Application of Neurodidactics in the Comprehensive Assessment of Learning in Early Childhood

Joseph Taro[1], Ruth Esther Peñafiel Villarreal[2], Mayra Antonieta Morán Aguilar[3]

[1] Universidad Estatal Península de Santa Elena, Ecuador
[2] Universidad Estatal Península de Santa Elena, Ecuador
[3] Universidad Estatal Península de Santa Elena, Ecuador

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ABSTRACT:
The objective of this study was to analyze, through a bibliometric approach, the scientific trends, collaboration networks, and thematic structure of research on neurodidactics applied to the comprehensive assessment of learning in early childhood, with particular emphasis on children aged 0–6 years. Methodology: A bibliometric analysis was conducted using the Scopus database, following the PRISMA 2020 guidelines and the SPICE framework to formulate the research question. The initial search identified 410 documents, of which 50 met the inclusion criteria after applying filters for peer-reviewed publications, open-access availability, and thematic relevance. Bibliometrix, Biblioshiny, and VOSviewer were employed to examine five bibliometric indicators: scientific production, research impact, collaboration networks, thematic evolution, and geographical distribution. Results: The evidences revealed a substantial increase in scientific production beginning in 2020, reaching its highest level in 2022. Collaboration networks were identified, highlighting several authors with prominent positions within the scientific community. The thematic analysis showed an interdisciplinary knowledge structure integrating neuroeducation, cognitive development, neuroscience, and artificial intelligence. Conclusions: Research on neurodidactics is undergoing steady consolidation; however, important challenges remain, including insufficient teacher training, limited validation of neurodidactic assessment instruments, and uneven geographical representation, particularly across Latin America.

Keywords: neurodidactics; comprehensive assessment; early childhood learning; neuroeducation; early childhood education.

1. Introduction

The comprehensive assessment of learning in children aged 0–6 years represents one of the most significant challenges in contemporary early childhood education. This challenge stems from the multidimensional nature of child development, which encompasses cognitive, motor, emotional, and social processes that occur simultaneously and interact dynamically (Sánchez Carranza & Egoavil Palacios, 2025). Consequently, assessing children's learning cannot be reduced to the use of standardized instruments, as these primarily promote memorization and repetition rather than

capturing the richness and complexity of holistic development during early childhood (Moreno Rus et al., 2025).

Traditional assessment approaches have historically focused on measuring factual knowledge and memory-based learning. When applied to young children, however, these methods present important limitations because they rely heavily on structured observation techniques that often fail to capture multiple developmental dimensions simultaneously. Monitoring attention, concentration, creativity, and social interaction at the same time remains a considerable challenge for educators (Burbano-Enríquez et al., 2025). Moreover, insufficient attention to individual learning needs and the limited availability of comprehensive assessment strategies contribute to persistent structural gaps within educational systems, particularly across Latin America. In this context, neurodidactics has emerged as an interdisciplinary field that integrates findings from neuroscience with educational practice.

Neurodidactics offers innovative approaches for designing both teaching and assessment strategies that are aligned with how the brain learns. One of its central theoretical contributions is the stimulation of both cerebral hemispheres during the teaching-learning process, promoting integrated brain functioning to support sustained learning and development (Zhumabayeva et al., 2025). From this perspective, recent studies suggest that assessment models grounded in neurodidactic principles foster children's cognitive, motor, emotional, and social development more effectively than conventional assessment practices. According to Gkintoni et al. (2025), neurodidactic assessment models overcome several limitations associated with traditional educational evaluation systems.

Despite these advances, significant barriers remain to the implementation of neurodidactic assessment. Ribeiro et al. (2025) argue that limited teacher training in neuroscientific principles, together with the scarcity of context-sensitive assessment instruments supported by neuroscientific evidence, constrains effective classroom practice. Similarly, Rodríguez Fuentes et al. (2025) highlight that institutional resistance to pedagogical innovation and the persistent gap between scientific knowledge and educational practice hinder the widespread adoption of neurodidactics in authentic school settings.

Over the past decade, research on the application of neuroscience to children's education has expanded considerably. Walsh et al. (2024), through a systematic review, demonstrated that neuroscience-informed professional development improves teachers' instructional practices and enhances teaching and learning processes. Likewise, Granado De La Cruz et al. (2025) examined the integration of education, neuroscience, and technology, concluding that the convergence of these three domains significantly improves learning outcomes. Within the Latin American context, Londoño Vega et al. (2024) analyzed the Montessori approach as a pedagogical strategy for promoting children's natural discovery processes in early childhood education, providing evidence that alternative educational approaches may be more effective than conventional assessment methods.

