International Journal of Sustainable Development and Planning
Vol. 20, No. 9, September, 2025, pp. 3717-3730
Journal homepage: http://iieta.org/journals/ijsdp

Mapping Global Trends and Emerging Themes in Learning Evaluation for Quality Education (SDG 4): A Bibliometric Analysis

Achmadi[1], Mukhamad Zulianto[2,3*], Ikhwan Ruslianto[4], Munawar Thoharudin[1]

[1] Department of Economics Education, Universitas Tanjungpura, Pontianak 78124, Indonesia
[2] Department of Asia-Pacific Regional Studies, National Dong Hwa University, Hualien 974301, Taiwan, R.O.C
[3] Department of Economics Education, Universitas Jember, Jember 68121, Indonesia
[4] Department of Computer Systems, Universitas Tanjungpura, Pontianak 78124, Indonesia

Corresponding Author Email: zulianto.fkip@unej.ac.id

https://doi.org/10.18280/ijsdp.200907

Received: 28 August 2025
Revised: 23 September 2025
Accepted: 25 September 2025
Available online: 30 September 2025

Keywords:
bibliometric analysis, learning evaluation, Sustainable Development goals (SDGs), VOSviewer

ABSTRACT

This article explores the intersection of learning evaluation, education, and the Sustainable Development Goals (SDGs), with particular attention to SDG 4 on Quality Education. The purpose of the study was to examine how scholarly attention to learning evaluation has evolved in relation to sustainability imperatives and to identify the intellectual structure of this field. Using a bibliometric approach, the study analyzed 198 publications indexed in Scopus between 2001-2025. Data were processed and examined with PRISMA screening and analyzed through VOSviewer and Bibliometrix (R), focusing on publication trends, influential sources, geographic distribution, collaboration patterns, and thematic evolution. The results show a sharp increase in research output after 2015, reflecting the influence of the global SDG agenda. Four dominant clusters were identified inclusive pedagogy, digital evaluation, teacher professional development, and competency-based learning along with emerging themes such as artificial intelligence in formative assessment and sustainability-integrated evaluation. Geographical analysis revealed imbalances, with strong contributions from advanced economies but growing representation from the Global South. Discussion highlighted how international policy agendas, collaborative networks, and technological innovations are shaping the field, while also drawing attention to gaps in equity, cultural responsiveness, and long-term effectiveness. This study contributes by mapping the intellectual landscape of learning evaluation and SDGs, offering insights for policymakers, educators, and researchers seeking to align evaluation practices with global sustainability goals. Future research should further investigate the integration of culturally responsive frameworks and ethical uses of technology to advance inclusive and sustainable education.

1. INTRODUCTION

The worldwide pursuit of the Sustainable Development Goals (SDGs): especially on provisioning for quality education under SDG 4, calls for the systematic restructuring of education. It is argued that if pertinent learning outcomes are not articulated, then there is an inherent risk of monitoring and evaluation being pointless [1]. It has been noted that relevance in evaluation rests on the participant's role and context, hence the need to factor engagement and diversity of context has been stressed [2]. Competency-based education that combines both soft and technical skill components is responsive to the evolving educational demands [3]. Assessments need to be more expansive and evaluative so that knowledge in its acquisition is confronted and critical reasoning, cooperation, and creative problem-solving are integrated [4].

The design of inclusive and supportive pedagogical frameworks requires careful attention and nurturing. Professional learning opportunities, for instance, influence teacher practice and, therefore, enhance student engagement and achievement across a wide range of classrooms [5]. Moreover, technology enhances personalized instruction [6] and provides more access to information, enabling students to collaborate [7]. Environmental integration within pedagogy is vital for equipping learners to cope with numerous challenges of the twenty-first century [8]. Thus, institutions are urged to develop sustainable values and behaviors that shape learners as active citizens of the world [9].

Assessment continues to be important in establishing the equity and efficiency of any given intervention. Self-assessments, for example, allow learners to think about and recognize their learning gaps, which enhances their performance [9]. Focused assessments have been shown to effectively measure retention and transfer, providing valuable data for curricular enhancement [10]. The use of inclusive practices helps to foster equity in education and responds to the UNESCO call for quality [11]. The evidence-based

approaches proposed in the student-centered quality frameworks have their merits [12]. Education for sustainability warrants appreciation for more sophisticated evaluative frameworks that enhance the quality of education [13]. Effectiveness also depends on social and cultural dimensions, which have been shown to be vital through the use of culturally relevant pedagogy [14-16].

Sustainability's effective integration within educational frameworks is still obstructed by institutional inertia [17]. There is a growing recognition that putting effective pedagogical frameworks in place that facilitate active engagement with sustainability by educators is critical [18]. There is a particular call directed at higher education institutions to advance more holistic approaches to align with the outcomes of SDG 4 [19]. Transformative learning approaches, in particular, enable personal development and active engagement with sustainability challenges [20]. There is also a positive relationship between the integration of sustainability within the curriculum and student attitudes and self-efficacy, suggesting that students will embrace the role of change agents [21].

E-learning platforms promoting sustainability are considered to be adaptive culture fostering environments [22]. Assessment and evaluative frameworks in secondary schooling are important to align curriculum and assess education frameworks to sustainability on a global level [23]. Alongside curriculum refinement, there is a demand for relevant professional development for teachers [2, 4]. Moreover, the social responsibility of a professional is fostered through sustainability in the curriculum of higher education [12]. Alongside this, the equity and quality of education is achieved through inclusive teacher-student dynamics with collaborative learning [24] and experiential learning that addresses gender equity in STEM [25]. New evaluative mechanisms are on the rise, including automated feedback [26] and AI-driven feedback frameworks [27-30]. These tools are promising with regard to advancing the SDG 4 goals of equity, inclusion, and the transformation of evaluative frameworks and education.

This review aimed to: (1) Examine how scholarly publications on Learning Evaluation and the SDGs have evolved in their distribution over time. (2) Identify the areas of Learning Evaluation and the SDGs that are gaining the most interest and analyze how interest in these areas has changed over time. (3) Determine the most impactful and highly active contributors, etc of Learning Evaluation and the SDGs. (4) Map the primary knowledge domains within Learning Evaluation and the SDGs. (5) Highlight the most notable newly emerging expectations in Learning Evaluation and the SDGs.

To address the conceptual fluidity present in the literature, this study raises a fundamental question: What precisely is meant by "learning evaluation" in the context of education and sustainable development? The terms "learning evaluation", "assessment", and "education evaluation" are often used interchangeably in educational research, yet they carry distinct connotations depending on theoretical framing and practical application. For this study, "learning evaluation" is operationally defined as the systematic process of collecting, analyzing, and interpreting evidence to determine the effectiveness, equity, and sustainability of learning processes and outcomes, particularly as aligned with the objectives of SDG 4 (Quality Education). This definition encompasses both formative and summative approaches, integrates learner-centered and system-level perspectives, and emphasizes the importance of contextual and cultural responsiveness. This operational definition informs the search strategy, keyword selection, data coding, and thematic analysis throughout the study. Consistency in terminology is maintained to ensure analytical coherence and to align with bibliometric conventions while addressing the interdisciplinary scope of the field.

2. METHODOLOGY

2.1 Research methods

A bibliometric analysis defines the scope and evolution of scholarship in a given discipline and seeks to quantify it. In the case of this study, relevant methods and techniques of bibliometric analysis were applied [31]. This study aims to evaluate research themes and trends to delineate authors, institutions, and countries to be clustered, as well as provide foresight based on keyword analysis. Three primary methods of bibliometric analysis were found to contribute to the understanding of learning evaluation and SDGs [12, 17, 32]. Figure 1 presents the specific processes and screening techniques. As for bibliometric analysis, it measures the productivity and impact of the research carried out in a particular area of study. This is achieved through the measurement of publication and citation counts as well as the evaluation of authors' or institutions' h-index which is a direct indicator of their influence in the area of study.

2.2 Research tools

The authors applied bibliometric software Bibliometrix and VOSviewer for the SDG and learning evaluation topic research published up until 2020 [13]. Since the research output of an academic field and an institution can be quantified in terms of publications, citations, and authorship networks, Bibliometrix was used to assess the scientific output in collaboration and publication activity in order to map the collaboration and productivity patterns. Through the integrated functions of Bibliometrix, it is possible to determine the most productive authors, institutions, and countries based on sophisticated bibliometric methodologies like publication growth per year, citation impact, and notable research collaborations [31]. Primarily focusing on keywords, authors, and references, VOSviewer [33] simplifies the exploration and visualization of co-occurrence networks. It has clustering capabilities which help researchers uncover relationships and patterns within large datasets. The use of VOSviewer in research practice can improve perceptions and insights in dealing with multidisciplinary realms, especially in education for sustainable development and collaborative interdisciplinary approaches.

