REVISTA INVECOM
ISSN en línea: 2739-0063

Universal design for learning and inclusive education: A bibliometric analysis

Diseño universal para el aprendizaje y la educación inclusiva: un análisis bibliométrico

Received: 15/08/2026 - **Accepted:** 03/11/2026

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How to cite this article:
Hinostroza-Noa, J., Díaz-Sulca, L., & Alca Gómez, A. (2026). Universal design for learning and inclusive education: A bibliometric analysis. *Revista InveCom*, *6*(Núm. Especial 3), 1-15. https://doi.org/10.5281/zenodo.24263356

Abstract

The present study aimed to characterize the evolution of research on Universal Design for Learning (UDL), with particular interest in inclusive education and rural contexts. To this end, a descriptive bibliometric and science-mapping analysis was conducted using a Scopus CSV export obtained in October 2026. Of the 1,802 initial records, three duplicates, two errata, and one retracted document were excluded, resulting in a corpus of 1,796 publications published between 1999 and 2026. Publication trends, document types, citations, sources, authors, country affiliations, author keywords, and cited references were examined; in addition, keyword co-occurrence maps and reference co-citation maps were generated. The corpus received 17,461 citations, with a mean of 9.72 and a median of 2. Scientific output reached 351 records in 2025 and 467 records assigned to 2026, although the latter corresponds to an incomplete year. The United States accounted for the largest number of affiliation-linked documents, with 721 publications. Furthermore, disability and neurodiversity (915), digital technology (814), and higher education (664) emerged as central themes. In contrast, only 41 documents matched the automated indicators related to rural, remote, or intercultural contexts. The findings show that research on UDL constitutes an expanding and thematically diverse field with identifiable intellectual foundations. Nevertheless, there remains a need to develop context-sensitive studies, particularly in rural settings. Finally, bibliometric findings should be interpreted with caution, as they do not constitute causal evidence of the effectiveness of educational interventions.

Keywords: Universal Design for Learning, inclusive education, rural education.

Resumen

El presente estudio tuvo como objetivo caracterizar la evolución de la investigación sobre el Diseño Universal para el Aprendizaje (DUA), con especial interés en la educación inclusiva y los contextos rurales. Para ello, a partir de una exportación en CSV de Scopus obtenida en octubre de 2026, se realizó un análisis bibliométrico descriptivo y

de mapeo científico. De los 1.802 registros iniciales se excluyeron tres duplicados, dos erratas y un documento retractado, con lo cual se trabajó con 1.796 publicaciones comprendidas entre 1999 y 2026. Se examinaron las tendencias de publicación, los tipos de documentos, las citas, las fuentes, los autores, las afiliaciones por país, las palabras clave de los autores y las referencias citadas; asimismo, se elaboraron mapas de coocurrencia de palabras clave y de cocitación de referencias. El corpus reunió 17.461 citas, con una media de 9,72 y una mediana de 2. La producción científica alcanzó 351 registros en 2025 y 467 registros asignados a 2026, aunque este último corresponde a un año aún incompleto. Estados Unidos concentró el mayor número de documentos vinculados a afiliaciones, con 721 publicaciones. Por otra parte, la discapacidad y la neurodiversidad (915), la tecnología digital (814) y la educación superior (664) destacaron como temas centrales. En contraste, solo 41 documentos coincidieron con los indicadores automatizados relacionados con contextos rurales, remotos o interculturales. Los resultados muestran que la investigación sobre el DUA constituye un campo en expansión, temáticamente diverso y con fundamentos intelectuales identificables. No obstante, persiste la necesidad de desarrollar estudios sensibles al contexto, especialmente en entornos rurales. Finalmente, los hallazgos bibliométricos deben interpretarse con cautela, pues no constituyen evidencia causal de la eficacia de las intervenciones educativas.

Palabras clave: Diseño Universal para el Aprendizaje, educación inclusiva, educación rural.

Introduction

Inclusive education requires learning environments that support the presence, participation, and achievement of students with diverse social, cultural, linguistic, cognitive, and functional characteristics. From this perspective, Universal Design for Learning (UDL) seeks to anticipate learner variability by providing multiple means of engagement, representation, and action and expression, rather than restricting educational responses to subsequent accommodations for specific groups (Meyer et al., 2014; CAST, 2024). This approach connects pedagogical accessibility with curriculum planning, assessment, and the removal of barriers within learning environments.

The conceptual development of UDL has been accompanied by reviews and empirical studies examining its outcomes, implementation conditions, and the alignment between theoretical principles and actual practice. Rao et al. (2014) identified different models of universal design in education; Capp (2017) examined intervention studies through a meta-analysis, whereas Almeqdad et al. (2023) synthesized more recent findings in a systematic review and meta-analysis. These approaches offer substantive evidence on interventions and their outcomes, but do not, on their own, describe the overall structure of the scientific literature.

Bibliometric analysis complements narrative and systematic reviews by examining metadata across large document collections, publication and citation indicators, collaboration patterns, and intellectual connections among publications (Aria & Cuccurullo, 2017; Donthu et al., 2021). Keyword co-occurrence maps can reveal associated research themes, while co-citation networks provide an approximation of the references shared by a research community (van Eck & Waltman, 2010). Their interpretation requires distinguishing scholarly visibility and thematic relevance from the quality or effectiveness of educational interventions.

The relevance of UDL extends beyond settings where specialized services and stable digital infrastructure are readily available. In rural, geographically dispersed, and intercultural learning environments, barriers may emerge from the interaction of curriculum design with language, access to materials, connectivity, multigrade teaching, and opportunities for students to demonstrate learning. Such conditions make it especially important to distinguish the transfer of a general pedagogical framework from its situated implementation. Studies of UDL in low- and middle-income countries, for example, indicate the need to account for local implementation conditions rather than assume that findings transfer unchanged across educational systems (McKenzie et al., 2025). Work connecting culturally sustaining pedagogy with UDL also calls attention to how language, identity, and disability intersect in inclusive practice (Waitoller & King Thorius, 2016).

