Article

Education for Sustainability—Some Bibliometric Insights

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Abstract: The opportunities and challenges related to sustainability impose not only a societal transformation but also a personal one. Higher Education Institutions (HEIs) have great potential to promote sustainability and shape future generations’ skills, knowledge, thinking, and actions. Addressing environmental, social, and economic pillars, education for sustainable development (ESD), or education for sustainability (EfS), is a catalyst for quality education towards a sustainable future. This paper aims to analyze the state of the art and prevailing trends in the scientific literature pertaining to ESD/EfS. In this regard, specific objectives were established to identify the following: (1) authors’ productivity over time; (2) countries’ contribution and collaboration; (3) the most relevant keywords; and (4) the most prominent themes—in terms of relevance and degree of development. To fulfill the research objectives, quantitative research employing bibliometric analysis was carried out in April 2023. The research data sample was collected from the Web of Science (WoS) database. By conducting the search using a combined topic (“education for sustainable development” OR “education for sustainability”), a total of 2827 documents in English were identified within a timeframe of 33 years (1989–2023). These documents served as the foundation for subsequent data processing, visualization, and analysis using Biblioshiny/Bibliometrix (version R-4.2.0), as well as Excel (version 2039) software. The visualization and analysis focused on examining the most prolific authors and countries, in addition to generating word clouds based on keywords. Moreover, the thematic map that was delineated into four quadrants—Basic, Motor, Niche, and Emerging or Declining themes—provides an overview of the researched subject. ESD—embracing environmental, social, and economic pillars—implies transformative learning, action-oriented pedagogies, and professional development. As a holistic framework, it requires interdisciplinarity, system thinking, critical and experiential thinking, problem-based learning, and the use of 4IR technologies to enhance the teaching-learning process.

Keywords: education for sustainable development (ESD); education for sustainability (EfS); higher education; sustainable development; sustainability; transformative learning

1. Introduction Related to Some Perspectives of Education for Sustainability

Within the contemporary academic context, sustainability is recognized as a key concept, attracting the attention of researchers and practitioners from a diverse spectrum of disciplines. The concept shares extensive inter- and trans-disciplinary interactions with a variety of topics that are relevant to both the public and private sectors, including, but not limited to resilience [1], digital transformation [2], stakeholder ecosystems [3], adaptive governance [4], dynamic capabilities [5], performance management [6], leadership [7], and higher education [8].

Inherently, in the context of a globally volatile, uncertain, complex, and ambiguous (VUCA) environment, sustainability has emerged as an important theme [9,10]. This re-
quires, inter alia, a thorough examination of the contributing determinants, the implications on organizational processes, and the transformation of human resources.

Furthermore, the introduction of innovative concepts induces a transformation in management approaches—from conventional, linear paradigms to more contextual, multifaceted ones. These advanced approaches preserve basic elements while incorporating advanced, adaptable frameworks to cover the intricacies of contemporary organizational environments.

Both sustainability and education for sustainability are linked to the major crises—economic, social, environmental, and health—that humanity has been going through over time. One such major crisis is considered to be the COVID-19 pandemic, which, beyond the economic and social implications, has also had a strong impact on educational activity [11–13]. In the wake of the pandemic, the resilience of society and, by implication, educational institutions, has increased. In this context, education for sustainability “is transformative education and requires transformational/sustainability pedagogies” [14] (p. 11).

Nowadays, exclusive reliance on formal education is deemed insufficient in preparing individuals to be agile, responsive, and resilient in the face of disruptive economic, social, environmental, and technological challenges and opportunities that generate profound changes. Given the prevailing circumstances, it is crucial to develop an in-depth understanding of the challenges that may have either adverse or favorable impacts on the prospects of achieving a sustainable future. However, it is imperative to recognize that the process of comprehending these challenges and opportunities is intricately connected to a lifelong learning journey that must commence during the formative years of childhood and continue throughout the educational trajectory of students (including primary, secondary, and tertiary education). Additionally, it is worth noting that, aside from the education of younger generations, the transformation of society is heavily contingent upon the education of teachers [15].

Today, the issue of education for sustainable development is being addressed in an inter-, multi-, and transdisciplinary way. Helen Kopnina, in an original approach, starting from the hard core of the Sustainable Development Goals (SDGs), combines the concepts of critical theory and ecopedagogy. She points out that “the call of critical pedagogy and ecopedagogy to reform education in such a way that it becomes critical but also emancipated, can offer much more than the unreflective pursuit of economic growth or the optimism of denial embraced by the SDGs” [16] (p. 12) Other scholars, such as Suming Khoo and Nanna Jordt Jørgensen, introducing the concept of global citizenship education (GCE), appreciate that “critical GCE and ESD have the opportunity to engage in immanent critique—to interrogate and gain a more explicit understanding of how we position ourselves as scholars and educators” [17] (p. 477).

To foster meaningful engagement in the learning process, it is crucial to impart a sense of motivation and stimulation. Moreover, to cultivate resilience in individuals, there is a demand for a concerted effort to interlink curriculum development and the teaching-learning process with practical, real-life experiences. With the advent of Information and Communication Technology (ICT) and the emergence of “ubiquitous” or “just-in-time” learning, there is a pressing need to reassess the entire learning ecosystem [18].

