

SUPPLEMENTARY MATERIAL S1

PRISMA 2020 Checklist

Education for Sustainable Development in Higher Education: Bibliometric Analysis of Trends, Innovations and Institutional Commitment to the SDGs (2018–2025)

Item #	Topic	PRISMA 2020 Checklist Item	Location / Response
TITLE			
1	Title	Identify the report as a systematic review.	Addressed. The title explicitly states 'Bibliometric Analysis' and the manuscript is framed as a PRISMA 2020-guided systematic bibliometric review throughout.
ABSTRACT			
2	Abstract	See the PRISMA 2020 for Abstracts checklist (table 2).	Addressed. The abstract identifies the study as a PRISMA 2020-guided bibliometric analysis, reports the database (Scopus), the period (2018–2025), the number of included studies (n = 126), the key findings, and the main conclusions.
INTRODUCTION			
3	Rationale	Describe the rationale for the review in the context of existing knowledge.	Addressed. Sections 1.1–1.8 establish the rationale: the growing mandate of higher education in the 2030 Agenda, the exponential growth of ESD literature (1 article in 2018 → 32 in 2025), and the documented gap between pedagogical innovation and institutional governance.
4	Objectives	Provide an explicit statement of the objective(s) or question(s) the review addresses.	Addressed. Section 1.4 states the main objective (bibliometric analysis of ESD and Institutional Commitment in HE, 2018–2025) and three specific objectives: (1) quantifying growth dynamics, (2) modelling the intellectual structure via clustering, and (3) predicting the emerging research agenda.
METHODS			
5	Eligibility criteria	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	Addressed. Section 2.3 defines criteria using the PICo framework (Population: Higher Education; Intervention: ESD/SDGs; Outcome: Engagement/Innovation). Table 3 (Exclusion Criteria Matrix) details specific reasons for exclusion at both screening and eligibility phases.
6	Information sources	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched.	Addressed. Scopus was the sole database used. The search covered articles published from 2018 to 2025. Data were extracted on 23 November 2025 (accessed date confirmed in Section 2.1).
7	Search strategy	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	Addressed. Table 1 presents the full Scopus search equation in Advanced mode using TITLE-ABS-KEY fields with Boolean operators, covering all three conceptual axes of the study. Filters included document type (articles), language (English/Spanish), and time period (2018–2025).
8	Selection process	Specify the methods used to decide whether a study met the inclusion criteria, including how many reviewers screened each record and how they worked.	Addressed. Section 2.3 specifies that screening was conducted independently by two authors (C.F.H.V. and J.A.L.A.) at both the title/abstract and full-text

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			eligibility stages. Disagreements were resolved by consensus; where consensus could not be reached, a third author (L.F.G.G.) acted as arbiter.
9	Data collection process	Specify the methods used to collect data from reports, including how many reviewers collected data and whether they worked independently.	Addressed. Bibliometric data were extracted from Scopus in CSV format (November 2025) using the full record and cited references export option. Data were imported into Bibliometrix (v.4.x; Aria & Cuccurullo, 2017) for cleaning and deduplication. Two authors independently verified a random 10% sample against the original Scopus records; no discrepancies were found. See Section 2.1.
10a	Data items – outcomes	List and define all outcomes for which data were sought.	Addressed. The study's outcomes are bibliometric indicators: annual publication trends, authorship and co-authorship patterns, keyword co-occurrence networks, country-level production, and thematic cluster evolution over time.
10b	Data items – other variables	List and define all other variables for which data were sought (e.g. participant and intervention characteristics).	Addressed. The following variables were extracted from each record: (1) publication year; (2) document type; (3) source title; (4) authors and co-authors; (5) institutional affiliation and country; (6) author keywords and indexed keywords (Scopus thesaurus); (7) abstract text; (8) total citation count at extraction date; and (9) DOI. See Section 2.1.
11	Study risk of bias assessment	Specify the methods used to assess risk of bias in the included studies.	Addressed. See Section 2.6 of the manuscript. Individual study-level risk of bias assessment (e.g., RoB 2, ROBINS-I) is not applicable to this bibliometric study. The methodological quality of the retrieved corpus is addressed through the PICO-structured eligibility criteria (Section 2.3), which excluded studies lacking a verifiable research methodology. The primary source of corpus-level bias — coverage bias from single-database reliance on Scopus — is explicitly acknowledged in Section 4.5 (Limitations).
12	Effect measures	Specify for each outcome the effect measure(s) used in the synthesis or presentation of results.	Not applicable. This study does not calculate effect measures (e.g., risk ratios, mean differences). Bibliometric indicators (publication counts, co-occurrence frequencies, centrality measures in VOSviewer networks) serve as descriptive quantitative measures.
13a	Synthesis methods	Describe the processes used to decide which studies were eligible for each synthesis.	Addressed. All 126 studies meeting inclusion criteria were included in the full bibliometric synthesis. No sub-group exclusions were applied at the synthesis stage; all eligible articles contributed to all analytical dimensions.
13b	Synthesis methods	Describe any methods required to prepare the data for presentation or synthesis.	Addressed. Raw Scopus metadata was imported into Bibliometrix (R package) for cleaning and standardisation. Author names, country affiliations, and keywords were normalised prior to network analysis. Duplicate records (n = 2) were identified and removed during Bibliometrix import.
13c	Synthesis methods	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	Addressed. Results are presented through: bar charts (annual production, country output), VOSviewer co-occurrence network maps (Figure 4), Sankey diagrams (Figures 7 and 9), word clouds (Figure 5), and stacked keyword frequency charts (Figures 6 and 8).
13d	Synthesis methods	Describe any methods used to synthesise results and provide a rationale for the choice(s).	Addressed. Keyword co-occurrence analysis was performed in VOSviewer (v.1.6.20; Van Eck & Waltman, 2010) with a minimum co-occurrence threshold of 2 and a modularity-based clustering algorithm (resolution parameter = 1.0).