2.3 Data sources

The data for this study were collected from Scopus in August 2025. The reason for this selection was that this database contains quality peer-reviewed journals that are universally accepted in the academic circles [17]. The data retrieval was done based on the keywords "learning evaluation" and "sustainable development goals" which produced 490 relevant documents. As noted by Uchima-Marin

et al. [34], only inapplicable documents were disregarded so long as the data was relevant. In this, the focus was on articles, and irrelevant documents were excluded which resulted in 198 articles that fulfilled the research requirements. Each of the 198 articles was screened in compliance with the designated research parameters. Data was preserved in plaintext files alongside complete annotations and citation references for advanced analytics.

2.4 Database and search strategy

To carry out this study, we started with 198 articles from the different Scopus databases, using technology-based music education as a keyword filter. The data underwent export in a uniform manner, followed by complementary bibliometric analysis as depicted in Figure 1. The bibliometric data was collected and analyzed by using different programs, firstly, Bibliometrix for gaining and calculating productivity, collaboration, and other relevant relations. It was possible to get qualitative measures such as yearly publication increase, yearly total citations, and author collaboration rate to provide a broader view of the research landscape. Later on, keyword, author, and reference co-occurrence as well as visualization were performed using Vosviewer. The items with stronger connections were grouped into clusters which helped to quickly interpret the major research areas. The generated network map clearly displayed the intersection of various fields of learning evaluation in relation to the SDGs.

Table 1 outlines the inclusion and exclusion criteria applied in the literature selection process, ensuring methodological rigor and transparency in identifying relevant studies.

Following a preliminary exploration of the Scopus database, a number of keywords relating to digital competence in the context of education were identified. Key words pertaining to education are “learning evaluation”, “education”, and “sustainable development goals”.

In refining the search strategy, this study deliberately used the query string: (TITLE-ABS-KEY ("learning evaluation") AND TITLE-ABS-KEY ("education") AND TITLE-ABS-KEY ("sustainable development goals")) for the Scopus database. The decision to focus on "learning evaluation" in its singular form reflects the dominant usage within the existing literature and was confirmed during preliminary scoping. While alternative terms such as "assessment," "appraisal," or "measurement" were considered, they were excluded due to their broad disciplinary ambiguity and high retrieval of irrelevant literature not aligned with the research focus on SDG 4. Including these terms in early trial searches significantly reduced precision.

Table 1. Inclusion and exclusion criteria

Inclusion	Exclusion
Peer-reviewed journal articles publications between 2001 and 2025	Non-peer-reviewed Articles, proceedings and book chapters Publication before 2001
Publication just in English	Articles not primarily focused and related to learning evaluation, education and sustainable development goals
Articles focusing on learning evaluation, education and sustainable development goals	Duplicate publications across database

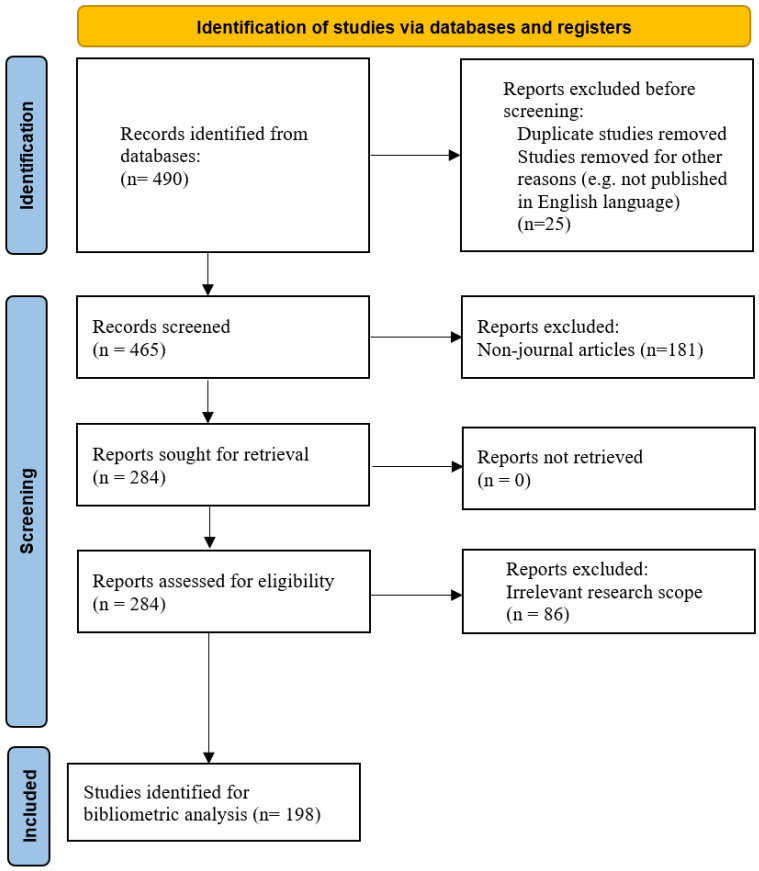

Figure 1. Searching procedure following PRISMA

The use of TITLE-ABS-KEY field codes ensures relevance by targeting terms found in the most conceptually significant locations within indexed articles. Although this approach may exclude some pertinent full-text results, it maximizes the inclusion of documents with a clearly articulated focus on the target concepts. To mitigate the risk of omitting relevant publications, the query was tested iteratively and cross-referenced with known seminal works in the field to ensure coverage.

2.5 Limitations of the bibliometric approach and validity of findings

Bibliometric analysis provides a valuable overview of the scientific landscape; however, the interpretation of the present findings must be approached with methodological caution. Several inherent limitations may affect the validity and generalizability of the results. Citation bias and the limits of citation-based metrics warrant careful attention, as the number of citations or indices, such as the h-index and g-index, do not necessarily reflect scientific quality. Citations can be negative, shaped by the Matthew effect, disciplinary citation norms, journal policies, and large-scale collaborations or self-citation practices that inflate citation counts without improving substantive quality.

Language bias emerges from the predominant focus on English-language publications, which may underrepresent contributions from non-Anglophone and Global South scholars, thereby influencing both thematic and geographic mapping. Third, database coverage and temporal scope pose another limitation. Reliance on a single database (Scopus) implies dependence on its indexing policy, update cycles, and curation scope. Some journals or communities may be under-indexed, while newly published works might not yet be captured as of the data retrieval date (August 2025). Given the dynamic nature of bibliographic databases, results may vary if the query is replicated at a later time.

The search strategy and precision–recall trade-off also shape the outcomes. The focused use of the term "learning evaluation" (singular form) in the TITLE-ABS-KEY field enhances precision but may reduce recall for relevant synonyms (e.g., assessment, appraisal, measurement) or plural and alternative spellings. Consequently, the results should be read as a mapping of core discourses that explicitly employ the target terms, rather than a comprehensive representation of the field. Fifth, document type and domain selection may limit diversity. Restricting the dataset to peer-reviewed journal articles strengthens the reliability of curation but excludes conference papers, book chapters, policy reports, and grey literature, which often contain innovative or context-specific evidence.

Author, affiliation, and country disambiguation challenges can lead to aggregation inaccuracies due to variations in name spelling, institutional structures, or changes in affiliation. Moreover, the choice between full and fractional counting schemes can affect productivity rankings and network centrality results. Seventh, network modeling sensitivity should be acknowledged, as clustering and visualization outcomes (e.g., in VOSviewer or Bibliometrix) depend on technical parameters such as minimum occurrence thresholds, normalization methods (e.g., association strength): and keyword type (author keywords vs. Keywords Plus). Parameter variations may shift cluster boundaries or alter thematic prominence.

The study recognizes that thematic co-occurrence and citation patterns are correlational rather than causal. Although the post-2015 increase in publications coincides with the adoption of SDG 4, this analysis does not establish a direct causal relationship. Broader research dynamics such as technological advancement, funding trends, or national curriculum agendas may also explain the observed surge. Ninth, geographical and institutional representativeness should be interpreted cautiously. Country and institutional productivity or citation rankings reflect a combination of research capacity, funding policies, publication norms, and database coverage, rather than intrinsic quality or policy relevance. Consequently, the observed North–South disparity should not be interpreted as an absence of research capacity in underrepresented regions.

3. RESULTS

3.1 Publication trends

As depicted in Figure 2, research advancement in this area can be classified into three distinct phases. The first phase, covering the years 2001 to 2007, was marked by an annual research output of no more than three publications. In the development phase 2008 to 2017, there was a marked increase to more than 5 publications per year, effectively doubling output of the preceding phase. Since 2018, the output of studies in this area has remained consistently above 5 publications per year, with a notable increase in 2024 when the total reached 39 publications. Considering the 2025 data collection deadline, a projection of 24 publications places this field poised for rapid advancement. The data indicate that the use of evaluations for learning, as well as the SDGs, has emerged within the scholarly discourse in education, signifying its potential as a fresh and vibrant area of investigation.