Presently and particularly in the future, Higher Education Institutions (HEIs) hold tremendous potential to contribute towards sustainability. These academic entities possess the capacity to shape the thinking and actions of future generations on intricate concerns such as life quality, environmental impact, social justice, egalitarianism, and the welfare state, among others. Drawing on stakeholder theory, the concept of University Social Responsibility (USR), which brings together notions of “social responsibility, corporate social responsibility (CSR), sustainable development, corporate environmental responsibility, and education for sustainability” [19], is a critical mechanism in equipping individuals with the knowledge and skills to act responsibly towards environmental and social issues beyond economic concerns.
Efforts to operationalize education for sustainability are made by a wide range of stakeholders, including teaching staff (or trainers) on the one hand and the educable subject (pupils, students) on the other. Concerns about addressing sustainability in education are based on the combined efforts of the two categories listed above. Both categories are products of a society that has a certain profile in understanding sustainability and creating sustainable values. At the level of analyses of good practice models, the success of the education for sustainability approach depends on both general factors (level of national economic performance) and specific factors (performance of the national education system, level of education funding, typology of public or private educational services, and so forth). The conclusion of a study undertaken in the UK, which aimed to engage learners in education for sustainable development, is that “Effective Education for Sustainable Development (ESD) requires appropriate pedagogies that engage learners in transformative learning. These pedagogies include reflective and active learning, involving experiential, collaborative and learner-centered activities” [20] (p. 1). Another study, carried out in Swedish higher education institutions, analyzed progress in implementing sustainable development (SD) paradigms. It showed that “less than half of the HEIs had overarching goals for integration of SD in education or had a systematic follow-up of these goals. Even fewer worked specifically with pedagogy and didactics, teaching and learning methods and environments, sustainability competences or other characters of education for SD” [21] (p. 685). In Romania, at the Academy of Economic Sciences in Bucharest, a study was carried out to find out students’ level of internalization of sustainable development values. The final results showed that “students report a perceived level of this knowledge slightly above average, and the highest values are reported for those components that belong to the economic dimension of sustainable development” [22] (p. 357).

Concerns for knowledge of practices for education for sustainability also exist in the following Asian countries. A study that was undertaken in 2021, based on the application of the online survey method to universities in 16 countries in the region, revealed that “Regarding the perceived commitment towards SD, the country-based analysis involving Bangladesh, Indonesia, Malaysia, Pakistan and Thailand shows that countries such as Indonesia, Malaysia and Thailand are very active in this respect, whereas in Bangladesh and Pakistan the HEIs do not seem to have shown substantial engagement in this area” [23] (p. 21).

As it might intuitively be expected, there are also differences in perception and approach to sustainability depending on the student’s educational background (engineering, art, security, biology, exact sciences, etc.), with a study completed with specific data collected from three polytechnic universities in Spain claiming that “engineering degrees should devote more time and effort to include Education for Sustainable Development in the curriculum” [24].

An example of a positive practice for broadening awareness of the sustainability phenomenon is the integration of a training process for university teachers, which subsequently facilitates them to link the topic of environmental protection with the content of the educational process and the overall political and social context [25], and the building of competences to connect work and expertise with the sustainability imperative has become a challenge [26]. At the same time, teachers need to determine the state of students’ knowledge of sustainability before the start of the course by providing appropriate tools to measure key sustainability competences [27]. Teaching methods are also subject to scrutiny as learners need to consider interconnected, multi-faceted aspects of sustainability, whereas a traditional case study generally presents a single situation to consider [28]. Innovation in teaching can increase the attractiveness of sustainability.

As areas where teachers are already focusing on sustainability, research shows that experimental and engineering sciences and social sciences stand out. However, the teachers surveyed were still addressing ESD in a one-off manner in the context of topics such as “environmental and energy awareness” or “social engagement” [29]. There is thus a need for transformation at the university education level, with a focus on transdisciplinary,
collaborative, and action-oriented academic work explicitly aimed at supporting societal transitions [30]. Also related to the analysis of academics as opinion-formers are studies that have tested their development in the field of sustainability as a result of going through training processes, with their perception of education for sustainable development evolving towards more complex views [31]. With the aim of preserving the quality of life and, above all, ensuring the quality of life of future generations, individuals are beginning to adopt new behaviors, such as rationalizing energy and water consumption, reducing paper use, recycling products, and eliminating the use of plastics, among other behavioral changes that they can propagate in society through education [32].

With regard to the educational curriculum, a topical article demonstrated that the physical education discipline approached correctly forms critical and systemic thinking conducive to sustainable development with a focus on concrete application actions in the teaching of physical education that have direct links to specific goals of the SDGs [33]. A study conducted at a Greek university showed that students show a positive attitude towards integrating sustainability issues into their ICT education. Once the sustainability phenomenon was understood, students proposed various awareness-raising activities to support their involvement in sustainability issues in an inclusive manner [34]. Stimulating student engagement can also be achieved through appropriate climate communication that can engage the public commitment needed to achieve change. An example of this is greening the university campus by sharing experiences and information on best practices and how to implement them [35]. Campus gardens can be an innovative practice in sustainability education [36].

