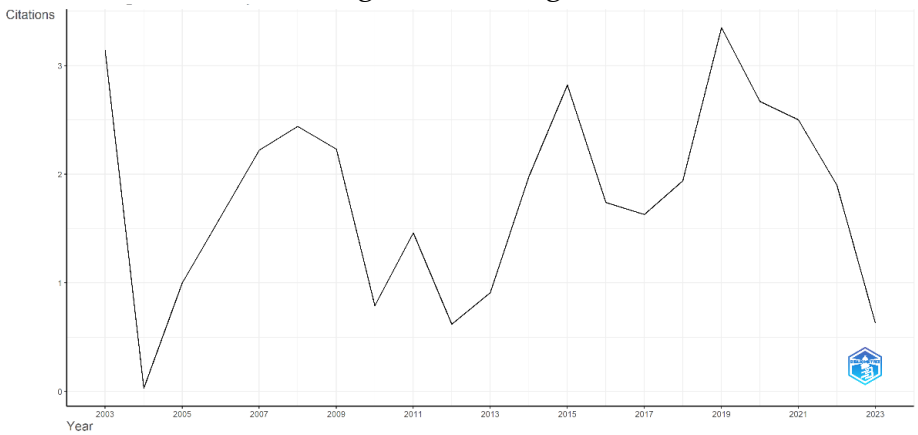

Figure 2. Average number of citations per article per year

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

Furthermore, Figure 3 presents the ten most prolific authors in the field of teaching and learning related to ESD, based on the number of articles they published between 2003 and 2023. This ranking highlights the scholars who have made substantial and sustained contributions to the development of the field, thereby shaping its conceptual foundations, methodological orientations, and emerging research trajectories. By identifying these leading authors, the analysis provides deeper insight into the core intellectual actors driving scholarly discourse on ESD pedagogy.

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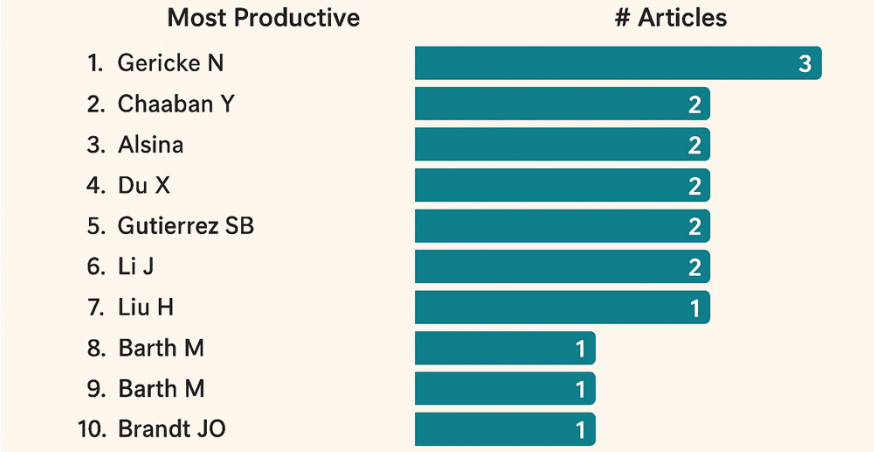

Figure 3. Most productive authors including number of published articles on teaching and learning on ESD research

Although several of the most prolific authors have demonstrated sustained engagement in the field by publishing regularly across the entire twenty-year period, a number of others have concentrated their scholarly output within a much narrower timeframe. Notably, many of these contributions emerged predominantly after 2019, indicating a more recent surge of academic interest and intensified research activity in the domain of teaching and learning on ESD (see Figure 4). This pattern suggests not only diversification in the temporal distribution of author productivity but also reflects broader developments in global sustainability discourse, which may have stimulated renewed scholarly attention and accelerated publication trends in the years following 2019.