In Figure 3, a detailed bibliometric analysis on the evaluation of learning against the SDGs is presented alongside the temporal distribution of publications. Based on the data, a relevant article appeared in the Scopus database for the first time in 2001, and it is projected that by 2025 there will be a total of 198 documents published. This data signifies that there is a 14.16% increase in research output for every year, which showcases the importance of learning evaluation in relation to SDGs. Additionally, there were 877 authors for the documents, which on average means 4.52 co-authors per document. This showcases strong collaborative research networks. Further, the data signifies that there were 825 distinct keywords from the documents highlighting the broad and diverse research topics. This emphasizes that the research conducted on the learning evaluation in relation to SDGs is a growing field featuring diverse, rapidly advancing international collaboration.

Figure 4 shows the connectivity between countries with keywords and authors. Based on the analysis using the Three-Field Plot, it is clear that Spain is the most active research performer on this topic, with major input from China, the UK, Australia, and the USA. The term "higher education" is the most prevalent as a keyword, suggesting that research activity on the SDGs is primarily centered on higher education. Moreover, "medical education" also appears as a keyword which suggests the relevant research is important within the context of SDGs. Other education related keywords,

"education for sustainable development," "curriculum development," and "evaluation" also dominate the results which suggests that the focus of research on learning and evaluation pertaining to SDGs is overwhelming.

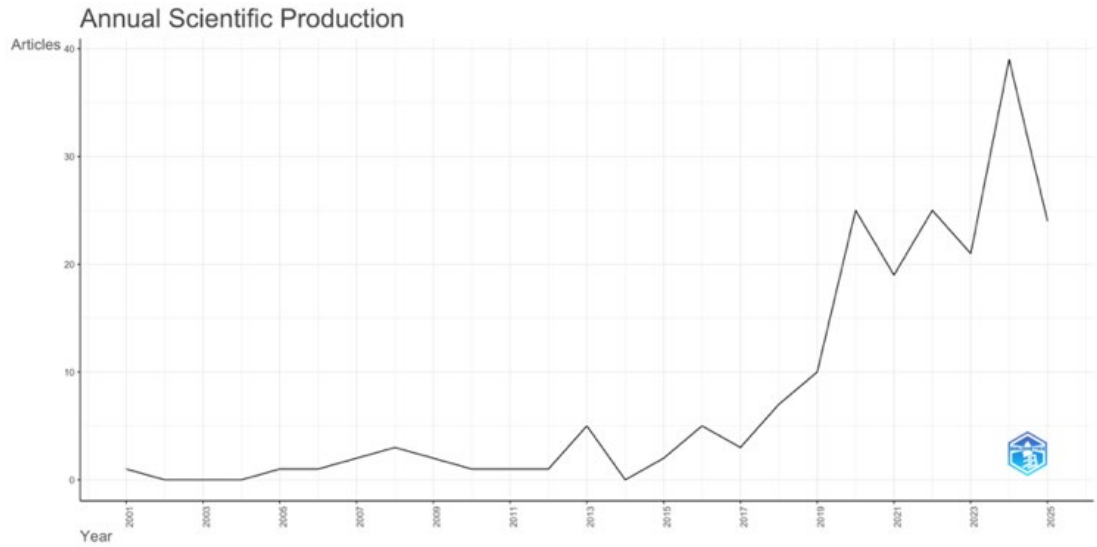

Figure 2. Distribution of paper publications

Figure 3. Main information about data

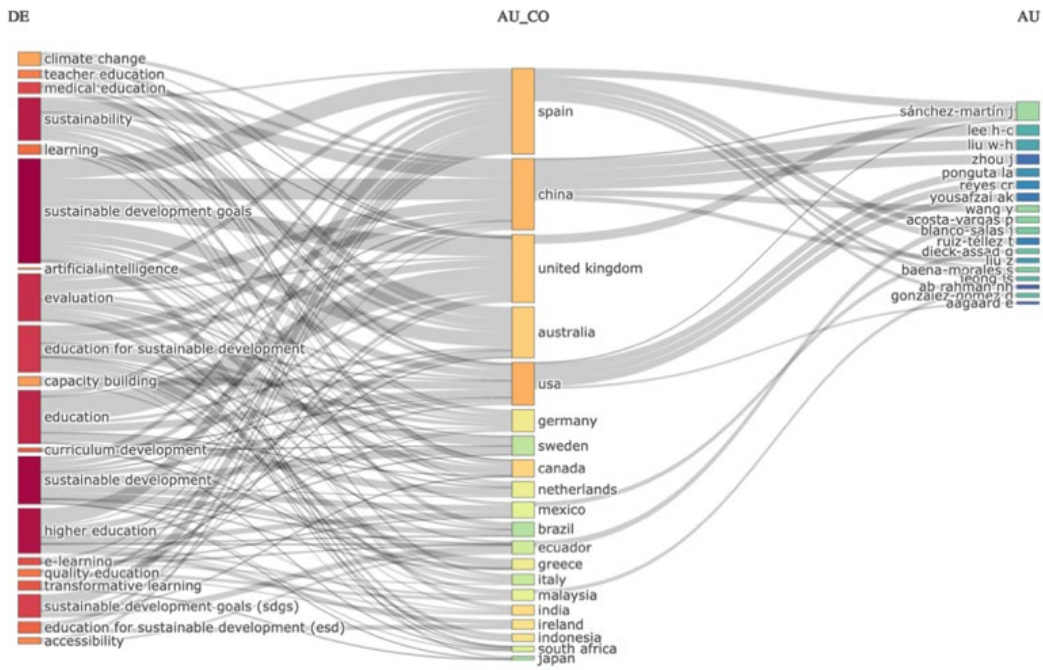

Figure 4. Three-field plot

3.2 Trending topics and evolution

The outcomes of the word cloud analysis of Keywords Plus are presented in Figure 5, where the font size indicates the rate of keyword usage. The terms "sustainable development," "learning," "education," and "sustainable development goal" are acknowledged as the most frequently utilized keywords. Also notable are "teaching," "curriculum," "student," and words pertaining to "higher education" and "medical education," which also rank as frequently occurring keywords.

Figure 6 presents and showing how research hotspots and directions in learning evaluation and the SDGs have evolved over time. Early research (before 2015) was dominated by terms such as professional development, total quality management, program development, and interinstitutional relations, reflecting a focus on institutional capacity building, quality assurance, and program evaluation frameworks. Following the 2015 launch of the SDGs, a transition occurred with keywords such as sustainable development, education program, capacity building, and curricula signaling a shift toward embedding sustainability principles into educational practices. Between 2018 and 2023, pedagogical and learner-centered terms such as teaching, learning, students, and sustainable development goal became increasingly prominent, alongside domain-specific themes like medical education, training, and clinical competence, indicating the integration of sustainability-oriented evaluation across disciplines. Most notably, the rise of artificial intelligence as a high-frequency keyword highlights a new frontier, reflecting the technological turn in evaluation practices with implications for personalization, scalability, and real-time feedback. Overall, the trend analysis illustrates a thematic evolution from foundational institutional concerns, to sustainability-centered reforms, and most recently to technology-driven innovations, underscoring the field's responsiveness to global policy agendas and technological advancements while stressing the importance of ensuring equity, cultural sensitivity, and alignment with the transformative goals of SDG 4.

Figure 7 depicts the changing conceptual emphasis regarding the growth of research keywords from 2001-2012 to 2013-2025 in learning evaluation vis-a-vis the SDGs. In the earlier period of 2001-2012, the prevailing thematic focus centered on training, sustainable development, as well as curriculum and students, which indicated a primary focus on instructional capacity building, curricular development, and student participation in the sustainability paradigm. In the subsequent period (2013–2025), these themes evolved into more specialized and diversified strands, with training and students strongly converging into the broader concept of learning, while curriculum and students also branched into medical education, indicating a disciplinary expansion of evaluation practices into professional and clinical contexts. Sustainable development persisted as a central theme, demonstrating continuity and consolidation as a core intellectual anchor while also expanding its connections with learning-oriented and sector-specific domains. This thematic trajectory suggests a field that has moved from foundational educational concerns toward applied and interdisciplinary frameworks, where sustainability remains a stable core but is increasingly articulated through learning-centered paradigms and domain-specific applications such a medical education. The results highlight the dynamic capacity of the field to adapt to global priorities and evolving educational demands, while reinforcing the centrality of sustainability as the guiding principle of research and practice in educational evaluation.