These issues are pertinent to territories such as Peru's Apurímac, Ene, and Mantaro River Valley (VRAEM), which serves here as a potential application context rather than as an empirically analyzed study site. A global map of publications cannot determine how many UDL interventions have actually been implemented there, nor can it establish the effects of such interventions. It can, however, show how prominently rural, remote, and intercultural concerns appear in indexed research and help identify priorities for context-sensitive investigation. In parallel, the implementation literature underscores the need to examine institutional conditions (Fovet, 2021), the accessibility of digital learning environments (Coy et al., 2014), and how UDL is applied across educational stages (Ok et al., 2017; Espada-Chavarria et al., 2023).

Accordingly, this study aimed to examine the development of Scopus-indexed UDL research from 1999 to 2026, characterizing scientific output, citation impact, leading contributors, keyword networks, and the structure of

cited references, together with the visibility of inclusive education and rural settings. Four research questions guided the analysis: How has publication output evolved? Which publications, sources, authors, and countries are most prominent? Which thematic and intellectual clusters can be identified? And what place do rural contexts occupy within the retrieved literature?

Methodology

A retrospective, descriptive, and exploratory bibliometric science-mapping study was conducted. The unit of analysis was the documentary record indexed in Scopus. The dataset was the CSV file supplied for this study, whose filename indicates an export dated 17 October 2026 (UTC). The original file contains 45 fields, including EID, title, publication year, author names and Scopus identifiers, source title, citation counts, DOI, affiliations, keywords, abstract, and cited references. The retrieved publication period spans 1999–2026. No additional databases were searched, and the corpus was not supplemented with records from external sources.

The bibliographic search was conducted in Scopus using the combined TITLE-ABS-KEY fields (title, abstract, and keywords), through a multilingual expression centered on Universal Design for Learning and terms related to inclusion, accessibility, disability, equity, and barriers to learning. The query reproduced below corresponds to the search used to retrieve the analyzed document corpus. The publication year was restricted to 2026 or earlier using PUBYEAR < 2027. No further filters were applied during data processing by language, subject area, or document type; the categories in the original export were retained.

Search string used in Scopus

TITLE-ABS-KEY("universal design for learning" OR "*diseño universal para el aprendizaje*" OR "*desenho universal para a aprendizagem*") AND TITLE-ABS-KEY(inclusi* OR accessib* OR disabilit* OR "learning barriers" OR equity OR equit*) AND PUBYEAR < 2027.

The retrieval yielded 1,802 records exported as CSV. Based on the timestamp embedded in the filename, the export dates to 17 October 2026 (UTC). The search expression and cutoff date define the documentary population examined; indexing for 2026 was still incomplete. Subsequent cleaning was performed on the exported corpus, without adding records from other databases.

Eligibility criteria and corpus cleaning

Records retrieved by the Scopus query were eligible when their bibliographic metadata were sufficient to identify at least the publication year and document type. All 1,802 records were checked using the Document Type, DOI, and normalized title fields. Two records classified as errata, one record marked as retracted, and three duplicates matching simultaneously on DOI and title were removed. Records with similar titles but different DOIs were retained because they could represent distinct publications. The resulting analytical sample comprised 1,796 records. Research articles, reviews, book chapters, conference papers, books, and other indexed document types were retained; the sample was not restricted to empirical studies of intervention effectiveness. Thus, cleaning concerned bibliometric records rather than systematic full-text screening.

Table 1

Flow of record cleaning in the Scopus corpus

Stage	Number of records
Records in original CSV	1,802
Duplicates (matching DOI and title)	−3
Erratum records	−2
Record flagged as retracted	−1
Analytical sample	1,796

Bibliometric indicators

Document frequencies were calculated by year, document type, country of affiliation, language, publication source, and author, together with the sum of Scopus “Cited by” counts, mean and median citations, and availability of bibliographic fields. Author productivity was measured through full counting by Scopus Author ID (one document contributes one count to each author). For countries, the final component of each affiliation was extracted, and common naming variants were standardized. Multinational publications were counted under every affiliated country;

country totals, therefore, are not mutually exclusive and cannot be added to obtain the corpus size. Citations refer to the snapshot captured in the CSV and are not stable or normalized for year, field, or document type.

Thematic and network analysis

Keyword co-occurrence analysis was based exclusively on the “Author Keywords” field. Keywords were separated using semicolons, standardized for capitalization and diacritics, and harmonized for explicit UDL variants and selected plurals and synonyms. Each keyword was counted no more than once per document. Terms appearing in at least 14 documents and links occurring in at least four documents were retained. The visualization displays up to the 45 most frequent nodes available after removal of isolated nodes; communities were identified using the Louvain algorithm. Node size represents document frequency, and link thickness represents co-occurrence strength. Network positions do not indicate geographic distance or establish causal relationships.

Cited references were segmented using bibliographic year markers and then assigned heuristic keys based on the first author, year, and opening segment of the title. This procedure yielded 80,527 appearances of normalized references across 1,753 documents containing a “References” field, grouped into 62,044 distinct keys, some of which may represent unresolved variants. For the co-citation figure, the 70 most frequent reference keys were considered; references connected through at least eight common citing documents were retained, and up to 42 of the most frequent nodes were displayed. Because references do not always contain DOIs and their formatting is heterogeneous, this network is exploratory. Its clusters require further verification if they are to serve as central findings in a journal submission.