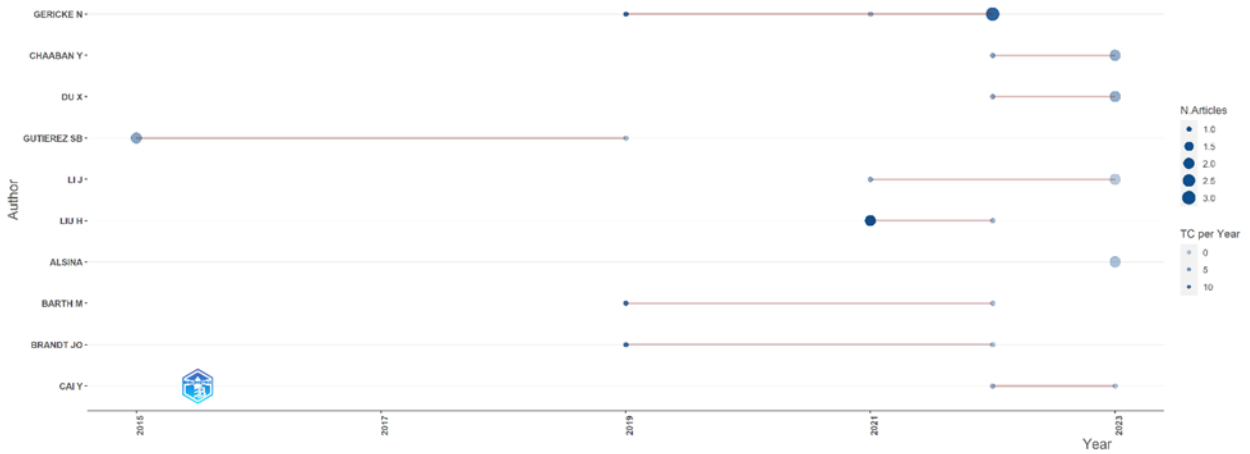

Figure 4. Top authors' production over the time in terms of published articles including the annual number of published articles (N. Articles) and the total number of citations (TC) per year

To capture a broader understanding of the global landscape of scholarly engagement in teaching and learning within the ESD research domain, this study conducted an analysis of the countries affiliated with the corresponding authors, alongside the distribution of single-country publications (SCPs) and multiple-country publications (MCPs). Examining these patterns provides insight into both the geographical concentration of research activity and the extent of international collaboration that characterizes the field (see Figure 5). Such an evaluation not only highlights which

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nations are most actively contributing to the discourse but also reveals the degree to which cross-border partnerships are shaping the development, dissemination, and evolution of knowledge related to ESD pedagogy.

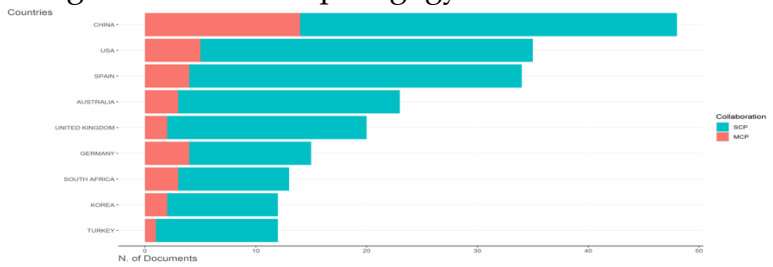

Figure 5. Number of country articles including the ratio of single country publications (SCP) and multiple country publications (MCP)

From the dataset comprising 65 countries, nine emerged as the leading contributors to research publications on teaching and learning within the field of Education for Sustainable Development (ESD). Among these, three European nations: Spain (34 publications), the United Kingdom (20), and Germany (15), and three Asian countries: China (48), Korea (12), and Turkey (12), ranked most prominently. Notably, China accounted for the largest share of publications, indicating its dominant role in advancing scholarly output in this area. The proportion of publications involving international collaboration reached 17%, with China exhibiting the highest rate of multi-country authorship (29.2%), followed by Germany (26.7%) and South Africa (23.1%). Figure 4 visually illustrates the distribution of publication productivity across the ten most active countries, offering a clearer comparative perspective on global research engagement in ESD.

Most Relevant Journals and Most Cited Articles on Teaching Learning in ESD

During the period from 2003 to 2023, the majority of publications addressing teaching and learning within the context of Education for Sustainable Development (ESD) appeared in the journal Sustainability, which accounted for 105 articles. This was followed by the Journal of Teacher Education for Sustainability, contributing 21 articles to the corpus. Collectively, these two journals comprised more than 55% of all articles included in the dataset, underscoring their central role as key dissemination outlets for ESD-related scholarship. Table 1 presents a detailed overview of the ten most influential and frequently utilized publication sources, offering insight into the primary platforms through which research in this domain has been communicated.