3.3 Productive sources of publication

The 10 most productive contributors in the field of Learning Evaluation and the SDGs are listed in Figure 8. The most productive was "Sustainability (Switzerland)", which published 52 works. "International Review of Education" published 5 related works and is in second place. "BMC Medical Education", "IEEE Access", "International Journal of Environmental Research and Public Health", "International Journal of Sustainability in Higher Education", and "Medical Teacher" contributed 4 articles each and shared third place. "Frontiers in Education" contributed 3 articles, while "Annals of Global Health" and "Buildings" contributed 2 and 3 articles, respectively.

Reveal some trends which are summarized in Table 2. "Sustainability (Switzerland)" clearly stands out as the most influential journal in the field, leading the h-index with 20, g-index with 35, and m-index = 1,538. "International Review of Education" also remains notable as the second most influential journal with h-index 4, g-index 5, and a total of 153 citations.

Figure 5. Word cloud (by keywords plus)

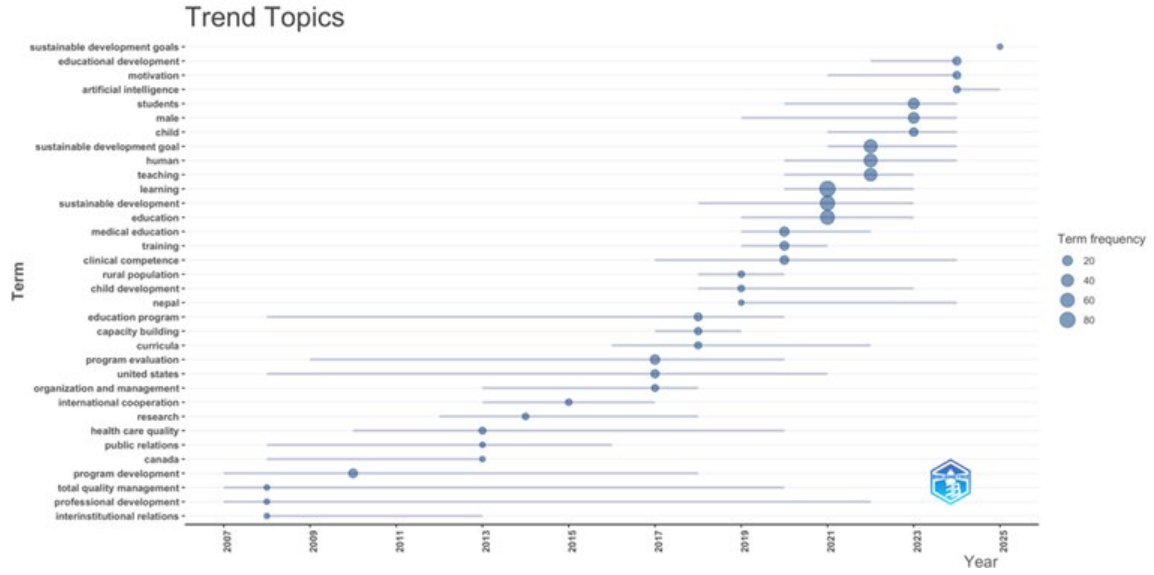

Figure 6. Trend topics (by author's keywords)

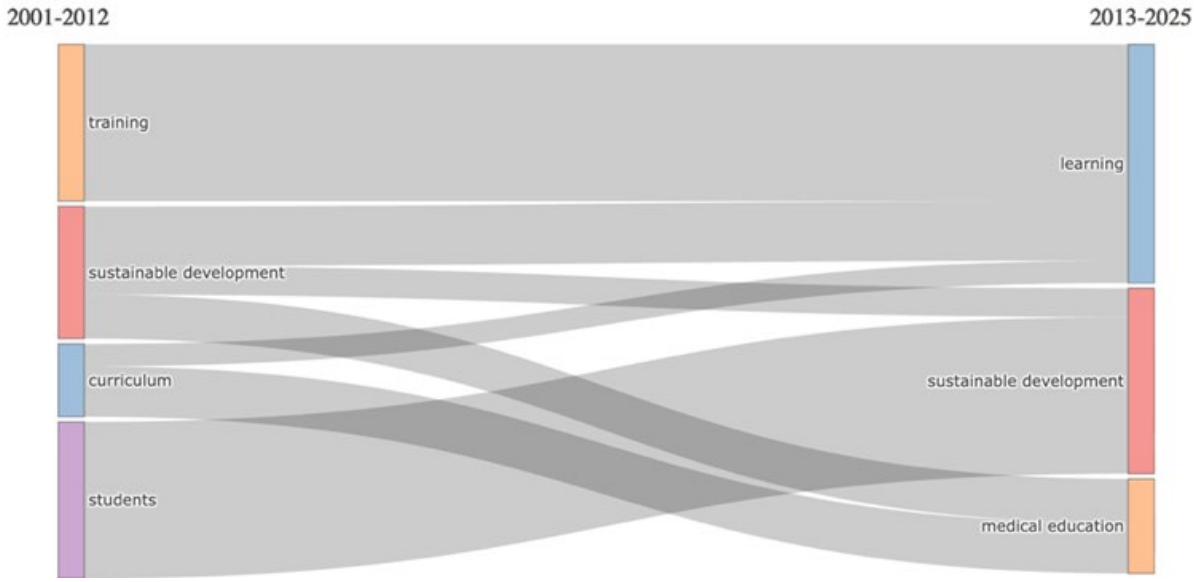

Figure 7. Thematic evolution

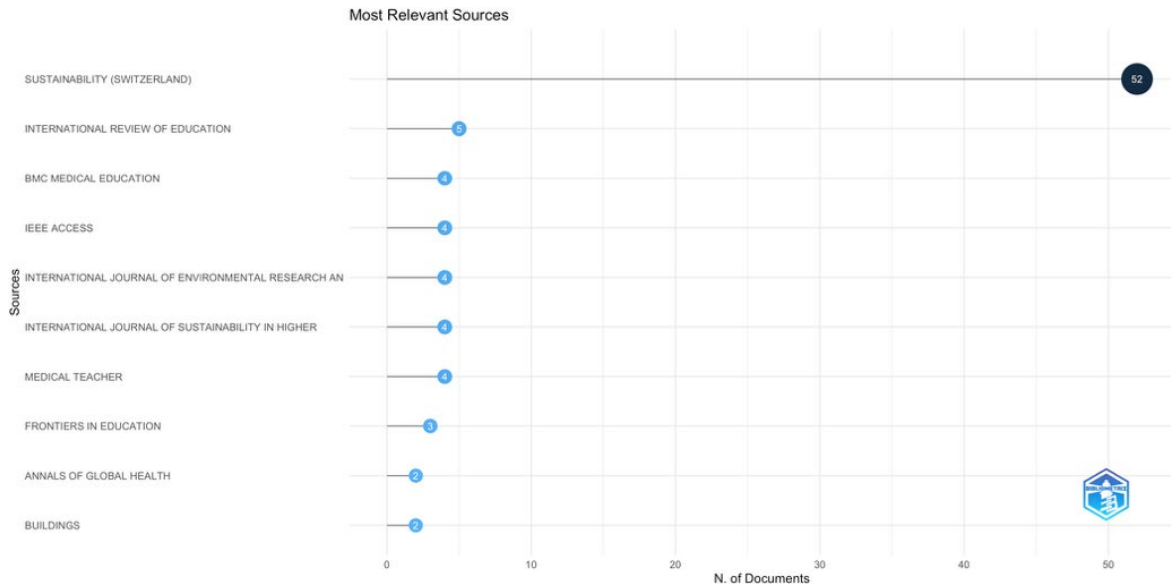

Figure 8. Top ten productive sources of publication

Table 2. Top ten most influential sources' local impact in the field

Source	h_index	g_index	m_index	TC	NP	PY_start
Sustainability (Switzerland)	20	35	1.538	1320	52	2013
International Journal of Environmental Research and Public Health	4	4	0.364	153	4	2015
International Review of Education	4	5	0.4	48	5	2016
IEEE Access	3	4	0.6	45	4	2021
International Journal of Sustainability in Higher Education	3	4	0.429	71	4	2019
Annals of Global Health	2	2	0.286	15	2	2019
BMC Medical Education	2	3	0.5	14	4	2022
Buildings	2	2	1	4	2	2024
Cogent Education	2	2	0.2	33	2	2016
Globalization and Health	2	2	0.154	35	2	2013

3.4 Most influential documents

The citation analysis of the most influential documents in the field highlights a small set of highly cited works that have shaped the theoretical and methodological development of learning evaluation in relation to the SDGs [17], with 374 citations, emerges as the most impactful publication, offering a comprehensive framework for integrating sustainable development into educational evaluation, and serving as a foundational reference for subsequent scholarship [35], cited 356 times, has advanced critical pedagogy and transformative learning perspectives, emphasizing the need for education systems to foster not only knowledge acquisition but also values and competencies aligned with sustainability. Giangrande et al. [4], with 141 citations, further reinforced the importance of embedding sustainability into competency-based education, thereby bridging curricular design with evaluative practices. Other highly cited works [21, 36, 37] extend the field by situating evaluation within medical education, teacher training, and environmental pedagogy, reflecting the diversification of contexts where sustainability-oriented evaluation is applied. These influential documents underscore the intellectual anchors of the field, providing theoretical clarity, practical models, and empirical validation for aligning evaluation practices with SDG 4. Their prominence also illustrates how scholarly impact is concentrated in works that combine conceptual innovation with direct implications for pedagogy, curriculum, and institutional reform. The enduring influence of these documents signals their pivotal role in guiding research agendas and in shaping policy-oriented discussions on inclusive and sustainability-driven education.