To assess thematic trends, predefined expressions were searched in titles, abstracts, and author keywords and grouped into seven categories: higher education, teacher education, digital technology, disability/neurodiversity, artificial intelligence, rural/remote contexts, and school education. Automated classifications measured mentions, were not mutually exclusive, and did not constitute full-text relevance assessments. Three periods were defined: 1999–2019, 2020–2023, and 2024–2026. Both absolute frequencies and percentages based on each period’s total were reported.

Data quality and ethical considerations

In the final sample, 1,660 documents had a DOI, 1,283 had author keywords, 1,753 included cited references, and 1,744 contained affiliations. Missing metadata were considered when determining denominators and interpreting networks. This investigation uses public or licensed bibliographic metadata provided for academic analysis; it neither processes sensitive participant information nor involves human-subject interventions. Analyses, tables, and figures were derived from the exported metadata using explicit computational routines for counting, normalization, graph construction, and visualization. Results are not described as outputs from Bibliometrix or VOSviewer because those applications were not run for this analysis.

Data availability and supplementary material

The analyses used a Scopus CSV export dated 17 October 2026 (1,802 original records; 1,796 after cleaning). For independent verification, the authors should submit the underlying export or a shareable, license-compliant record-level metadata file as Supplementary File S1. The raw CSV is not embedded in this manuscript; the cleaning procedures and network thresholds are detailed in the Methodology section.

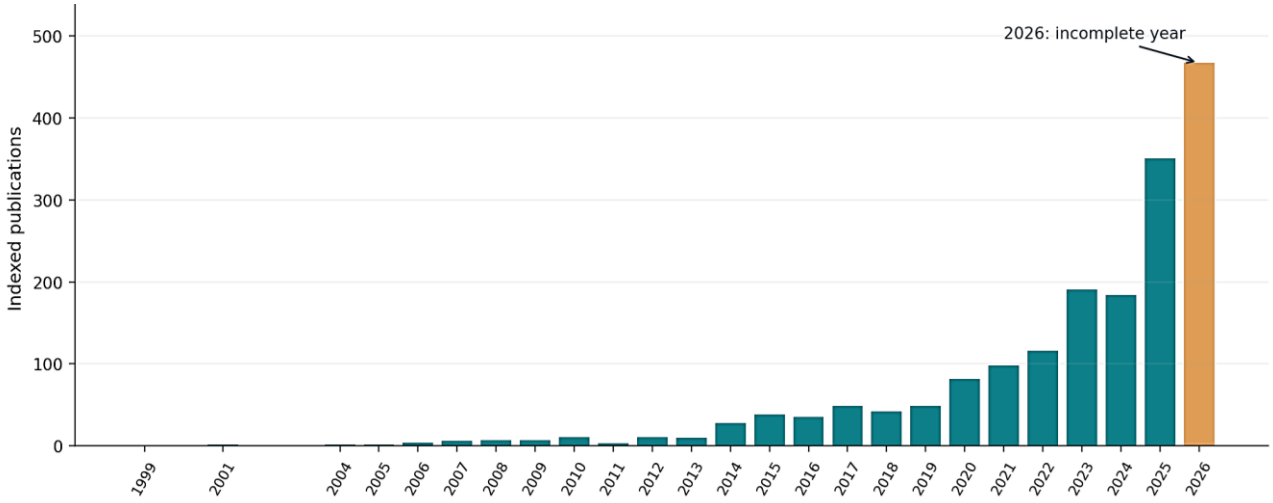
Results

Corpus composition and temporal evolution

Of the 1,796 documents analyzed, 966 were journal articles (53.8%), 447 were book chapters (24.9%), 220 were conference papers (12.2%), and 98 were reviews (5.5%). Publications were distributed across 1,004 distinct sources. English was the predominant language, accounting for 1,724 records (96.0%), followed by Spanish (41) and Portuguese (15). This composition demonstrates the diversity of document types and cautions against assuming that all records represent intervention studies.

Figure 1

Annual scientific output in the cleaned corpus (1999–2026); the 2026 count is provisional



The time series shows scattered output in the earliest years and an acceleration beginning in 2020: 82 documents in 2020, 98 in 2021, 116 in 2022, 191 in 2023, 184 in 2024, and 351 in 2025. The 467 records assigned to 2026 do not represent a completed year; moreover, the original CSV contains some “article in press” records. Accordingly, the 2026 figure reflects only the state of the export and must not be interpreted as a definitive annual publication rate.

Table 2

Distribution of the most frequent document types

Document type	n	%
Article	966	53.8%
Book chapter	447	24.9%
Conference paper	220	12.2%
Review	98	5.5%
Book	36	2.0%
Note	15	0.8%
Conference review	7	0.4%

Citation impact and publication sources

The 1,796 publications accumulated 17,461 citations, with a mean of 9.72 and a median of two citations per record. The difference between the mean and median indicates a skewed distribution, consistent with citations being concentrated in a relatively small set of publications. These figures reflect Scopus “Cited by” counts at the time of export and are sensitive to publication age, disciplinary context, and the date of data collection.