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			Thematic evolution was mapped using the thematicEvolution() function in Bibliometrix with a time-slice division at 2021 to distinguish early-phase (2018–2021) from consolidation-phase (2022–2025) production. See Section 2.4.
13e	Synthesis methods	Describe any methods used to explore possible causes of heterogeneity among study results.	Addressed in context. Heterogeneity in publication patterns is explored by temporal analysis (Figure 8), country of origin (Figure 3), author productivity (Figures 7 and 9), and disciplinary focus, identifying the structural shift from pedagogical to governance-oriented clusters.
13f	Synthesis methods	Describe any sensitivity analyses conducted to assess robustness of the synthesised results.	Not formally conducted as a separate analysis. Robustness of keyword clustering was assessed by varying VOSviewer co-occurrence thresholds (2 and 3 tested), yielding consistent 4-cluster structures in both cases.
14	Reporting bias assessment	Describe any methods used to assess risk of bias due to missing results in a synthesis.	Addressed as a limitation. The exclusive use of Scopus may introduce indexing bias, as journals not covered by Scopus are excluded. This is acknowledged in the limitations section of the Discussion. No formal funnel plot or Egger test was applied, as these are not applicable to bibliometric synthesis.
15	Certainty assessment	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	Addressed. See Section 2.8 of the manuscript. Formal certainty frameworks such as GRADE are not applicable to bibliometric analyses. Confidence in the findings rests on three methodological pillars: (1) a reproducible, single-date search strategy (Section 2.2); (2) a dual-reviewer screening protocol with arbiter-based conflict resolution (Section 2.3); and (3) a sensitivity analysis confirming the four-cluster solution is stable across VOSviewer threshold variations (Section 2.7).
RESULTS			
16a	Study selection	Describe the results of the search and selection process, ideally using a flow diagram.	Addressed. Section 2.3 and the PRISMA 2020 flow diagram (Figure 1) detail the full selection process: 390 records identified in Scopus → 2 duplicates removed → 388 screened → 236 excluded (thematic irrelevance) → 152 full texts assessed → 26 excluded (off-topic n=14; no clear methodology n=8; scope not relevant n=4) → 126 studies included.
16b	Study selection	Cite studies that might appear to meet the inclusion criteria but were excluded, and explain why.	Partially addressed. Table 3 (Exclusion Criteria Matrix) provides detailed categorical reasons for exclusion. Individual citation of excluded studies was not undertaken, consistent with standard bibliometric review practice.
17	Study characteristics	Cite each included study and present its characteristics.	Addressed. The characteristics of the 126 included studies are presented through bibliometric indicators across Sections 3.1–3.5: publication year, authorship, country, journal, citation count, and keyword profiles. Individual studies are cited in the reference list.
18	Risk of bias in studies	Present assessments of risk of bias for each included study.	Not applicable. Individual risk of bias assessment is not applicable to bibliometric analyses. The methodological quality of the bibliometric process itself is described in Section 2 and limitations are addressed in the Discussion.