Education for sustainable development (ESD), or education for sustainability (EfS), which advocates for a balanced approach encompassing three pillars—environmental, social, and economic—is acknowledged to be a catalyst for delivering quality education (SDGs 4), which is one of the 17 Sustainable Development Goals (SDGs). Target 4.7 explicitly recognizes the role of ESD in developing the knowledge and skills required to contribute towards sustainable development (Figure 1).

Figure 1. SDG 4—Quality education, Target 4.7 (source: authors).

In addition to maintaining high standards of quality, it is imperative that education also pursues sustainability. Sustainable education, in alignment with a ‘Sustainable Curricula’, is centered on equipping students with interdisciplinary knowledge and values that are essential in the pursuit of sustainability. It requires a shift from traditional teaching methods to approaches that link learning with actual global challenges, cultivating essential skills like communication for building a sustainable future [37].

Policy and strategic decision-makers also argue the importance of EfS in terms of making it easier to address current and future sustainability issues. There are approaches that suggest addressing the topic of sustainable development to pupils aged 12–16 years as well, in order to test pupils’ competence for further action on sustainability [38]. A Swedish development and research project, Sustainable Preschool, involving about 200 preschool teachers, aimed at raising early environmental awareness through thematic activities related to sustainable development [39]. Primary education has benefited from several
studies on redefining the conceptual framework of professional competencies related to sustainable development for preschool teachers [40]. However, recent studies looking at teachers’ personal environmental activism and commitment to implementing sustainability education among students show that less than half applied this when describing actual classroom behavior [41].

In reviewing the literature, we identified a gap in the analysis of interest in the topic of sustainability for education through the lens of what has been written on the subject. By highlighting the evolution of the literature on education for sustainability, by year, author, country, and key terms, this article aims to raise awareness of the topic.

The research paper is organized in a systematic manner, following the structure outlined below for seamless reading and easy comprehension:

1. Introduction to education for sustainability: This provides an overview of the principles and concepts of education for sustainability, outlining its relevance and importance in the contemporary academic landscape.
2. Study objectives, methodologies, and deployed software: This section clarifies the objectives of the study, as well as details the methodologies employed and software tools utilized.
3. Presentation of main findings:
   a. Main information derived from the bibliometric analysis;
   b. Highlighting of the most prolific authors and their productivity trajectory over time;
   c. Featuring of the most prolific countries and their collaboration networks on a global scale;
   d. Word clouds generated from authors’ keywords and keywords plus, providing a visual representation of the most predominant ones;
   e. Thematic Maps based on authors’ keywords and keywords plus, as well as the identification of Basic, Niche, Motor, and Emerging or Declining Themes, offering insights into the diverse subject matters covered.
4. Conclusions and future directions

2. Main Objectives and Methodology

This article undertakes an investigation and presentation of the prevailing state of the art and trends within the scholarly literature on education for sustainable development (ESD) and education for sustainability (EfS). The specific aim is to provide a nuanced analysis of the topics by employing a bibliometric approach, utilizing Biblioshiny/Bibliometrix, to offer empirical insights into current developments and research endeavors in the domains of ESD and EfS, thereby contributing to the broader discourse in sustainable education. To accomplish this, specific objectives were set forth as follows:

1. To identify and rank the authors who have made significant contributions to this research area and assess their productivity patterns over time;
2. To determine the contributions and collaborative efforts of different countries in the field;
3. To identify the most relevant keywords that emerge from the literature;
4. To examine the most prominent themes—in terms of their relevance and degree of development.

To achieve the objectives set forth, both a qualitative approach based on a literature review and a quantitative method based on bibliometric analysis were employed.

In April 2023, the research data sample was collected using the Web of Science Core Collection (WoS CC). This study used the WoS CC as a data repository because of its comprehensive nature comprising ten sub-datasets and its use in academic research across over 200 Web of Science categories. In addition, the Web of Science Core Collection is one of the world’s leading citation databases, offering multidisciplinary perspectives from over 18,000 journals. This comprehensive and varied collection is an invaluable asset
to scholarly research, providing extensive amounts of information and knowledge from diverse disciplines and sources [42]. Sub-datasets are the distinct databases comprising the Web of Science Core Collection [43]. For this study, all 10 sub-datasets were included to ensure an all-inclusive analysis. The years covered for our scope extend from 1989 to 2023, incorporating articles from the inception year, when the first article was published (1989), to the most current publications available in the selected timeframe (2023). Importantly, no years were excluded, allowing for an uninterrupted examination of evolving research trends across the specified timeframe, facilitating a nuanced insight into the progressive trajectories of academic research during this period. The query utilized for this purpose was based on two key concepts: “education for sustainable development” (Topic) AND “education for sustainability” (Topic). The selection of the topic-based search option entailed querying titles, abstracts, and keywords. As a result of this search approach, a total of 3024 documents were obtained. Notable emphasis should be placed on the distribution of the resulting sample between the two respective concepts, specifically, “education for sustainable development” (ESD) with 2328 documents and “education for sustainability” (EfS) with 696 documents. A noteworthy observation is that the concept of “education for sustainable development” (ESD) is more prevalent in research compared to “education for sustainability” (EfS). The only criterion applied as a filter in the database was the language. Accordingly, after applying the filter for the English language, the final research sample consisted of 2827 documents. The remaining 197 documents were written in other languages, with the following distribution: Spanish (79), German (52), Portuguese (24), Polish and Russian (8 each), Turkish (5), Bulgarian, Czech, French, and Slovenian (3 each), Croatian and Maltese (2 each), and other languages that were represented by a single document each.