Table 1. The most relevant sources in terms of the number of published articles on teaching and ;earning on ESD research.

Most Relevant Scources	# Articles
Sustainability (Switzerland)	105
Journal of Teacher Education for Sustainability	21
Environmental Education Research	19
International Journal of Sustainability in Higher Education	18
Professional Development in Education	9
Education Sciences	8
Frontiers In Education	8
Mediterranean Journal of Social Sciences	6
Educational Action Research	5
Journal of Education for Teaching	5

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The substantial influence of Sustainability within the research landscape of teaching and learning on ESD is evident not only in its high volume of published articles but also in its prominence among the field's most impactful works. Notably, five out of the ten most highly cited publications in this domain appeared in Sustainability, demonstrating the journal's pivotal role in shaping scholarly dialogue and advancing core research themes. This concentration of widely referenced articles further highlights Sustainability as a central venue for disseminating influential contributions to ESD pedagogy.

Table 2. 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

Collaborations among Researchers and Countries in Teaching Learning in ESD Research

Although scientific collaboration can take multiple forms and is not exclusively reflected through co-authored publications (Melin & Persson, 1996), the number of jointly written articles remains a widely accepted proxy for measuring collaboration among researchers scholars (Finardi & Buratti, 2016). Accordingly, we conducted a co-authorship analysis to examine the extent and structure of collaborative relationships within the research community focusing on *teaching and learning in ESD*. For the visualisation of the network, VOSviewer software (van Eck & Waltman, 2010) was employed. In this analysis, each node in Figure 5 represents an individual author, with node size corresponding to the author's publication output (i.e., weight). Connections between nodes indicate co-authorships, and the thickness of each link signifies the frequency of joint publications. The colour-coding reflects clusters, which represent groups of researchers who have produced at least one publication together.

Figure 6 reveals the presence of several small, disconnected clusters, each consisting of only a limited number of authors. This pattern suggests that while certain collaborative relationships do exist within the field, these collaborations tend to be localised and are not broadly interconnected. Furthermore, only a few clusters demonstrate linkages beyond their immediate group, indicating limited cross-group or international collaboration. Overall, these findings highlight that the teaching and learning in ESD research community has, to date, exhibited relatively modest levels of global or inter-network cooperation in terms of co-authored publications.

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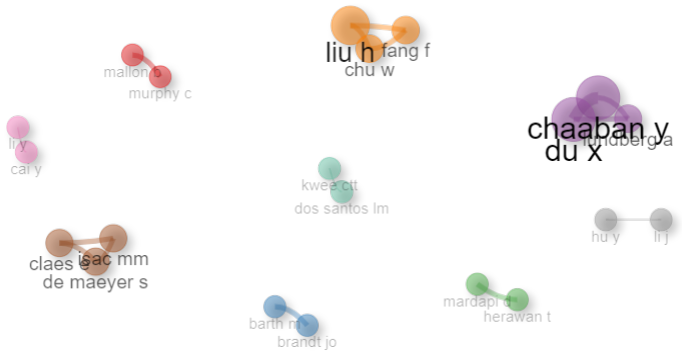

Figure 6. Co-authorship network focusing on authors of teaching and Learning in ESD articles From 2003-2023

Discussion

Based on these findings, it contend that the results provide valuable insights for the future development of the global research landscape on teaching and learning about ESD. The geographical distribution identified through our analysis shows that ESD-related studies have been conducted across all major world regions,Asia, Europe, the Americas, Africa, and Australia, indicating that scholarly interest in ESD has become broadly international rather than regionally concentrated. The outcomes of research questions 1 and 2 further demonstrate substantial potential for strengthening scholarly communication, particularly within the European and Asian academic communities, through publications in internationally indexed journals. As evidenced in the analysis for research question 3, Sustainability, a journal based in Europe, emerges as the most central and influential outlet for disseminating research on teaching and learning in ESD. Consequently, we argue that hosting dedicated special issues on ESD pedagogy in prominent European journals could serve as a strategic mechanism for amplifying the visibility and scholarly dialogue of researchers in this field. Such initiatives could also broaden contributions beyond recurrent authors such as Niklas Gericke, thereby diversifying intellectual voices within the community.