Figure 2
Publication sources with the largest number of documents in the analytical corpus

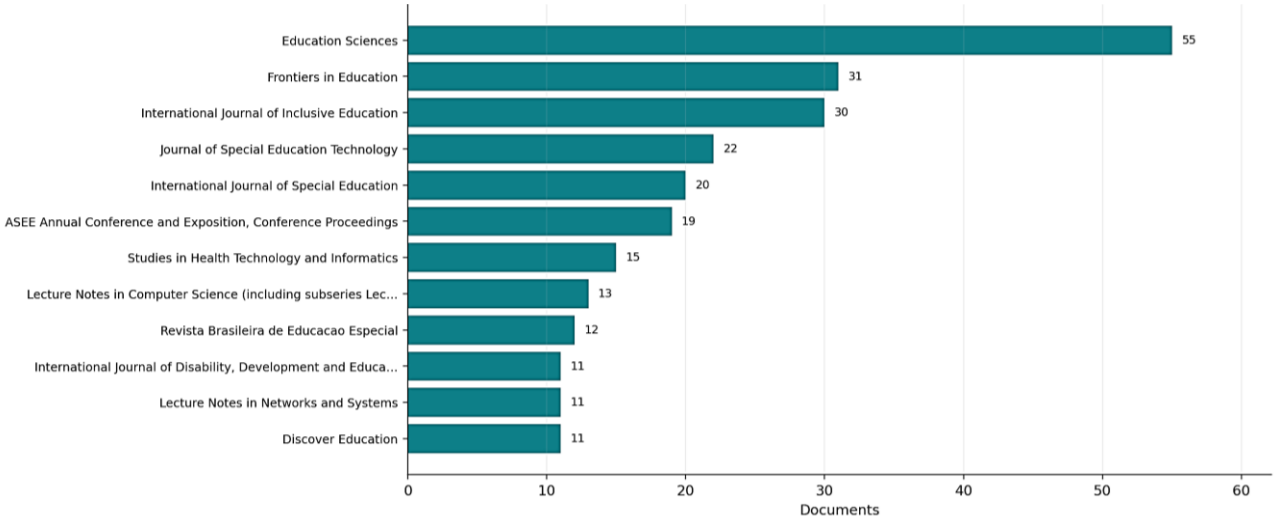


Table 3
Most productive publication sources and cumulative citations of their documents

Publication source	Documents	Citations
Education Sciences	55	715
Frontiers in Education	31	241
International Journal of Inclusive Education	30	781
Journal of Special Education Technology	22	543
International Journal of Special Education	20	7
ASEE Annual Conference and Exposition, Conference Proceedings	19	55
Studies in Health Technology and Informatics	15	51
Lecture Notes in Computer Science (including subseries Lecture Note…)	13	38
Revista Brasileira de Educacao Especial	12	60

Education Sciences published 55 documents, followed by *Frontiers in Education* (31), *International Journal of Inclusive Education* (30), and *Journal of Special Education Technology* (22). The most productive journal was not necessarily the most cited: *International Journal of Inclusive Education* accumulated 781 citations across 30 documents, whereas *Education Sciences* received 715 across 55. Because this comparison does not adjust for publication age, subject distribution, or self-citations, it should be interpreted only as a descriptive feature of the retrieved corpus.

Highly cited documents and leading authors

Table 4
Most cited documents in the Scopus collection (unnormalized citation counts)

Author (year)	Publication / abbreviated title	Citations
Capp M.J. (2017)	The effectiveness of universal design for learning: a meta-analysis of…	328
Edyburn D.L. (2010)	Would you recognize universal design for learning if you saw it? Ten…	295
Waitoller F.R. (2016)	Cross-pollinating culturally sustaining pedagogy and universal design…	246
Rao K. (2014)	A Review of Research on Universal Design Educational Models	223
McGuire J.M. (2006)	Universal design and its applications in educational environments	193
Hamilton L.G. (2023)	Compassionate pedagogy for neurodiversity in higher education: A concept…	182
Mitchell D. (2014)	What really works in special and inclusive education: Using evidence…	164
Basham J.D. (2016)	An Operationalized Understanding of Personalized Learning	163
McMahon D.D. (2016)	Augmented reality for teaching science vocabulary to postsecondary…	162

Capp (2017) ranked first with 328 citations, followed by Edyburn (2010), with 295, and Waitoller and King Thorius (2016), with 246. Other highly cited entries reflect the breadth of the field, including conceptual discussion of educational applications of universal design (McGuire et al., 2006), neurodiversity in higher education (Hamilton & Petty, 2023), evidence-based inclusive teaching strategies (Mitchell, 2014), personalized learning environments (Basham et al., 2016), and augmented reality for accessible science learning (McMahon et al., 2016). The presence of methodological studies, reviews, and conceptual contributions among the most cited works indicates that bibliometric prominence is not confined to controlled evaluations. Citation counts should not be interpreted as direct measures of study quality or as evidence that reported educational effects are generalizable.

Table 5
Most productive authors identified by Scopus Author ID

Author	Documents	Citations to their documents*
Rao K.	14	864
Fovet F.	12	26
Israel M.	11	361
Angrave L.	11	70
Marino M.T.	10	326
Alam A.	9	7
Chini J.J.	9	230
Cumming T.M.	9	258
Smith S.J.	8	184
McMahon D.	8	297

*Full counting by author: the same document's citations may be credited to multiple coauthors. The sum does not represent unique citations across the field