The research sample, comprising 2827 documents, was exported in plain text format and subsequently imported for further processing, visualization, and analysis using Biblioshiny, a web app powered by the Bibliometrix R package. Additionally, a thesaurus file was created to consolidate singular and plural forms of the concepts, as well as abbreviations and full names. In accordance with the established objectives, various analyses were conducted utilizing Biblioshiny and Microsoft Excel. These analyses focused on identifying the most prolific authors and countries, generating word clouds, and constructing thematic maps.

As such, the data from WoS CC was synthesized using Excel and Biblioshiny to present main insights from bibliometric analysis, profiles of the most prolific authors and their developmental trajectories, depictions of dominant countries and their global collaboration networks, and visual and thematic representations of predominant keywords, thus offering comprehensive insights into the diverse subject matters discussed.

3. Results

This section presents the main results regarding the researched topic.

3.1. Main Information

Figure 2 displays the primary general information pertaining to the subject of investigation across a time span of 33 years (1989–2023). The time frame of 1989 to 2023 was chosen to provide a more holistic view of progressive trends and patterns in the research and includes the year of the first publication up to the present day. This avoids year-specific omissions and allows for a systematic and comprehensive analysis of developments in the academic literature. It enables the reader to appreciate the complexity of scientific development and gain a nuanced understanding of the various advances and developments in scientific research over this time period. There is, however, a limitation due to the lack of accessible abstracts, authors’ keywords (AK), and keywords plus (KP) fields for older publications within the Web of Science Core Collection. This scarcity, particularly for earlier publications, could potentially hinder the thoroughness and comprehensiveness of the subsequent analysis within the defined research scope [44].
As can be observed, a total of 2827 documents have been identified from 780 sources (books, journals, etc.), with an annual growth rate of 13.8% and an average citation per document calculated at 12.92. The sources that are particularly noteworthy, each comprising over 200 documents, include “Sustainability” (505 documents) “Environmental Education Research” (231 documents), and “International Journal of Sustainability in Higher Education” (215 documents).

Annual publication trends indicate an initial phase of minimal research activity from 1989 to 1995, transitioning to a steady ascent until 2005, and then experiencing a notable surge, peaking at 381 publications in 2020. A minor decline is observed post-2020, possibly due to a shift in research focus amidst the COVID-19 pandemic (Figure 3).

Furthermore, the subsequent sections of this paper present a more comprehensive analysis, focusing on relevant information concerning keywords, namely authors’ keywords (AK—5507) and keywords plus (KP—1664). Figure 2 illustrates additional interesting insights regarding the authors, including the total number of authors (5765), authors of single-authored documents (551), the number of single-authored documents (694), the average number of co-authors per document (2.82), and the extent of international co-authorship (20.23%).

**Figure 2.** Main information (source: authors’ own computation based on data processed with Biblioshiny).

**Figure 3.** Scientific production over time (source: Web of Science Core Collection—Citation Report).
3.2. Authors

As previously emphasized, a total of 5765 authors have made contributions to research in the domains of education for sustainable development (ESD) and education for sustainability (EfS) over a span of 33 years. It is worth noting that the vast majority of authors (4715, i.e., 82.8%) have only published one document on the topic at hand. Figure 4 illustrates a subset of eleven authors who have contributed more than 15 papers per author to the relevant literature. The top three contributors (highlighted in red in Figure 4) in terms of publications are Barth, M. (33 documents), Gericke, N. (25), and Leal W. (25). These are followed by Eilks I (19), Rieckmann M (19), Shephard K (19), Van Petegem P (18), Kopnina H (17), Azeiteiro UM (15), Bogeholz S (15), and Thomas I (15). Other authors have also contributed to the research, but with fewer than fifteen papers, and they are not included in the graphic: Lozano R (14); Boeve-de Pauw J, Caeiro S, Huisingh D, Riess W, and Sanchez-Carracedo F have (13 papers each); Olsson D (12); Cebrian G, Dlouha J, and Segalas J (11 papers each); and Fischer D, Lotz-Sisitka H, and Singer-Brodowski M (10 papers each). The remaining authors’ distribution is as follows: 4 authors (9 documents), 11 authors (8 documents), 15 authors (7 documents), authors (6 documents), 54 authors (5 documents), 91 authors (4 documents), 200 authors (3 documents), and 635 authors (2 documents).

Figure 4. Authors’ production (source: authors’ own computation based on data processed with Biblioshiny).

Figure 5 displays the author’s productivity trends over time, revealing that Barth, Gericke, Leal, Eilks, and Van Petegem were the most active authors during 2022–2023. The more articles published by the author in a given year, the larger the circle. The darker the circle, the more citations the author has received in the year in question.