More recently, Sánchez Carranza and Egoavil Palacios (2025) conducted a systematic review of neurodidactics research published between 2015 and 2024, reporting sustained growth in scientific production while emphasizing the need for further research in Spanish-speaking contexts. These findings underscore both the increasing relevance of the field and the necessity for comprehensive bibliometric studies capable of mapping its scientific evolution. Accordingly, the present bibliometric analysis aims to characterize the current state of research on neurodidactics applied to learning assessment in early childhood.State the problem and research objectives

From a theoretical perspective, neurodidactics can be defined as the scientific discipline that seeks to optimize teaching and learning processes through the application of knowledge about brain functioning. Its conceptual framework is founded on three essential principles: brain plasticity, multisensory stimulation, and emotion-based

learning (Gkintoni et al., 2025). These principles are particularly relevant during early childhood, as the period from birth to six years of age represents a critical window for neurological development. Within this developmental stage, comprehensive assessment extends beyond the measurement of cognitive competencies to include motor, emotional, and socio-emotional dimensions of child development (Burbano-Enríquez et al., 2025). Consequently, integrating neurodidactics with comprehensive assessment establishes a promising research domain with considerable potential to transform assessment practices in early childhood education.

To address the research objective, this study adopted the SPICE framework (Setting, Population, Intervention, Comparison, Evaluation) to formulate the research question: How does neurodidactic contribute to the design of strategies for the comprehensive assessment of learning in early childhood? The framework defined the scope of the analysis as follows: Setting: early childhood education; Population: children aged 0–6 years; Intervention: neurodidactics; Comparison: traditional assessment approaches; and Evaluation: comprehensive learning assessment.

Based on this framework, the objective of the study was to analyze the scientific trends, collaboration networks, and thematic evolution of research on neurodidactics applied to the comprehensive assessment of learning in early childhood through a bibliometric approach.

2. Methodology

This study adopted a quantitative approach using a descriptive bibliometric research design to examine the scientific literature on neurodidactics applied to the comprehensive assessment of learning in early childhood. Bibliometric analysis provides a methodological framework for mapping the evolution of scientific knowledge within a research field by identifying publication trends, collaboration networks, thematic structures, and research impact through quantitative indicators and network visualization techniques (Rodríguez Dueñas et al., 2026). The data collection process focused on two key components: the data source and the search strategy.

The literature search was conducted using the Scopus and Web of Science (WoS) databases, as both index high-quality, peer-reviewed scientific publications. The search targeted studies addressing neurodidactics and learning assessment in early childhood education. Document retrieval was performed on September 1, 2025, using the following search strategy: TITLE-ABS-KEY ("neurodidactics" OR "neuroeducation") AND TITLE-ABS-KEY ("assessment" OR "development") AND TITLE-ABS-KEY ("early childhood" OR "early childhood education").Instruments: Tools, tests, or questionnaires used

The search equation was designed to retrieve the most relevant publications at the intersection of neurodidactics and learning assessment in early childhood. Equivalent search terms in Spanish were also incorporated to maximize the retrieval of studies published in Spanish-speaking countries and ensure comprehensive thematic coverage.

The document selection process followed the PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines, ensuring methodological transparency and reproducibility. The screening procedure comprised four sequential phases:

Identification: the initial database search yielded 410 records, including original research articles, systematic reviews, and bibliometric studies related to neurodidactics and the comprehensive assessment of learning in early childhood. Eligible publications were limited to studies published during the previous ten years, written in English, Spanish, or Portuguese, and available through open-access sources.

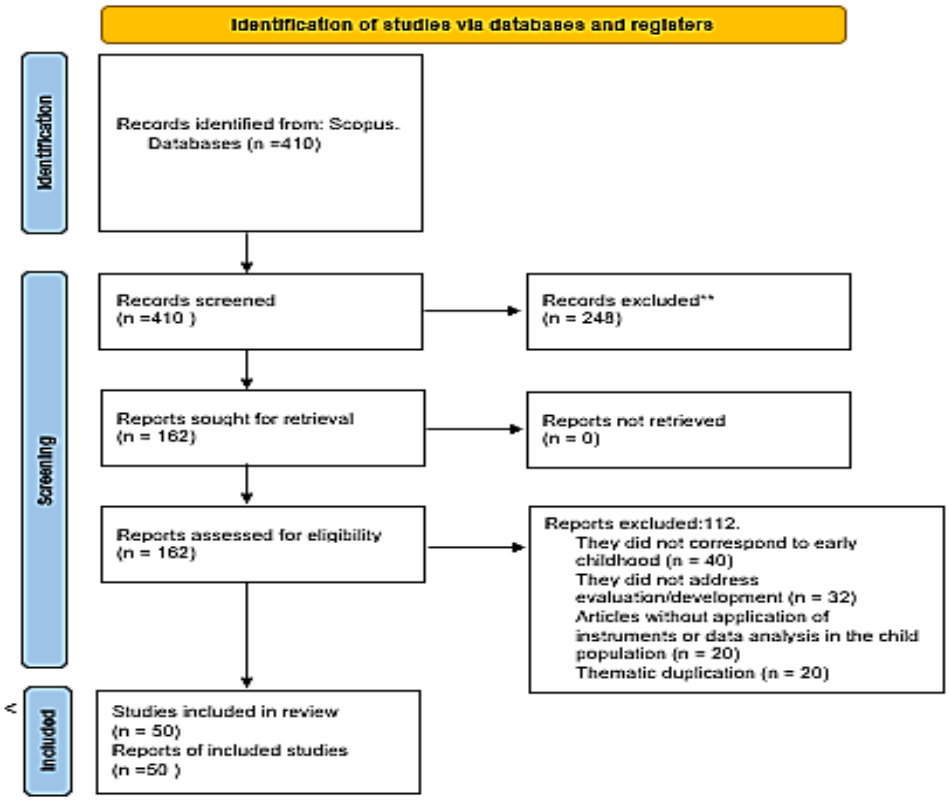
Screening: during the screening stage, publications that did not meet the predefined eligibility criteria were excluded. These included non-peer-reviewed documents, books, book chapters, conference abstracts without full text, editorials, letters to the editor, and unpublished theses. Studies that did not explicitly address neurodidactics, comprehensive learning