As displayed in Figure 9, the most cited countries concerning the evaluation of learning in relation to the SDGs are illustrative of citation influence and scholarly impact in global and transnational contexts. The United Kingdom is in the lead with 695 citations, followed by Spain (428), the Netherlands (367), and the United States (343). These countries demonstrate strong leadership in shaping relevant policy scholarship and intellectual discourse. China (300) and Brazil (156) emerged as contributors, showcasing the impact of research from emerging economies. On the other hand, Australia (108), Canada (94), Austria (77), and Mexico (74) demonstrate persistent citation influence, albeit to a lesser degree than other countries. All in all, the figure shows advanced economies are the primary drivers of citation influence, with emerging economies from the Global South becoming more visible. This highlights the slowly widening structure of research leadership in educational evaluation and sustainability.

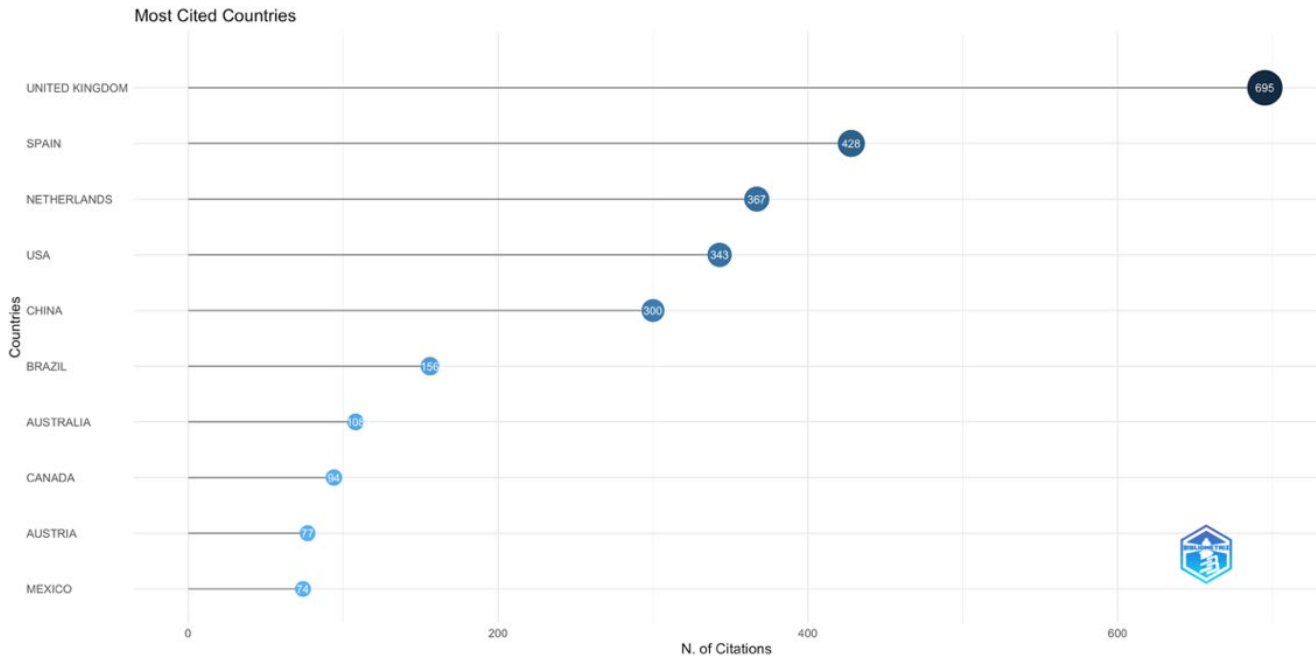

Figure 9. Most cited countries

3.5 Productive authors and affiliations

Figure 10 illustrates the production trends of the most influential and productive authors in the field of learning evaluation and the SDGs, highlighting both temporal activity and scholarly impact. Authors such as Sánchez-Martín J. (3 documents), Baena-Morales S. (2 documents), and Blanco-Salas J. (2 documents) demonstrate consistent productivity since 2020, with multiple contributions that have gained growing recognition. Dieck-Assad G. (2 documents) and González-Gómez D. (2 documents) appear as emerging contributors, with publications concentrated in the early 2020s. Including Lee H.-C. (2 documents) and Liu W.-H. (2 documents): show sustained engagement since 2016, while Wang Y. (3 documents) and Acosta-Vargas P. (2 documents) extend the field's global reach through their recent works.

Table 3, the ranking of the top ten published authors is displayed. Sánchez-Martín J heads the list with h-index and g-index of 3. In the total citations, González-Gómez D and Jeong JS are the leaders with 52 citations, followed by Sánchez-Martín J with (TC = 43) and then Blanco-Salas J with (TC = 40).

Figure 11 demonstrates that Queens University Belfast is the foremost institution contributing to the evaluation of the learning process and the SDGs, having published (N = 13). The University of the Basque Country UPV/EHU comes next with 11 publications. The remaining positions in the top seven are held by Universidad De Extremadura with (N = 10): Bond University (N = 9): University of Rwanda (N = 9): University of Wollongong (N = 9): the International Centre for Diarrhoeal Disease Research with (N = 8): Maynooth University (N = 8): Mohammed Bin Rashid University of Medicine and Health Sciences (N = 7): and Office of Public Health Scientific Services (N = 7).

The identification and analysis of the most impactful journal articles systematically provide researchers with substantial information on the foundational works which have contributed to the evolution of research in the domain, aiding in grasping the key ideas, concepts, theories, methods, and the socio-intellectual history of the research. This comprehension is fundamental in addressing emerging challenges for advancing new innovations and strategies.

Table 4 highlights the ten most globally cited papers in the field of learning evaluation within the context of the SDGs: underscoring the intellectual anchors that have shaped the trajectory of research. Kioupi and Voulvoulis [17], with 374 citations, provide one of the most influential frameworks for embedding sustainability in education, while Kopnina [35], cited 356 times, advances critical and transformative pedagogical approaches. Giangrande et al. [4], with 141 citations, emphasize competency-based education as a pathway to integrate sustainability skills into curricula, whereas De Carvalho-Filho et al. [36] contribute 136 citations by bridging sustainability with medical education and professional training. Lameiras-Fernández et al. [21] (88 citations) and El-Adaway et al. [38] (62 citations) extend these debates into specific disciplinary contexts such as teacher education and engineering. Saxena et al. [39] (62 citations) and Finnveden et al. [40] (55 citations) enrich the discussion by linking sustainable practices with organizational and institutional strategies, while Yan and Chiou [41] (55 citations) and Foster and Stagl [37] (50 citations) strengthen the evidence base on curriculum innovation and environmental education.

3.6 Network analysis

Figure 12 presents the co-citation analysis of references concerning learning evaluation within the context of SDGs as a clustered network. The red cluster, with the most prominent words sustainable development, student, learning, higher education, and sustainability, reveals the focus of the framework evaluation research which captures the relation between sustainability oriented reform and curriculum integration. The green cluster with human, procedures, adult, child, and female as its nodes reflect the studies which have been concerned with the demographic, social, and human development aspects of evaluation, showing the various populations within the learning evaluation. The blue cluster which has as its keywords program evaluation, systematic review, organization and management, global health, focuses on the methodological and policy oriented strands of the field, which have integrated educational evaluation at the institutional and cross-sectoral levels. The yellow cluster associates motivation, surveys, questionnaires, and medical students as applied evaluation in a professional and discipline-centered context. The red cluster is anchored by Kioupi and Voulvoulis [17] and Kopnina [35], who framed sustainable education and developed techniques for accelerated learning. Giangrande et al. [4] add to the red cluster with curriculum integration which contributes to competency-based education and sustainability. de Carvalho-Filho et al. [36] associate the yellow cluster with linking evaluation to medical education.