Figure 5. Authors’ production over time (source: authors’ own computation based on data processed with Biblioshiny).
3.3. Countries

The examination of the collected data, where the country is the unit of analysis, discloses that the research’s epicenter is distinctly located in Europe, with Germany securing 3763 citations and the UK 3717, thereby occupying the first two positions. This ranking is derived from the total number of citations allocated to each country and serves as a measure of the scholarly focus and recognition within these regions. Figure 6a depicts the top 15 countries of which 10 are European nations. Only five countries, namely, Australia (2947 citations), the USA (2669 citations), China (1369 citations), and Canada (920 citations), are located outside of Europe. Nonetheless, Figure 6b—representing the Collaboration World Map—reveals that these countries have robust research links concerning ESD and EfS with the European nations.

![Top 15 countries based on total citations](image)

(a) Top 15 countries based on total citations

![Collaboration world map](image)

(b) Collaboration world map

Figure 6. Top 15 countries based on total citations and a collaboration world map (source: authors’ own processing with data from WoS CC and Biblioshiny).

3.4. Word Cloud

In relation to the theme of the paper, the most frequently used keyword is ESD (AK-1201; KP-43), followed by EfS (AK-289). “Sustainable development” (AK-421; KP-107) and “sustainability” (AK-405; KP-76) play central roles in ESD research, with a novel topic being the “Sustainable Development Goals”—SDGs (AK-192, KP-10). Higher education is a main focus of the researched concepts, as indicated by the word cloud analysis, which highlights “higher education” (AK-291; KP-118), “universities” (AK-62; KP-187), “engineering education” (AK-52; KP-16), and “higher education institutions” (AK-45; KP-8). Environmental topics are also frequently addressed, including “environmental education” (AK-207; KP-101), “climate change” (AK-60; KP-48), and “environment” (AK-39; KP-27). It is evident that ESD prompts changes in “curriculum” (AK-98; KP-99) and “curriculum development” (AK-24; KP-0), as well as the development of “competences” (AK-66; KP-141), “key competences” (AK-12; KP-126), “knowledge” (AK-25; KP-164), “attitudes” (AK-25; KP-125), “behavior” (AK-7: KP-67), and “values” (AK-15; KP-48) (Figure 7).

![Word cloud](image)

Figure 7. Word cloud—based on AK and KP (source: authors’ own processing with Biblioshiny).
The word cloud is a visual representation of word frequency and as such, the size of each word or phrase is proportional to its frequency. The term “esd” dominates the AK word cloud with 1,201 occurrences, making it the most prominent term. Because of this high frequency, “esd” is displayed in a much larger font compared to the other terms, especially those having below 50 occurrences, making them less prominent. The top 50 AK keywords, which have less than 50 occurrences, are: “sustainability education” (48 occurrences), “higher education institutions” (45 occurrences), “environment” (39 occurrences), “pedagogy” (38 occurrences), “teacher training” (37 occurrences), “transdisciplinarity” (35 occurrences), “systems thinking” (32 occurrences), “professional development” (31 occurrences), “case study” (30 occurrences), “early childhood education” (30 occurrences), “learning” (30 occurrences), “science education” (30 occurrences), “teachers” (29 occurrences), “project-based learning” (28 occurrences), “e-learning” (27 occurrences), “interdisciplinarity” (26 occurrences), “attitudes” (25 occurrences), “knowledge” (25 occurrences), “assessment” (24 occurrences), “critical thinking” (24 occurrences), “curriculum development” (24 occurrences), “stem” (24 occurrences), “early childhood” (23 occurrences), “transformation” (22 occurrences), “schools” (21 occurrences), “sustainability competences” (21 occurrences), “policy” (20 occurrences), “environmental sustainability” (19 occurrences), “learning outcomes” (19 occurrences), “service learning” (19 occurrences), “experiential learning” (18 occurrences), “global citizenship education” (18 occurrences), “students” (18 occurrences), and “sustainable education” (18 occurrences).

In the pursuit of ESD, “pedagogy” plays a crucial role (AK–38, KP–30), requiring a shift towards “transformative learning” (AK–56) that promotes “transdisciplinarity” (AK–35), “interdisciplinarity” (AK–26), “systems thinking” (AK–32), “project-based learning” (AK–28), “critical thinking” (AK–24), and “experiential learning” (AK–18). While “students” (AK–33) are important, “teachers” (AK–29; KP–61), “teacher education” (AK–74; KP-7), and “teacher training” (AK–37) are also significant stakeholders in the ESD process. Despite the predominant focus on higher education, the authors also recognize the need to examine ESD concepts in the context of “primary and secondary education” (AK–21; KP–69) as well as “early childhood education” (AK–30; KP–19).

### 3.5. Thematic Map

Table 1 presents seven thematic clusters derived from authors’ keywords (AK). The distribution of these clusters within the four-quadrant thematic map is represented using distinct characteristics, namely, Name, CallonCentrality, CallonDensity, RankCentrality, RankDensity, and ClusterFrequency.