Regarding author performance, Gericke (h-index: 26; g-index: 35) is identified as the most prolific contributor, followed by Chaaban (h-index: 9; g-index: 13), who performs most strongly in terms of multi-authored publications. This trend aligns with broader bibliometric observations indicating that co-authorship rates have increased over time in many academic disciplines (Jho, 2018). , reflecting a shift toward more collaborative research practices. Notably, the list of the most frequently cited works does not fully overlap with the list of the most productive authors. As shown in Figure 3, Gericke appears as the leading author among those with the highest publication counts, with influential contributions on topics such as ESD effectiveness, pedagogical implementation, teachers' conceptual understanding, sustainability consciousness, and ESD-related action competence (Berglund & Gericke, 2016; Gericke et al., 2019; Olsson & Gericke, 2016; Berglund et al., 2014; Olsson et al., 2016), themes that have gained prominence particularly after 2010. In contrast, Table 2 identifies Cebrián as the lead author of the most highly cited works in the field. As a Serra Hunter Fellow at Universitat Rovira i Virgili, Spain, her scholarship focuses substantially on the development of competencies for ESD (Brundiers et al., 2021; Cebrián et al., 2020; Cebrián & Junyent,

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2015), an area that has become increasingly central to contemporary ESD research agendas. Accordingly, this misalignment should not be interpreted as a discrepancy in scholarly quality, but rather as evidence of differentiated contributions across sub-fields within ESD research. Highly productive authors such as Gericke contribute to the consolidation and empirical maturation of ESD pedagogy, particularly in school-based contexts, whereas highly cited authors such as Cebrián exert field-shaping influence by advancing conceptual and competency-oriented frameworks that transcend specific educational levels. Recognizing this distinction enables a more nuanced interpretation of bibliometric indicators and supports a broad-minded understanding of scholarly impact in teaching and learning research within ESD (Hallinger & Nguyen, 2020; Yang & Xiu, 2023).

Moreover, our co-authorship analysis shows that the research community working on teaching and learning in ESD has not yet established strong or extensive international collaboration networks. Instead, the field is characterised by relatively small, fragmented, and often nationally bounded research clusters. We argue that these findings underscore the need for more robust cross-national and interdisciplinary collaborations to enhance theoretical development, methodological rigor, and global relevance. This observation is consistent with prior investigations into the evolution of scientific collaboration networks. Anderson et al. (2017) demonstrated that in emerging research areas, initial collaboration patterns typically resemble fragmented "islands" of individuals working largely in isolation. Over time, however, and often following major structural developments, such as the establishment of specialised conferences, journals, or international research consortia, these isolated clusters tend to consolidate into cohesive, well-connected scholarly communities. Thus, the current state of the ESD teaching-and-learning research network may be interpreted as part of a broader developmental trajectory that has the potential to evolve into a more integrated and collaborative global field.

CONCLUSION

Fundamental Finding: this study reveals a substantial and sustained growth in research on teaching and learning in ESD, increasing from only five publications in 2003 to more than eighty publications in 2023, with an annual growth rate of approximately 6.9%. The findings indicate that ESD pedagogy has evolved into a mature and internationally distributed research field, characterized by geographically diverse contributions, with China emerging as the most productive country and Sweden, particularly through the work of Gericke, exerting strong individual scholarly influence. Moreover, Sustainability is identified as the most influential journal for disseminating ESD-related teaching and learning research, underscoring its central role in shaping the field's intellectual discourse. **Implication:** The implication of this study suggest that policymakers, educators, and academic institutions should leverage this momentum by promoting transnational research collaboration, integrating ESD more systematically into curriculum design, and supporting scholarly dissemination through special journal issues, conferences, and institutional research initiatives. Such strategic actions have the potential to accelerate pedagogical innovation, enhance the coherence of ESD research agendas, and improve the effectiveness of ESD implementation across educational contexts. **Limitation:** Nevertheless, this study is limited to journal articles indexed in Scopus, which may not fully capture the breadth of scholarly contributions in the field.

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Therefore, **future research** is recommended to broaden the scope by incorporating additional sources such as books, book chapters, and conference proceedings to obtain a more holistic understanding of the landscape of ESD-related scholarship.

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