Table 5 presents the top ten countries with the highest number of corresponding authors contributing to research in this field. The distribution reflects both the geographical concentration of scholarly productivity and the global research capacity on the topic. As shown, certain countries consistently dominate in terms of publication output, indicating established research infrastructures, robust international collaboration networks, and sustained investment in the field. This overview highlights not only the global reach of the field but also the disparities across regions.

The thematic network reveals four major clusters: the red cluster focuses on integrating sustainable development within higher education; the green cluster highlights human-centered empirical research in medical and psychological learning; the blue cluster emphasizes evidence-based program evaluation in health and education; and the yellow cluster centers on experiential learning and curriculum development aimed at fostering learner motivation and engagement (see Figure 7).

Red cluster keywords: This cluster highlights the intersection of sustainable development and higher education. Prominent terms include sustainable development, learning, students, critical thinking, problem solving, and higher education. The cluster reflects an emphasis on embedding sustainability and cognitive skill development within university-level curricula and pedagogy.

Green cluster keywords: This cluster centers on empirical research involving human subjects, particularly in medical and psychological educational contexts. Terms such as human, female, child, young adult, and medical student suggest a focus on learning processes shaped by demographic and behavioral variables. The cluster is closely tied to clinical trials and educational psychology.

Blue cluster keywords: This cluster is concerned with the design and assessment of educational programs, especially within healthcare and public health. Key terms include program evaluation, systematic review, nursing education, and

developing countries. It emphasizes the integration of evidence-based evaluations to inform effective training and health education initiatives.

Yellow cluster keywords: This smaller cluster focuses on learner-centered approaches such as experiential learning, curriculum development, motivation, and awareness. It reflects educational research centered on active learning methodologies in early education and professional training.

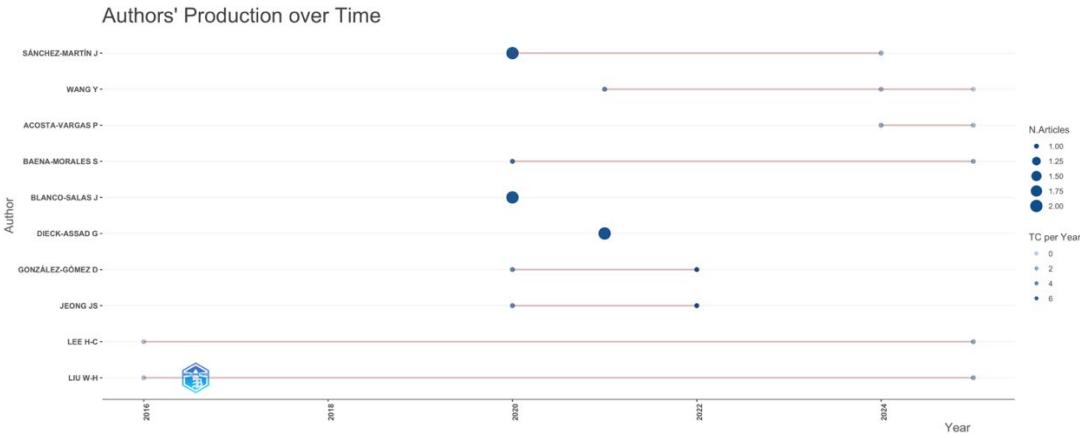

Figure 10. Top ten productive authors

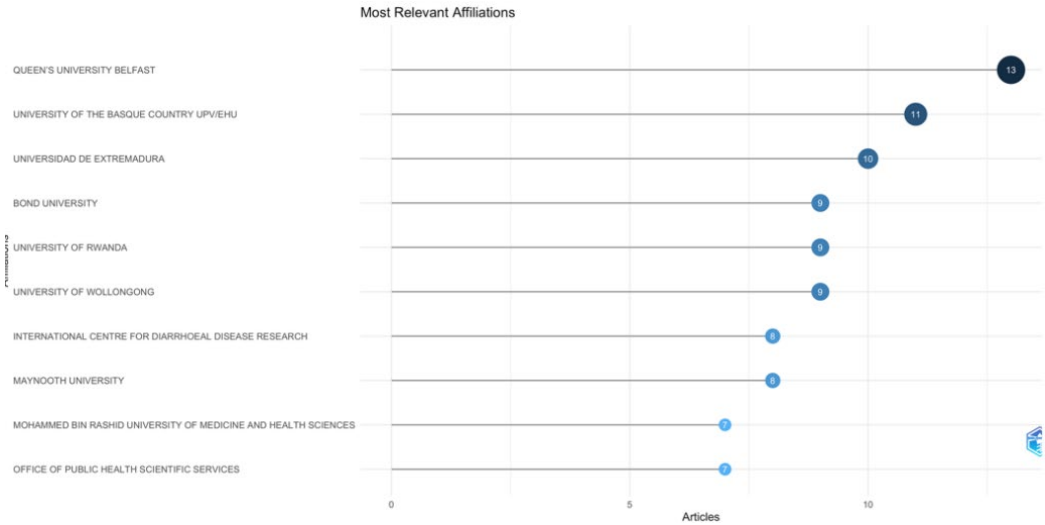

Figure 11. Top ten most productive affiliations

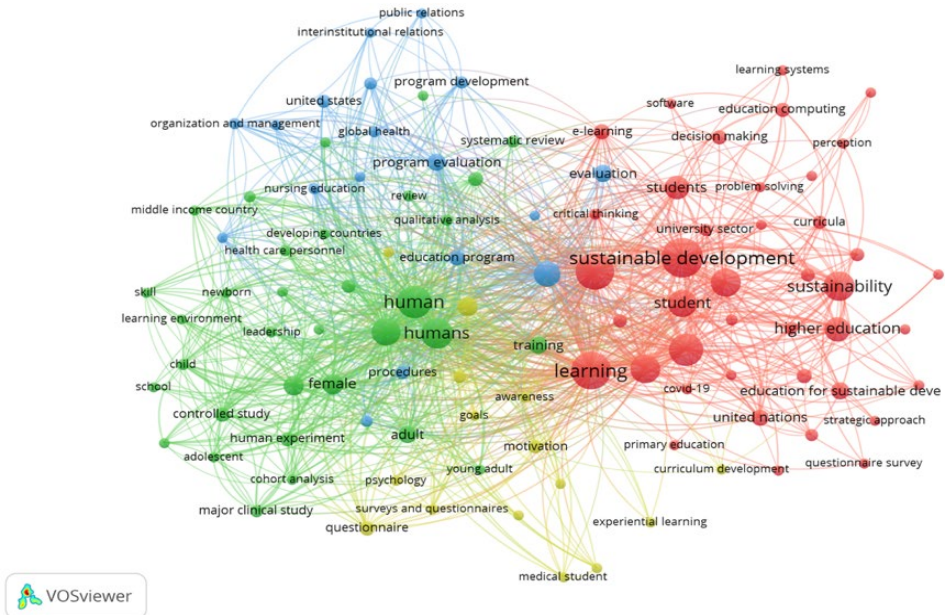

Figure 12. Network visualization

Table 3. Top ten most authors' local impact

Source	h_index	g_index	m_index	TC	NP	PY_start
Sánchez-Martín J	3	3	0.5	43	3	2020
Baena-Morales S	2	2	0.333	35	2	2020
Blanco-Salas J	2	2	0.333	40	2	2020
Dieck-Assad G	2	2	0.4	34	2	2021
González-Gómez D	2	2	0.333	52	2	2020
Jeong JS	2	2	0.333	52	2	2020
Lee H-C	2	2	0.2	8	2	2016
Liu W-H	2	2	0.2	8	2	2016
Ponguta LA	2	2	0.25	18	2	2018
Reyes CR	2	2	0.25	18	2	2018

Table 4. Top ten most globally cited papers

Refs.	DOI	Total Citations	TC per Year	Normalized TC
[17]	https://doi.org/10.3390/su11216104	374	53.43	5.65
[35]	https://doi.org/10.1080/00958964.2019.1710444	356	59.33	9.13
[4]	https://doi.org/10.3390/su11102832	141	20.14	2.13
[36]	https://doi.org/10.1080/0142159X.2018.1552782	136	22.67	3.49
[21]	https://doi.org/10.3390/ijerph18052555	88	17.60	4.24
[38]	https://doi.org/10.1061/(ASCE)EI.1943-5541.0000208	62	5.64	1.19
[39]	https://doi.org/10.1007/s43621-021-00029-8	62	12.40	2.99
[40]	https://doi.org/10.1108/IJSHE-09-2019-0287	55	9.17	1.41
[41]	https://doi.org/10.3390/su13094958	55	11.00	2.65
[37]	https://doi.org/10.1016/j.jclepro.2018.02.177	50	6.25	1.78

Table 5. Top ten most productive corresponding authors' countries in the field

Country	Articles	Articles %	SCP	MCP	MCP %
USA	25	12.6	18	7	28
Spain	22	11.1	19	3	13.6
China	21	10.6	20	1	4.8
United Kingdom	17	8.6	8	9	52.9
Australia	9	4.5	5	4	44.4
India	6	3	4	2	33.3
Canada	5	2.5	1	4	80
Ecuador	4	2	1	3	75
Germany	4	2	2	2	50
Indonesia	4	2	4	0	0

4. DISCUSSION

The outcomes highlight a scholarship's change regarding learning assessment in relation to the SDGs. Publications on SDG 4 (Quality Education) increased significantly after 2015 [23]. While the responsiveness of educational research is noteworthy, the sustainability and coherence of evaluative frameworks are worrisome. Emerging intellectual foundations include interdisciplinary constructs that integrate education, environmental studies, and even digital innovation, such as the journal Sustainability (Switzerland) [3]. Most of the research published in a few journals, however, stifles diversity and increases the risk of fragmentation. There is a strong need to reach out to a wider audience.