#### Table 1. Thematic clusters—based on AK (sources: authors’ own processing with Biblioshiny).

<table>
<thead>
<tr>
<th>Cluster</th>
<th>Callon Centrality</th>
<th>Callon Density</th>
<th>Rank Centrality</th>
<th>Rank Density</th>
<th>Cluster Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>environment</td>
<td>0.021618884</td>
<td>3.782051282</td>
<td>5</td>
<td>1</td>
<td>59</td>
</tr>
<tr>
<td>sustainable consumption</td>
<td>0.007924493</td>
<td>6.470588235</td>
<td>3</td>
<td>6</td>
<td>64</td>
</tr>
<tr>
<td>transformative learning</td>
<td>0.092701604</td>
<td>4.739053728</td>
<td>6</td>
<td>3</td>
<td>316</td>
</tr>
<tr>
<td>transformative education</td>
<td>0.004166667</td>
<td>6.25</td>
<td>1</td>
<td>5</td>
<td>16</td>
</tr>
<tr>
<td>global citizenship education</td>
<td>0.006538948</td>
<td>6.481481481</td>
<td>2</td>
<td>7</td>
<td>33</td>
</tr>
<tr>
<td>sustainable development</td>
<td>0.190502491</td>
<td>4.627566732</td>
<td>7</td>
<td>2</td>
<td>2482</td>
</tr>
<tr>
<td>case study</td>
<td>0.011876266</td>
<td>5.468671671</td>
<td>4</td>
<td>4</td>
<td>58</td>
</tr>
</tbody>
</table>

The seven identified clusters are distributed across the four quadrants of the thematic map, as determined by their respective values of RankCentrality (ranging from 1 to 7) and RankDensity (also ranging from 1 to 7). Each cluster is automatically assigned a name based on the concept with the highest frequency within it. The respective cluster names are as follows: “sustainable development” (2428), “transformative learning” (316), “sustainable consumption” (64), “environment” (59), “case study” (58), “global citizenship education” (33), and “transformative education” (16).
Figure 8 illustrates the thematic map of the research subject, utilizing RankCentrality and RankDensity measures to graphically represent the concepts. It is essential to highlight that centrality refers to the degree of relevance, while density pertains to the degree of development. The map is divided into four quadrants: Basic Themes, Motor Themes, Niche Themes, and Emerging or Declining Themes. In constructing the thematic map, the option to display three keywords with the highest frequency within each cluster was chosen. As can be seen, the distributions of the seven clusters across the quadrants are as follows:

- **In the Basic Themes quadrant**, there are three clusters and eight representative keywords: (1) sustainable development, sustainability, and higher education; (2) transformative learning, system thinking, and professional development; and (3) environment, and policy.

- **The Niche Themes quadrant** encompasses three clusters and six representative keywords: (4) sustainable consumption, action competence, and action research; (5) global citizenship education and global citizenship; and (6) transformative education.

- **The Motor Themes and Emerging and Declining Themes quadrants** do not contain topics that are exclusively confined to their respective quadrants but rather exhibit central positioning.

- **At the center of the map**, encompassing properties from all four quadrants, lies one cluster with three representative keywords: (7) case study, entrepreneurial sustainability, and systematic review.

![Figure 8. Thematic map—based on AK (source: authors' own processing with Biblioshiny).](image)

The largest and most central cluster in the Basic Themes quadrant is the Sustainable Development Cluster, which is characterized by a frequency of 2482 and a RankCentrality of 7 (high relevance degree). In addition to the eponymous concept of “sustainable development” (414), the top three most prominent concepts in the cluster are “sustainability” (405) and “higher education” (290). Other related concepts present in the cluster include “environmental education” (198), “education” (170), and “engineering education” (52), among others.

The Transformative Learning Cluster, also located in the Basic Themes quadrant, is notable for its high centrality (6) and relatively high frequency (316). Along with the “transformative learning” concept (56), the cluster’s top three concepts include “systems thinking” (32) and “professional development” (31). Other concepts encompass “science education” (30), “transdisciplinarity” (28), and “critical thinking” (24), among others.

Lastly, the Environment Cluster, a smaller cluster (59), comprises only two concepts: “environment” (39) and “policy” (20).
In the Niche Themes quadrant, the Global Citizenship Education Cluster is a small cluster (33) that is characterized by the highest RankDensity (7). The cluster is centered around the concept of “global citizenship education” (18), with another closely related concept, “global citizenship” (15), also prominent within the cluster.

The Sustainable Consumption Cluster, on the other hand, is a larger cluster with a Cluster-Frequency of 64 and a RankDensity of 6. In addition to “sustainable consumption” (17), this cluster also includes the concepts of “action competence” (16), “action research” (16), and “self-efficacy” (15). Furthermore, situated within the same quadrant is the Transformative Education Cluster (RankCentrality—1; RankDensity—6).

The Case Study Cluster, situated at RankCentrality 4 and RankDensity 4, exhibits moderate centrality and density. Comprising a smaller number of entities (58), the cluster includes the terms “case study” (25), “environmental sustainability” (19), and “systematic review” (14).