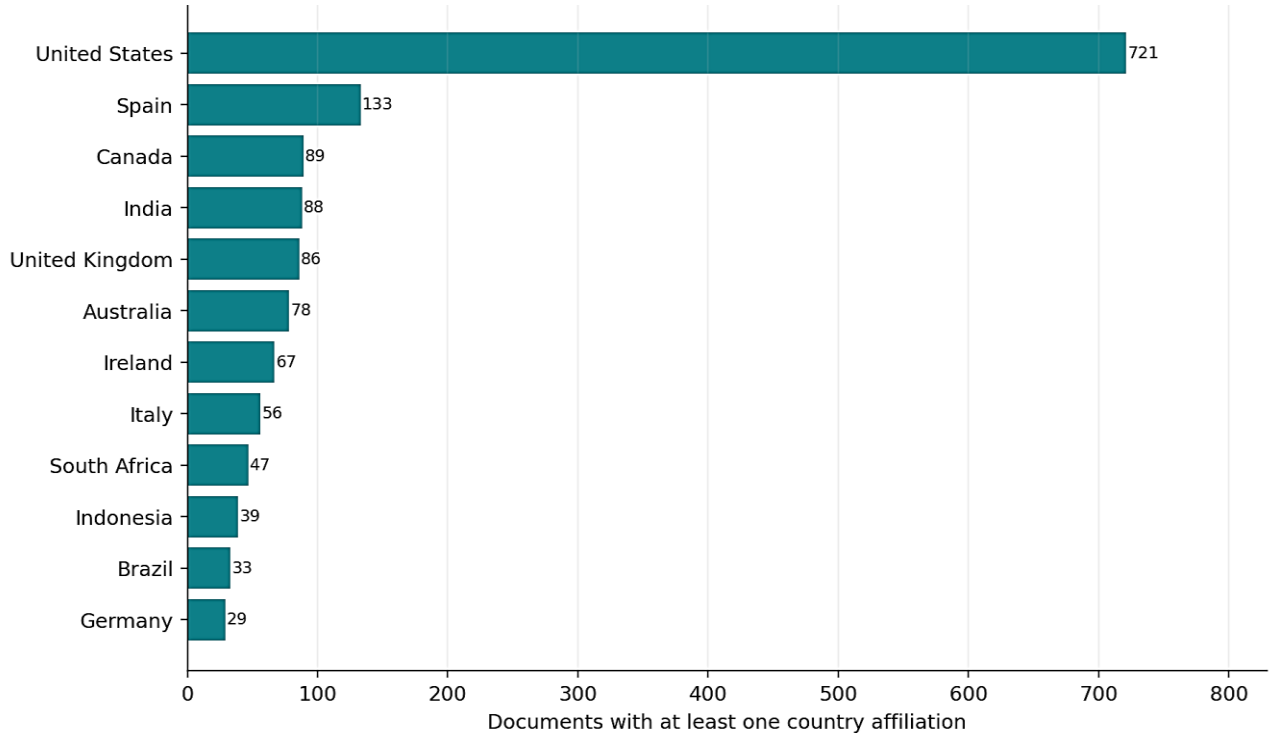
By Scopus identifier, K. Rao contributed 14 documents, F. Fovet 12, M. Israel 11, and L. Angrave 11. These figures depend on Scopus author disambiguation and the coverage of this particular collection; they are not rankings of each scholar's total output. The names reported in Table 5 are bibliometric metadata rather than citations to a single publication. Consequently, a representative work is provided for each highlighted researcher to support bibliographic identification, without treating those examples as a reconstruction of all records assigned to the corresponding Scopus Author ID.

Illustrative publications address institutional implementation (Fovet, 2021), UDL-informed computer science education (Israel et al., 2022), accessible engineering learning-management systems (Liu et al., 2022), online instruction (Coy et al., 2014), AI-supported inclusive design (Alam, 2026), postsecondary STEM education (Schreffler et al., 2019), UDL practices in a special school (Cumming & Gilanyi, 2023), intellectual disability (Smith & Lowrey, 2017), and augmented reality (McMahon et al., 2016). These sources contextualize the range of topics associated with the researchers; the numerical author rankings and citation totals remain those reported in the original Scopus extraction.

Geographic distribution and international collaboration

Figure 3

Countries most frequently represented in the "Affiliations" field, using full counting by document



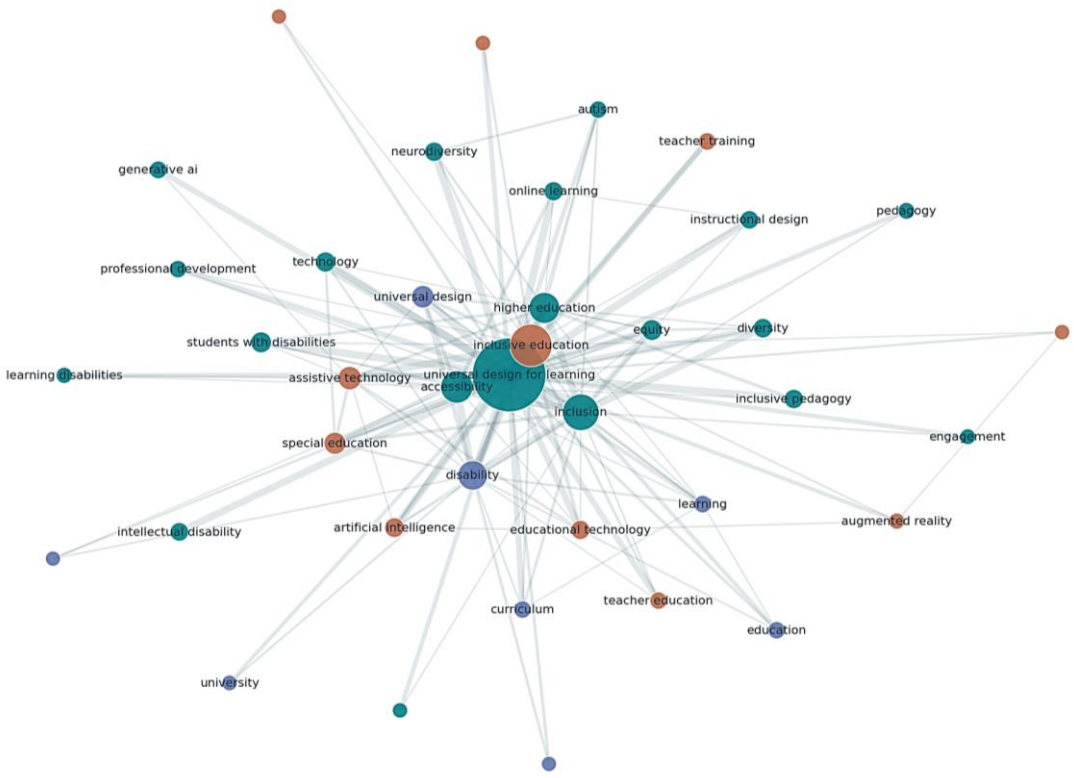
The United States was represented in 721 documents, followed by Spain (133), Canada (89), India (88), and the United Kingdom (86). A total of 238 documents included affiliations from at least two countries, corresponding to 13.3% of the sample. The most frequent bilateral connections in the CSV included Canada–United States (16 documents), Colombia–Spain (10), and United Kingdom–United States (10). These connections indicate international co-affiliation, not necessarily formal institutional exchange or a link to the territory where a given study collected data.