The contribution data gaps are clearly defined with the United States, Spain, China, and the United Kingdom dominating the data and contribution gaps. This shows how the United States, Spain, China, and the UK, alongside other advanced economies, have a dominating structural advantage towards research production as the limited resources from developing countries hinders them from participating further [16]. Encouraging emerging participation from countries such as Indonesia and Ecuador is a promising sign that under the support from collaborative frameworks, inclusivity is possible. Cross-national partnerships indeed support the inclusivity aim as they add visibility and citation impact. This is shown through the UK and Canada and Ecuador which have a high rate of international co-authorship [42]. China, on the other hand, highly lacks the rate of international collaboration which demonstrates isolation, indicating that they need to broaden the scope of collaboration to diversify the cultural and contextual frameworks for evaluation.

Thematic mapping identifies four principal pedagogic clusters inclusive pedagogy, digital evaluation, teacher professional development, and competency-based learning that shape the intellectual topography of the discipline. Inclusive pedagogy prioritizes equity and access, advocating for education that meets the needs of all learners [11]. Digital evaluation focuses on technology's ability to transform assessment at both scale and personalization [5]. Teacher professional development is critical for sustainability-oriented reforms because of the influential role that teachers as professionals have on the impacts that reforms bring [16]. Competency-based learning moves away from rote and passive knowledge to more sustainable cross-cutting skills like, problem solving, teamwork, and critical thinking [4]. The evolution of themes is increasingly sophisticated, narrowing from focuses on sustainability to more specialized fronts like, artificial intelligence, automated feedback, and culturally

responsive teaching [14, 15, 26, 29]. Influential publications [4, 17, 35] explore the connections between sustainability and transformative pedagogy and evaluation, inspiring theoretical and empirical advancements. However, the focus on a singular, foundational body of work introduces a distinct risk of becoming too reliant on dominant theories and overlooking alternative perspectives. Regional analyses illustrate further differences: Europe and North America focus on policy integration and institutional change; Asia, on technology and scalability; and the Global South, on equity and access [14, 15]. This variety, while intellectually enriching, poses challenges towards constructing universal frameworks.

The use of educational technology presents opportunities for personalization and access, it risks widening existing disparities without proactive measures to bridge the digital divide. Formative assessment is a process whereby information is evaluated and learning activities are evaluated to determine whether the learning objectives in the classroom have been achieved and to assess students' academic performance [15, 27]. The research demonstrates the longitudinal timeline of the integration of sustainability education, evaluation theory, and digital innovation. This confluence highlights an ever-evolving future of value, one marked by the potential for evaluation to be driven by technology, yet steeped in cultural appreciation and inclusivity. Still, the evaluating learning with the SDGs largely showcases the uniqueness of the interdisciplinary and policy-oriented innovation in the global south, revealing attempts to address enduring inequities. In the future, the path forward depends on the degree to which new technologies can be integrated while considering the socio-cultural context, which will make sure evaluation goes beyond measuring learning to actively supporting the transformative vision of SDG 4.

Bibliometric trend analysis indicates that the marked increase in publications coincides with the formal adoption of the United Nations Sustainable Development Goals in 2015. Prior to 2015, the annual output of publications on learning evaluation and education averaged fewer than 50 per year; this number rose to more than 200 annually in the years following SDG 4's adoption. Keyword co-occurrence analysis reveals that terms directly related to SDG 4 (e.g., "quality education," "inclusive education," "lifelong learning") began to appear with greater frequency after 2015, suggesting a thematic alignment between global policy initiatives and scholarly output. These patterns should be interpreted with caution, as bibliometric indicators are inherently descriptive and subject to citation, language, and database coverage biases. Therefore, while the observed clusters and trends provide valuable insights into the intellectual landscape of learning evaluation research, they should not be read as causal or exhaustive representations of the field.

5. CONCLUSION

This study has shown that academic research focusing on learning evaluation concerning the SDGs has grown considerably since 2001, motivated by the international initiative SDG 4 on Quality Education. The study's bibliometric analysis of 198 publications not only focused on major thematic clusters, which included inclusive pedagogy, digital evaluation, teacher professional development, and competency-based learning, but also brought to light new frontiers of the field such as technology in formative evaluation and culturally responsive pedagogy. The findings underscore persistent asymmetries in global research productivity, with the Global North dominating output but the Global South increasingly contributing critical perspectives. Discussion of these results suggests that while the field is moving toward more technologically advanced and context-sensitive evaluation practices, challenges remain in addressing equity, cultural inclusivity, and long-term effectiveness. The study contributes to the body of knowledge by providing a comprehensive mapping of the intellectual and thematic structure of this research domain, offering evidence-based insights for policymakers, educators, and scholars. Future research should explore culturally responsive and technologically mediated evaluation practices in greater depth, with an emphasis on comparative perspectives across diverse contexts. Future bibliometric studies should therefore integrate multiple databases and languages and test parameter sensitivity to strengthen generalizability and robustness.

REFERENCES

[1] Barrett, A.M., Bainton, D. (2016) Re-interpreting relevant learning: An evaluative framework for secondary education in a global language. Comparative Education, 52(3): 392-407. https://doi.org/10.1080/03050068.2016.1185271

[2] Edwards Jr, D.B., Sustarsic, M., Chiba, M., McCormick, M., Goo, M., Perriton, S. (2020). Achieving and monitoring education for sustainable development and global citizenship: A systematic review of the literature. Sustainability, 12(4): 1383. https://doi.org/10.3390/su12041383

[3] Ducl, V., Çaro, E., Kapllanaj, M. (2024). Integrating ICT in vocational education and training: Expectations, challenges, and the path towards modernisation. Journal of Research, Innovation and Technologies, 3(2): 109-118. https://doi.org/10.57017/jorit.v3.2(6).02

[4] Giangrande, N., White, R.M., East, M., Jackson, R., et al. (2019). A competency framework to assess and activate education for sustainable development: Addressing the UN Sustainable Development Goals 4.7 challenge. Sustainability, 11(10): 2832. https://doi.org/10.3390/su11102832

[5] Jordanova, T., Cronk, R., Obando, W., Medina, O.Z., Kinoshita, R., Bartram, J. (2015). Water, sanitation, and hygiene in schools in low socio-economic regions in Nicaragua: A cross-sectional survey. International Journal of Environmental Research and Public Health, 12(6): 6197-6217. https://doi.org/10.3390/ijerph120606197

[6] Podoliak, M., Zagranovska, O., Posmitna, V., Golovchak, N., Kushnirchuk, O. (2025). Evaluating the impact of AI-based tools on language proficiency and motivation: Experimental evidence from philology students in Ukraine. Journal of Research, Innovation and Technologies, 4(3): 271-282. https://doi.org/10.56578/jorit040303

[7] GAIKWAD, S.S., Wadegaonkar, A., Dib, F.K. (2025). Rewiring andragogy: The teaching-learning-evaluation (TLE) hackathon blueprint. Frontiers in Education, 10: 1633267. https://doi.org/10.3389/feduc.2025.1633267