assessment, or children aged 0–6 years were also removed. Following this screening process, 162 records remained for full-text assessment.

Eligibility: the remaining studies underwent a detailed full-text review. Only open-access articles indexed in Scopus that specifically addressed early childhood education and comprehensive developmental assessment were retained. Abstracts and full texts were evaluated to determine their alignment with the objectives of the bibliometric analysis. This process resulted in 50 eligible publications.

Inclusion: a final corpus of 50 articles was included in the bibliometric analysis. Each publication was examined to verify its consistency with the research question, study objective, and inclusion criteria established for the review.

Figure 1. Illustrates the document identification, screening, eligibility, and inclusion process according to the PRISMA 2020 guidelines.



Note. Step-by-step process used to identify, retrieve, and select the studies included in the bibliometric analysis.

The bibliometric indicators and analytical tools were used to evaluate the scientific literature from multiple complementary perspectives. To ensure a comprehensive analysis, the bibliometric indicators were organized into five dimensions:

1. Scientific production: Temporal evolution of publications and authors' scientific productivity.

2. Research impact: Average citations per year, most cited publications, and authorship distribution based on Lotka's Law.

3. Collaboration: Co-authorship networks analyzed using VOSviewer.

4. Thematic analysis: Co-occurrence of keywords and thematic clusters identified through VOSviewer, complemented by word cloud visualization generated with Bibliometrix.

Three complementary software tools were employed for data processing and visualization. Bibliometrix and its web interface Biblioshiny, implemented within the RStudio environment, were used to analyze scientific production, citation impact, authorship patterns, and geographical distribution. VOSviewer was used

to construct and visualize co-authorship networks as well as keyword co-occurrence networks, enabling the identification of collaboration patterns and the thematic structure of the research field.

Table 1. Bibliometric indicators used in the study.

Bibliometric indicators	Sub-indicators
I1. Scientific production	• Annual scientific production • Authors' scientific production over time • Scientific production by country • Lotka's Law
I2. Research impact	• Bradford's Law
I3. Collaboration	• Co-authorship network
I4. Thematic analysis	• Keyword co-occurrence network

Note: Prepared by the authors.

3. Results

The results are presented according to the five bibliometric indicators defined in the methodology and aligned with the overall objective of the study. The bibliometric analysis of indicator 1 (Scientific Production; fig.2,3,4 and 5) revealed a sustained increase in scientific output on neurodidactics applied to learning assessment throughout the study period, with publication activity reaching its highest level in 2022. This upward trend reflects the growing academic interest in the area of neurodidactics and early childhood assessment, particularly from 2020 onward. The expansion of the literature appears to be driven by increasing recognition of the value of integrating neuroscience into teaching, learning, and educational assessment processes.

Regarding authors' productivity, the researches indicate that the most productive researchers published five articles during the study period. Considering Lotka's Law, only two authors produced five publications each, whereas 22 authors contributed with a single publication, reflecting the characteristic distribution of scientific productivity commonly observed in emerging research fields.