Author keyword co-occurrence and thematic structure

Across 1,283 documents reporting author keywords, 3,284 distinct normalized terms were identified. The most frequent descriptors were "universal design for learning" (831 documents, after harmonizing variants), "inclusive education" (261), "inclusion" (188), "accessibility" (143), "higher education" (128), "disability" (115), and "assistive technology" (63). These counts do not sum to 1,796 because individual documents may contain multiple keywords or none at all.

Figure 4

Author keyword co-occurrence network; minimum term frequency ≥ 14 and minimum edge weight ≥ 4



The network retained 39 connected nodes and 139 edges and identified three Louvain communities. The first combined UDL, inclusion, accessibility, higher education, equity, and neurodiversity. The second linked inclusive education, assistive technology, special education, artificial intelligence, and teacher preparation. The third brought together disability, universal design, curriculum, and social justice. These communities represent lexical relationships within the corpus rather than independent disciplines or rigid thematic boundaries.

Evolution of research themes

Figure 5

Percentage of documents containing thematic terms across time periods; categories are not mutually exclusive

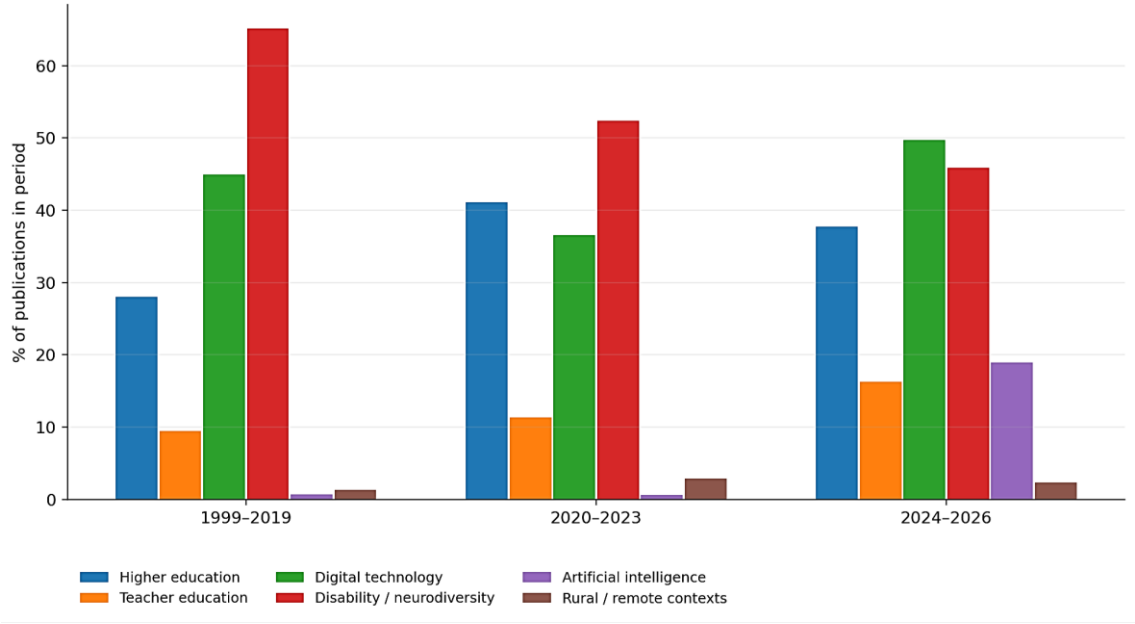


Table 6

Document frequencies by period based on predefined thematic expressions

Research theme	1999–2019 (n=307)	2020–2023 (n=487)	2024–2026 (n=1,002)	Total
Higher education	86 (28.0%)	200 (41.1%)	378 (37.7%)	664
Teacher education	29 (9.4%)	55 (11.3%)	163 (16.3%)	247
Digital technology	138 (45.0%)	178 (36.6%)	498 (49.7%)	814
Disability / neurodiversity	200 (65.1%)	255 (52.4%)	460 (45.9%)	915
Artificial intelligence	2 (0.7%)	3 (0.6%)	190 (19.0%)	195
Rural / remote contexts	4 (1.3%)	14 (2.9%)	23 (2.3%)	41
School education	38 (12.4%)	58 (11.9%)	137 (13.7%)	233

The most prevalent categories were disability/neurodiversity (915; 50.9%), digital technology (814; 45.3%), and higher education (664; 37.0%). Artificial intelligence appeared in 195 documents (10.9%), including 190 published in 2024–2026. This pattern suggests a recent discursive connection between UDL and emerging automated tools, although the mere appearance of the term does not demonstrate that AI-based interventions were implemented or that measurable benefits were achieved.

The rural/remote context category, defined through references to rural settings, remote schools, Indigenous communities, interculturality, or the VRAEM, was identified in 41 documents (2.3%). This proportion was lower than that of the other predefined fields, but it is not an exhaustive estimate of rural research: studies conducted in these settings may omit the corresponding words from their titles, abstracts, or keywords. The procedure likewise yielded insufficient specific evidence to claim an established UDL intervention research agenda in the VRAEM.