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19	Results of individual studies	For all outcomes, present summary statistics for each study.	Addressed in aggregate. Results are presented at the corpus level, standard for bibliometric research: annual output (Figure 2), country production (Figure 3), author productivity (Figure 9), and keyword frequencies (Figures 4–8).
20a	Results of syntheses	Briefly summarise the characteristics and risk of bias among studies contributing to each synthesis.	Addressed. The 126 studies are summarised: 46.8% published in 2024–2025; predominance of contributions from Latin America, Europe, and Australia; concentration in journals dedicated to sustainability and higher education.
20b	Results of syntheses	Present results of all statistical syntheses conducted.	Addressed. Results are presented for all syntheses: (1) keyword co-occurrence networks with 4 clusters (Figure 4); (2) temporal keyword evolution (Figures 6 and 8); (3) collaborative networks — country Sankey (Figure 7) and author-keyword Sankey (Figure 9); (4) word cloud (Figure 5).
20c	Results of syntheses	Present results of all investigations of possible causes of heterogeneity among study results.	Addressed. Temporal analysis (Figures 6 and 8) identifies the structural shift from the Pedagogical Innovation cluster (dominant pre-2022) to the Strategic Governance cluster (dominant 2023–2025) as the principal source of thematic heterogeneity.
20d	Results of syntheses	Present results of all sensitivity analyses.	Not formally applicable. Consistency of cluster structures across VOSviewer threshold variations (thresholds 2 and 3) confirmed robustness of the 4-cluster solution.
21	Reporting biases	Present assessments of risk of bias due to missing results for each synthesis assessed.	Addressed as a limitation. Single-database reliance (Scopus) is acknowledged as a potential coverage bias. The Discussion notes that articles in non-indexed journals or grey literature may not be captured.
22	Certainty of evidence	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	Not applicable. Formal certainty assessment (e.g., GRADE) is not applicable to bibliometric analyses. The Discussion contextualises findings within the broader ESD literature and addresses limitations affecting confidence in the results.
DISCUSSION			
23a	Discussion	Provide a general interpretation of the results in the context of other evidence.	Addressed. The Discussion interprets the four-cluster structure and the governance shift in the context of existing theoretical frameworks (Leal Filho et al., Manteaw, Wright, and others cited in the Introduction), confirming the field's transition to strategic maturity.
23b	Discussion	Discuss any limitations of the evidence included in the review.	Addressed. Limitations discussed include: (1) reliance on a single database (Scopus); (2) possible language bias toward English-language publications; (3) exclusion of grey literature and conference proceedings; (4) inherent limitations of bibliometric methods in capturing qualitative nuance.
23c	Discussion	Discuss any limitations of the review processes used.	Addressed. Methodological limitations include: (1) the co-occurrence threshold choices in VOSviewer may affect cluster granularity, mitigated by the sensitivity analysis reported in Section 2.7; (2) temporal cut-off at November 2025 means that publications from the final weeks of 2025 are only partially captured, and production figures for 2025 should be understood as provisional.

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23d	Discussion	Discuss implications of the results for practice, policy, and future research.	Addressed. The Conclusions section derives practical implications for HEI governance, policy recommendations for SDG-aligned institutional frameworks, and identifies future research directions including impact assessment methodologies and disciplinary specialisation in engineering education.
OTHER INFORMATION			
24a	Registration and protocol	Provide registration information for the review, or state that the review was not registered.	Addressed. The PRISMA 2020 Compliance Statement in Section 2 explicitly states that prospective registration (e.g., PROSPERO) was not applicable given the retrospective bibliometric nature of the study using a pre-existing Scopus database.
24b	Registration and protocol	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	Addressed. No formal protocol was prepared prior to the review, consistent with the retrospective and exploratory bibliometric nature of the study. The PRISMA Compliance Statement in Section 2 addresses this.
24c	Registration and protocol	Describe and explain any amendments to information provided at registration or in the protocol.	Not applicable. No registration or protocol was prepared; therefore, no amendments apply.
25	Support	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors.	This research was funded by Universidad Continental. The APC was funded by Universidad Continental . https://ucontinental.edu.pe/ Universidad Continental S.A.C. R.U.C. No. 20319363221
26	Competing interests	Declare any competing interests of review authors.	The authors declare no conflicts of interest. The funder had no role in the design of the study; in the collection, analysis, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.
27	Availability of data, code, and materials	Report which of the following are publicly available and where: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials.	Addressed. The bibliometric dataset was extracted from Scopus (publicly accessible). Bibliometrix (R package, open-source) and VOSviewer (free software) were used for analysis. The full search equation is reported in Table 1. Authors may consider depositing the Scopus export file in an open repository (e.g., OSF, Zenodo) prior to publication.