4. Conclusions and Discussion

To combat climate change and ensure a liveable future, humanity needs fundamental and rapid social change. Improving sustainability practices can also be achieved through community education projects that can complement and support institutional education efforts. An example of this is a larger community environmental education project involving participatory action research, which involved 14 volunteer monitors who gained skills in using air sensors at a low cost. They taught other community members about air monitoring and local air quality and devised strategies to improve air quality and community health [45].

The education for sustainable development (ESD) and education for sustainability (EfS) concepts are closely linked to the challenges and opportunities arising from the paradigm shift towards sustainability and embody a transformative and holistic educational approach that encompasses not only curriculum, students, and teachers, but also knowledge, attitudes, behaviors, values, and more. This statement resulted from both qualitative research—based on literature review—and quantitative research—based on bibliometric analysis.

The literature addressing education for sustainability and its integration into university curricula [46] is growing. Over time, the importance of relational capacities for the successful development of partnerships has been highlighted as a key element in overcoming the challenges of implementing education for sustainability in higher education institutions [47].

Against the backdrop of the 2030 Agenda with its Sustainable Development Goals (SDGs), ESD principles must be integrated into all forms of education, including formal, non-formal, and informal education, across all institutions and at all levels of education—from primary to secondary and tertiary ones. ESD involves the cultivation of sustainability knowledge and competences for both students and teachers, which is a complex undertaking that requires a comprehensive, innovative, and transformative educational approach. As Cebrián and his collaborators emphasize, to foster positive and lasting outcomes in ESD competences, curriculum development, innovative pedagogy, novel learning content, and innovative learning environments are essential elements [48].

ESD is characterized as a “transformative education”, which implies “transformative learning” and “professional development”. González-Salamanca outlines that transformative education is based on a personalized educational process and learning experience that promotes various aspects such as motivation, interest, autonomy, flexible learning paths, participation, interconnection, interdisciplinary learning, and more [49]. Transformative or transformational learning, drawing on constructivist theories, plays a critical role in fostering sustainability competencies for both younger learners and educators, as well as for participants in sustainability leadership programs. This type of teaching and learning can also facilitate the development of a systems-thinking experience and a strategic approach to promoting sustainability [50].
Within the context of digital transformation, to effectively achieve the learning objectives of ESD, educational institutions such as schools, colleges, and universities have the opportunity to employ various Fourth Industrial Revolution (4IR) technologies such as robots, 5G, Internet of Things (IoT), virtual reality (VR), and augmented reality (AR). A recent study [51] employed an interdisciplinary approach to design the learning content based on STEAM and ESD, incorporating game interaction and an experiential problem-oriented methodology within the teaching and learning process. Furthermore, the utilization of VR and digital course content facilitated the creation of an experiential learning environment that closely resembles real-world scenarios.

A group of eleven authors made noteworthy contributions to the field, as evidenced by their authorship, with Barth being the most prolific with 33 publications, followed closely by Gericke and Leal with 25 papers each. Regarding countries as the unit of analysis, Germany, the UK, and Australia are the top three contributors to the research field, based on the number of documents. The keyword analysis revealed that “education for sustainable development” is the most frequently used term, surpassing “education for sustainability”. “Sustainable development” and “sustainability” play central roles in ESD/EfS research, with “Sustainable Development Goals” emerging as a novel topic. “Higher education” is a key focus for the researchers, and “environmental education” is also an important topic addressed. The thematic map analysis revealed seven clusters distributed among four quadrants. Within the Basic Themes quadrant, three distinct clusters emerge, focusing on “sustainable development”, “transformative learning”, and “environment”. Moving to the Niche Themes quadrant, three clusters are observed, encompassing “sustainable consumption”, “global citizenship education”, and “transformative education”. The “case study” cluster occupies a central position, exhibiting attributes from all four quadrants.

As the present bibliometric research demonstrates, besides the use of novel technologies and pedagogical methods, ESD is interlinked with student and teacher development and transformation. Educators who possess a deep comprehension of sustainability issues and demonstrate a genuine enthusiasm for engaging with them may serve as “role models” and “learning facilitators”, thus effectively advancing the cause of sustainable development through the implementation of EfS initiatives and, moreover, contributing significantly to promoting systemic change towards sustainability [52]. Furthermore, the research underscores noteworthy aspects pertaining to “attitudes,” “behaviors,” and “values”—three significant concepts that accompany the changes associated with ESD. In this regard, related to these concepts, the research also reveals several different keywords that sustain the transformation: (1) for “attitudes” there are the following: “environmental attitudes”, “sustainability attitudes”, “attitudes towards sustainability”, and “entrepreneurial attitudes”, amongst others; (2) for “behavior” there are the following: “environmental behavior”, “pro-environmental behavior”, “planet behavior”, “theory of planet behavior”, “behavior change”, “conservation behavior”, “sustainable behavior”, “sustainability behavior”, “responsible behavior”, “sustainable consumption behavior”, “energy saving behavior”, “consumer behavior”, “health behavior”, etc.; and (3) for “values” there are the following: “environmental values”, “ecological values”, “biocentric nature values”, “sustainable development values”, “humanistic values”, “civic values”, “economic and social values”, “value-based indicators”, and so on.