Intellectual structure based on cited references

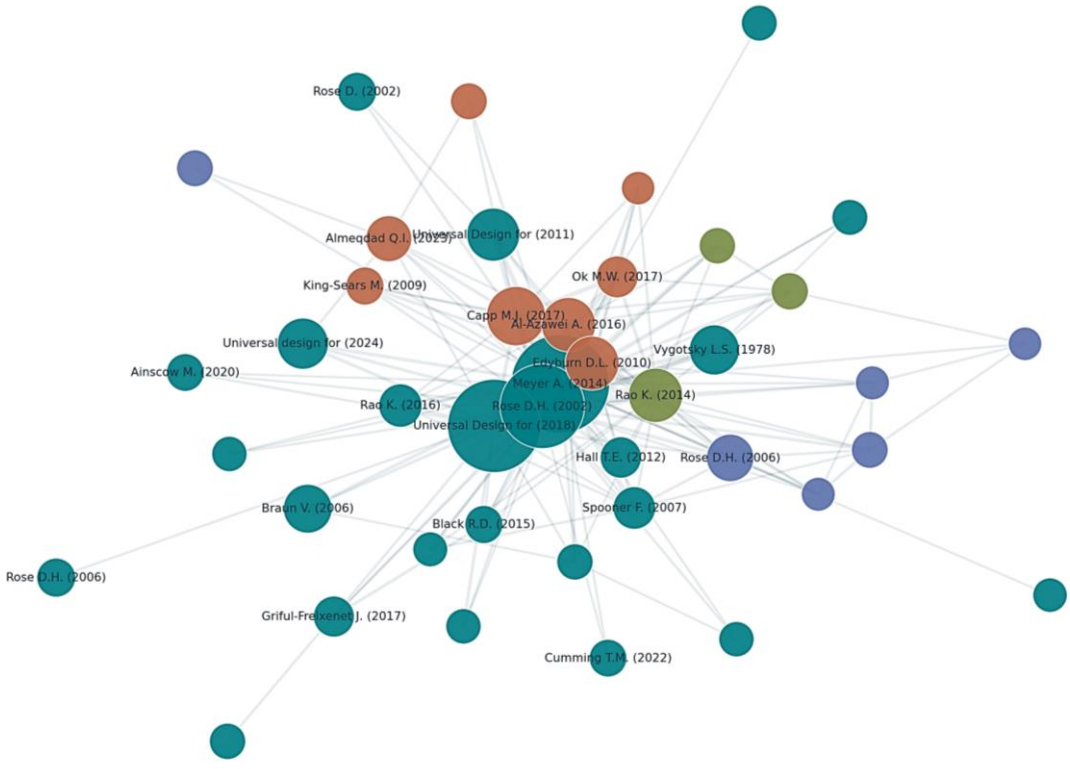
Heuristic reference normalization revealed a concentration of citations to foundational works and UDL guidance documents. Among the most frequently identified sources were Meyer, Rose, and Gordon (2014), cited by 290 documents; the 2018 UDL Guidelines, cited by 259; and Rose and Meyer (2002), cited by 213. Capp (2017),

cited by 103 documents, and Al-Azawei, Serenelli, and Lundqvist (2016), cited by 86, were also prominent. These counts depend on how Scopus exported the reference lists and on the accuracy of author and title matching.

Table 7
Most frequently cited references according to heuristic citation keys

Abbreviated reference	Citing documents
Meyer A.; Rose D.H.; Gordon D., Universal Design for Learning: Theory and Practice (2014)	290
Universal Design for Learning Guidelines version 2.2 (2018)	259
Rose D.H.; Meyer A., Teaching Every Student in the Digital Age: Universal Design for Learning (2002)	213
Capp M.J., The effectiveness of universal design for learning: A meta-analysis of literature between…	103
Al-Azawei A.; Serenelli F.; Lundqvist K., Universal Design for Learning (UDL): A Content Analysis of…	86
Rao K.; Ok M.W.; Bryant B.R., A Review of Research on Universal Design Educational Models, Remedial …	86
Edyburn D.L., Would you recognize universal design for learning if you saw it?, Learning Disability …	85
Universal Design for Learning Guidelines Version 2.0 (2011)	82
Universal design for learning guidelines version 3.0 (2024)	76
Vygotsky L.S., Mind in society: The development of higher psychological processes (1978)	73

Figure 6
Reference co-citation structure derived from normalized heuristic citation keys



The calculated network comprised 62 nodes and 207 edges after application of the thresholds specified in the methods, before the principal graph nodes were visually selected. The clusters indicate proximity among foundational UDL works, implementation research, and studies of higher and school education. Because heuristic

keys were used to reconcile references with inconsistent author and title formatting, the map provides an exploratory representation of the intellectual structure rather than a complete, error-free census of bibliographic variants.

Discussion

Growth of the literature and diversification of approaches

The growth observed since 2020, particularly the output recorded in 2025, indicates increasing scholarly attention to UDL. This pattern is conceptually consistent with a shift from accessibility in learning materials and assessments toward the design of environments that recognize multiple forms of participation, belonging, and learner agency—dimensions emphasized in the UDL Guidelines 3.0 (CAST, 2024). Nevertheless, growth in publication volume cannot automatically be interpreted as stronger causal evidence or improved educational outcomes: a substantial proportion of the corpus consists of book chapters, conference contributions, and conceptual publications.

The prominent role of higher education and digital accessibility reflects the importance of university settings and educational platforms in the UDL research agenda. The overlap among assistive technologies, disability, and teacher preparation points to an interdisciplinary field bringing together design, pedagogical support, and institutional organization. Recent studies have identified difficulties in translating all components of the framework into practice (Zhang et al., 2024), while a review of technology-related UDL research in secondary education reported imbalances among the principles examined (Bray et al., 2024). A keyword network cannot establish whether interventions implement all three UDL principles in a balanced manner; doing so requires examining their content and assessment methods.