[8] Burhin, M., Isom, V., Ogaoga, D., Devine, S., et al. (2024). Child health nurses in Solomon Islands, piloting

the 'Bachelor of nursing: Child health'. International Nursing Review, 71(1): 44-53. https://doi.org/10.1111/inr.12836
[9] Boned-Gómez, S., Ferriz-Valero, A., Baena-Morales, S. (2025). Education for sustainability: Analysing the Spanish curriculum in primary education and physical education. Curriculum Studies in Health and Physical Education, 1-18. https://doi.org/10.1080/25742981.2025.2466543
[10] Badran, A.S., Keraa, K., Farghaly, M.M. (2022). Applying the Kirkpatrick model to evaluate dental students' experience of learning about antibiotics use and resistance. European Journal of Dental Education, 26(4): 756-766. https://doi.org/10.1111/eje.12758
[11] Matus, N., Botella, F., Rusu, C. (2025). SteXMeC: A student eXperience evaluation methodology with cultural aspects. Applied Sciences, 15(10): 5314. https://doi.org/10.3390/app15105314
[12] Wang, Y., Liu, Z., Tu, C. (2025). Advancing Sustainable Development Goal 4 through a scholarship of teaching and learning: The development and validation of a student-centered educational quality scale in developing countries. Sustainability, 17(10): 4369. https://doi.org/10.3390/su17104369
[13] Liu, Z., Yang, H.C., Shiau, Y.C. (2020). Investigation on evaluation framework of elementary school teaching materials for sustainable development. Sustainability, 12(9): 3736. https://doi.org/10.3390/su12093736
[14] Göç, N., Hassan, S., Bani, I., Babiker, S., Hilali, M., Ibrahim, Z., Gaddal, A., Saleh, L., Salih, E.M., Desai, M.M., Linnander, E. (2022). Strengthening public health scholarship in Sudan: The role of leadership and mentorship development. The American Journal of Tropical Medicine and Hygiene, 107(6): 1323-1330. https://doi.org/10.4269/ajtmh.22-0377
[15] Gutiérrez-García, L., Blanco-Salas, J., Sánchez-Martín, J., Ruiz-Téllez, T. (2020). Cultural sustainability in ethnobotanical research with students up to K-12. Sustainability, 12(14): 5664. https://doi.org/10.3390/su12145664
[16] Rodriguez-Dono, A., Hernández-Fernández, A. (2021). Fostering sustainability and critical thinking through debate—A case study. Sustainability, 13(11): 6397. https://doi.org/10.3390/su13116397
[17] Kioupi, V., Voulvoulis, N. (2019). Education for sustainable development: A systemic framework for connecting the SDGs to educational outcomes. Sustainability, 11(21): 6104. https://doi.org/10.3390/su11216104
[18] Lai, Y.C., Peng, L.H. (2019). Effective teaching and activities of excellent teachers for the sustainable development of higher design education. Sustainability, 12(1): 28. https://doi.org/10.3390/su12010028
[19] Renta-Davids, A.I., Camarero-Figuerola, M., Tierno-García, J.M. (2020). Assessment of the quality education awareness competence of pre-service educators using vignettes. Sustainability, 12(23): 10203. https://doi.org/10.3390/su122310203
[20] Engebretsen, E. (2024). Towards a transformative health humanities approach in teaching the Sustainable Development Goals (SDGs). Medical Humanities, 50(4): 740-747. https://doi.org/10.1136/medhum-2023-012855
[21] Lameiras-Fernández, M., Martínez-Román, R., Carrera-Fernández, M.V., Rodríguez-Castro, Y. (2021). Sex education in the spotlight: What is working? Systematic review. International Journal of Environmental Research and Public Health, 18(5): 2555. https://doi.org/10.3390/ijerph18052555
[22] Jeong, J.S., González-Gómez, D. (2020). Assessment of sustainability science education criteria in online-learning through fuzzy-operational and multi-decision analysis and professional survey. Heliyon, 6(8): e04706. https://doi.org/10.1016/j.heliyon.2020.e04706
[23] Barrett, A.M., Bainton, D. (2016): Re-interpreting relevant learning: An evaluat ive framework for secondary education in a global language. Comparative Education, 52(3): 392-407. https://doi.org/10.1080/03050068.2016.1185271
[24] Maguire, K., O'Connor, N., Condron, R., Archbold, P., Hannevig, C., Honan, D. (2024). Examining the alignment of tourism management related curriculum with the United Nations Sustainable Development Goals (SDG's) in higher education institutions in Ireland. Sustainability, 16(19): 8554. https://doi.org/10.3390/su16198554
[25] Campbell, C., Hobbs, L., Xu, L., McKinnon, J., Speldewinde, C. (2022). Girls in STEM: Addressing SDG 4 in context. Sustainability, 14(9): 4897. https://doi.org/10.3390/su14094897
[26] Aquino-Llinares, N., Moreno-Navarro, P. (2022). Engaging environmental sciences students in statistics through an inclusive experience in a Spanish University. Sustainability, 14(14): 8352. https://doi.org/10.3390/su14148352
[27] Abdelmagid, A.S., Jabli, N.M., Al-Mohaya, A.Y., Teleb, A.A. (2025). Integrating interactive metaverse environments and generative artificial intelligence to promote the green digital economy and e-entrepreneurship in higher education. Sustainability, 17(12): 5594. https://doi.org/10.3390/su17125594
[28] Gómez-Ruiz, M.L., Morales-Yago, F.J., de Lázaro-Torres, M.L. (2021). Outdoor education, the enhancement and sustainability of cultural heritage: Medieval Madrid. Sustainability, 13(3): 1106. https://doi.org/10.3390/su13031106
[29] Nakamoto, R., Flanagan, B., Dai, Y., Yamauchi, T., Takami, K., Ogata, H. (2023). Enhancing self-explanation learning through a real-time feedback system: An empirical evaluation study. Sustainability, 15(21): 15577. https://doi.org/10.3390/su152115577
[30] Sposato, M. (2025). A call for caution and evidence–based research on the impact of artificial intelligence in education. Quality Education for All, 2(1): 158-170. https://doi.org/10.1108/QEA-09-2024-0087
[31] Piramanayagam, S., Mallya, J., Payini, V. (2023). Sustainability in hospitality education: Research trends and future directions. Worldwide Hospitality and Tourism Themes, 15(3): 254-268. https://doi.org/10.1108/WHATT-02-2023-0021
[32] Wang, J., Zhang, H., Tian, Z. (2024). Research on evaluation model of physical education learning and training effect of college students based on data mining technology. International Journal of High Speed Electronics and Systems, 2540040. https://doi.org/10.1142/S0129156425400403
[33] Zyoud, S. (2024). Unveiling the potential of biomarkers in the context of climate change: Analysis of knowledge landscapes, trends, and research priorities. Regional

Environmental Change, 24(2): 76. https://doi.org/10.1007/s10113-024-02246-z
[34] Uchima-Marin, C., Murillo, J., Salvador-Acosta, L., Acosta-Vargas, P. (2024). Integration of technological tools in teaching statistics: Innovations in educational technology for sustainable education. Sustainability, 16(19): 8344. https://doi.org/10.3390/su16198344
[35] Kopnina, H. (2020). Education for the future? Critical evaluation of education for sustainable development goals. The Journal of Environmental Education, 51(4): 280-291. https://doi.org/10.1080/00958964.2019.1710444
[36] de Carvalho-Filho, M.A., Tio, R.A., Steinert, Y. (2020). Twelve tips for implementing a community of practice for faculty development. Medical Teacher, 42(2): 143-149. https://doi.org/10.1080/0142159X.2018.1552782
[37] Foster, G., Stagl, S. (2018). Design, implementation, and evaluation of an inverted (flipped) classroom model economics for sustainable education course. Journal of Cleaner Production, 183: 1323-1336. https://doi.org/10.1016/j.jclepro.2018.02.177
[38] El-Adaway, I., Pierrakos, O., Truax, D. (2015). Sustainable construction education using problem-based learning and service learning pedagogies. Journal of Professional Issues in Engineering Education and Practice, 141(1): 05014002. https://doi.org/10.1061/(ASCE)EI.1943-5541.0000208
[39] Saxena, A., Ramaswamy, M., Beale, J., Marciniuk, D., Smith, P. (2021). Striving for the United Nations (UN) sustainable development goals (SDGs): What will it take? Discover Sustainability, 2(1): 20. https://doi.org/10.1007/s43621-021-00029-8
[40] Finnveden, G., Friman, E., Mogren, A., Palmer, H., et al. (2020). Evaluation of integration of sustainable development in higher education in Sweden. International Journal of Sustainability in Higher Education, 21(4): 685-698. https://doi.org/10.1108/IJSHE-09-2019-0287
[41] Yan, W.J., Chiou, S.C. (2021). The safeguarding of intangible cultural heritage from the perspective of civic participation: The informal education of Chinese embroidery handicrafts. Sustainability, 13(9): 4958. https://doi.org/10.3390/su13094958
[42] Lee, J., Tan, E., Barrow, J., Bocala, C., Seymour, B. (2021). Crossing the innovation chasm: Identifying facilitators and barriers to early adoption of the global health starter kit curriculum. Annals of Global Health, 87(1): 113. https://doi.org/10.5334/aogh.3356