“Global citizenship education” is another concept revealed from the thematic map analysis and is closely linked with the research topic. As Chen and Liu emphasize, transformative and action-oriented pedagogies are crucial for developing action competencies among future citizens. These competencies empower individuals to analyze the causal relationships of their actions, make changes, and take responsibility for solving authentic problems that contribute to a sustainable future for the planet [33].

As the present research emphasizes, the holistic framework of ESD comprises multiple pillars—environmental, social, and economic—that require “transdisciplinarity”, “interdisciplinarity”, “system thinking”, and “critical thinking”. Cooperation and communication across diverse disciplines and faculties are a must. Therefore, the interdisciplinary approach
assumes great significance as it enables universities to acquire the necessary knowledge and skills and implement ESD effectively [54].

Although looking quantitatively at the literature on education for sustainability, authors’ concerns on the topic are growing, and they are looking at it in a more specific way, it is still an issue that needs more effort and time to be implemented. Arguments for this are as follows: there is no uniformity at the level of school legislation in the field of education for sustainability, there are few countries showing solid scientific concerns for the topic, and the level of awareness for the importance of the topic at the individual level (student, teacher, or community member) is still quite low. Educational institutions can develop sustainably through an integrated approach to sustainable development starting from the creation and shaping of sustainability goals, their effective implementation, and their propagation in society.

The Web of Science, while a valuable repository for academic research, presents several inherent limitations that warrant consideration: (1) its dynamic list of journals is subject to frequent additions and removals; (2) the occasional omissions of certain journal issues or book series; (3) exclusive provision of citation data from indexed journals, overlooking a substantial number of academic publications; and (4) its specific focus on academic, rather than popular interest, publications [55]. Another limitation refers to the language coverage, with an estimated 19% to 38% of non-English documents omitted, impacting the accurate assessment of research impact in these languages [56].

Even with the exclusive reliance on the Web of Science Core Collection, the present study stands as a significant contribution to the enrichment of the existing body of knowledge and provides valuable and meaningful insights into the field of education for sustainability (EfS). To achieve more nuanced and comprehensive insights in future research endeavors, incorporating multiple databases and languages could be a viable option.

Implications to Theory

The research paper employed bibliometric techniques to conduct a comprehensive and unbiased analysis in the field of education for sustainable development (ESD), with significant implications for the advancement of theoretical frameworks. The study assessed impact and productivity by deploying a performance analysis, while science mapping was employed to identify knowledge clusters, prominent themes, the evolution of the field, as well as niche and emerging trends.

Therefore, this research broadens the theoretical understanding and perspective within the field of ESD, providing a holistic approach. In addition, it has the potential to advance theoretical progress in the field through its findings, diagrams, and other visual representations.

By interweaving theoretical frameworks with empirical applications, future academic endeavors in the field of ESD can explore emergent themes that have derived from the research conducted.

Implication to Practice

This article provides key insights that are relevant for top management within HEIs, academic professionals, organizations from both public and private sectors, as well as government entities. Primarily, the research findings enhance the understanding of sustainability-oriented strategies among HEI leaders, specifically in the development of graduates who are not only professionally skilled but also exhibit behaviors that contribute towards advancing sustainable development.

The process of transforming education to embrace sustainability should start by establishing the institution’s mission, vision, values, and strategy. This conveys a powerful message of genuine management commitment and endorsement towards sustainable development, influencing the teaching–learning process, as well as the behavior and mindset of educational stakeholders: students, teachers, support staff, and education policy makers, among others.
The subsequent stage involves the design, development, and implementation of a suitable structure, encompassing faculties, departments, centers, and academic programs, with the aim of ensuring strategic alignment in the endeavor to cultivate relevant skills and competences.

Concerning the crucial imperative of instituting a transformative educational approach, this article extends invaluable insights for teachers. It provides compelling evidential support highlighting the importance of incorporating trans-, inter-, and cross-disciplinary approaches within the curriculum, courses, subjects, and projects. Such integration is indispensable in cultivating students’ critical and systems thinking. In addition, teachers should also use project-based and experiential learning methods in order to develop action skills that prepare students for the real world.

Systematic development of competences, for both teachers and students, is a must, along with promoting sustainable consumption behaviors and citizenship competences. Moreover, this paper emphasizes that teachers—as key stakeholders in the educational ecosystem—should apply pedagogical innovation as much as they need to update educational content.

In view of the prevalence of the green movement, this paper is also useful for sustainable organizations in their search for talent with green skills and genuine commitment towards environmental and social responsibility. A further practical implication is the use of the findings by governments and ministries of education in the development of their education strategies in synergy with both the transition towards sustainability and the 4th SDG—Quality of Education.

Future Research

Aiming to enhance a nuanced understanding regarding ESD, the authors suggest two prospective research directions as a future endeavor:

1. To develop a performance management framework for ESD that encompasses a balanced set of key performance indicators (KPIs) and metrics that consider in a holistic approach all three dimensions of SD: economic, social, and environmental. Such research is linked to our interest in rethinking performance management systems in the context of the opportunities and challenges posed by sustainability.

2. A comparative study regarding ESD implementation in both civilian and military institutions. Such an endeavor can be carried out due to the fact that the authors have extensive experience in the professional development of both students and professionals and are part of two types of educational institutions: civilian and military.


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