Scientific visibility versus evidence of effectiveness

Citation concentration around Capp (2017), Edyburn (2010), Rao et al. (2014), and other influential works highlights the central role of reviews and conceptual contributions. Capp (2017) argued that, despite UDL's potential for learning, certain educational outcomes required more conclusive evidence. The review and meta-analysis by Almeqdad et al. (2023) likewise provides an updated point of reference for discussing substantive outcomes. This bibliometric study identifies the associated knowledge base, but does not calculate effect sizes, assess the risk of bias in experimental studies, or determine which educational program performs best.

Consequently, a doctoral project investigating the "effectiveness of a UDL-based program in promoting inclusive education" may use the present analysis to situate the state of research and identify relevant comparative studies. Local effectiveness, however, must be examined using an appropriate intervention design and valid measures of inclusion, participation, and learning. It would be methodologically inappropriate to transfer an effect estimated by an international meta-analysis directly to the VRAEM without accounting for differences in students, infrastructure, language, intervention duration, and implementation fidelity.

Technology, artificial intelligence, and inclusion

The prominence of digital technology terms and the recent appearance of artificial intelligence represent both research opportunities and conceptual challenges. In inclusive education, technology may expand means of access and expression, but being labeled "innovative" does not automatically make a tool an example of universal design. Research should assess accessibility, linguistic appropriateness, meaningful participation, pedagogical oversight, and potential biases in automated systems.

The growing association between AI and UDL, particularly visible in 2024–2026, warrants a more focused analysis distinguishing generative artificial intelligence, adaptive learning, and assistive technology, including their relationship with specific provisions of the UDL Guidelines 3.0. Bibliometric evidence does not support a claim that AI has already produced broad improvements in inclusion, but it does indicate that the subject is increasingly visible in recent scholarly discussions.

Rural education, intercultural relevance, and opportunities for the VRAEM

Only 41 of the 1,796 documents met the predefined automated indicators for rural, remote, or intercultural contexts. This limited visibility in titles, abstracts, and author keywords is important because questions of educational access can differ markedly between well-resourced urban institutions and schools serving dispersed or linguistically diverse communities. The figure is not an exhaustive count of studies conducted in rural locations, since relevant papers may not use the selected descriptors. McKenzie et al. (2025), in their review of UDL in low- and middle-income countries, highlight why implementation conditions deserve closer consideration. This

combination of bibliometric findings and substantive literature therefore supports a research question about local adaptation, not a claim that UDL is absent from rural settings.

Nasri et al. (2021) examined a STEM-oriented program involving eighth-grade students in a rural setting, providing a potentially useful precedent for intervention design. However, its findings cannot be extrapolated directly to the VRAEM population. Local knowledge production requires identifying the educational level, principal learning barriers, student and family participation, teaching resources, and territorial conditions, and assessing outcomes against culturally appropriate inclusion criteria.

This perspective also calls for moving beyond an understanding of UDL as a set of accommodations only for students with disabilities. The framework is intended to anticipate learner variability more broadly. Accordingly, in rural schools, the language of instruction, learning schedules, multigrade organization, connectivity, cultural belonging, and opportunities to demonstrate competence through different means may all be relevant considerations.

The literature also identifies conceptual tensions in the adoption of UDL. Anastasiou et al. (2025) critically examined its theoretical foundations, while Griful-Freixenet et al. (2021) empirically tested a conceptual UDL model in preservice teacher education. These contributions help distinguish the spread of academic terminology from the accumulation of evidence concerning specific pedagogical mechanisms. In secondary education, Phelan et al. (2025) mapped the integration of UDL principles across subjects, raising questions about curricular transferability and the design of accessible assessments.

Scope and limitations

Five limitations must be considered when interpreting these findings. First, retrieval was limited to Scopus and may therefore omit regional publication sources and non-indexed literature. Second, the query, focused on explicit UDL terms and predefined inclusion-related expressions, may miss relevant research using other descriptors; the observed frequencies characterize this particular search strategy, not the entirety of worldwide output. Third, document-type heterogeneity and differences in publication age affect the comparability of citation indicators. Fourth, affiliation, keyword, and reference normalization relied on algorithmic and heuristic procedures; unmatched variants may influence the resulting links and communities. Fifth, thematic counts based on titles, abstracts, and keywords measure mentions rather than actual interventions or causal outcomes. In addition, 2026 was incomplete when the export was obtained. Accordingly, this is a descriptive science-mapping study, not an effectiveness review or a test of causality.

Conclusions

The field of Universal Design for Learning showed pronounced growth in the examined Scopus collection, comprising 1,796 documents published between 1999 and 2026 and a substantial expansion in recent years. The concentration of citations around reviews and foundational publications reflects an identifiable intellectual structure, while author keyword co-occurrence suggests increasing thematic diversity spanning accessibility, higher education, disability, digital technology, teacher education, and artificial intelligence.

The United States accounted for the largest number of documents by country of affiliation, and international networks showed collaboration across different territories. Nevertheless, geographic concentration must be interpreted in light of full-counting methods and Scopus coverage. Automated thematic indicators showed markedly fewer mentions of rural and intercultural contexts than of other fields, justifying more detailed identification and critical assessment of context-sensitive research.

This study offers a literature map that can inform inclusive program design and research priorities, but it does not provide direct evidence of the effectiveness of a particular intervention. To support future doctoral research in the VRAEM, the findings should be complemented with a systematic review of relevant empirical studies and a context-sensitive evaluation of UDL-based educational practices.

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AUTHOR CONTRIBUTIONS: All authors contributed to the conception and design of the bibliometric study, the definition of the search strategy, the processing and analysis of the corpus, the interpretation of the results, and the writing or critical revision of the manuscript. All authors approved the final version of the article.