Figure 2. Annual Scientific Production

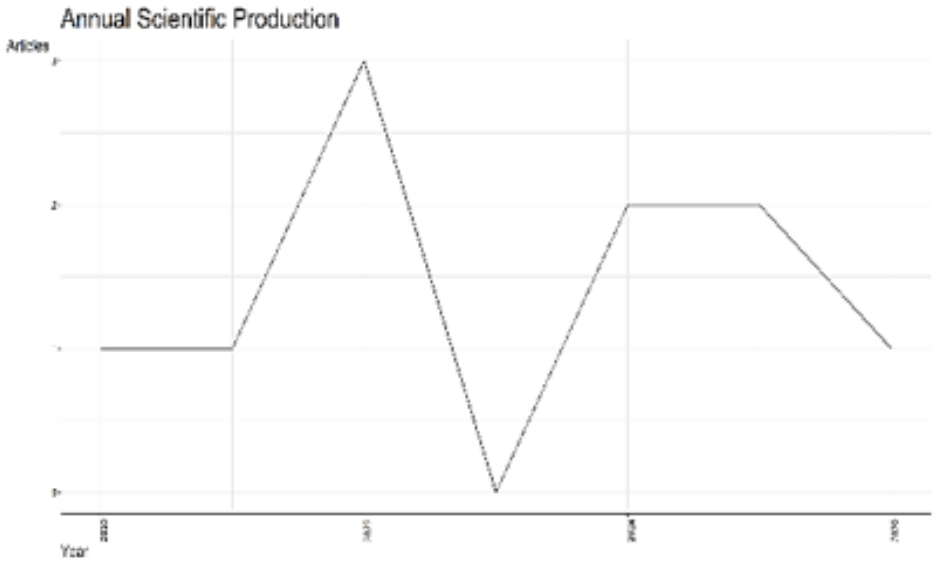


Figure 3. Author Production Over Time

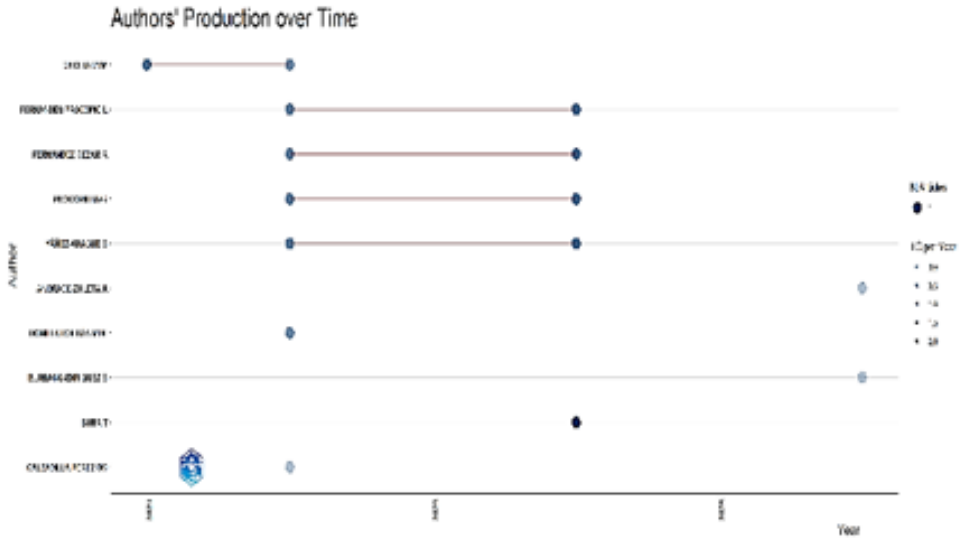


Figure 4.Scientific Production by Country Over Time

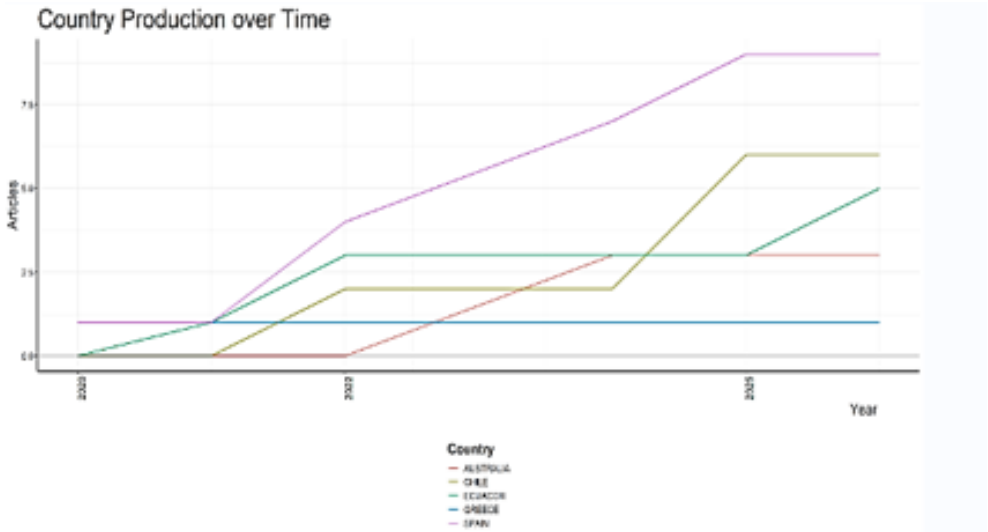
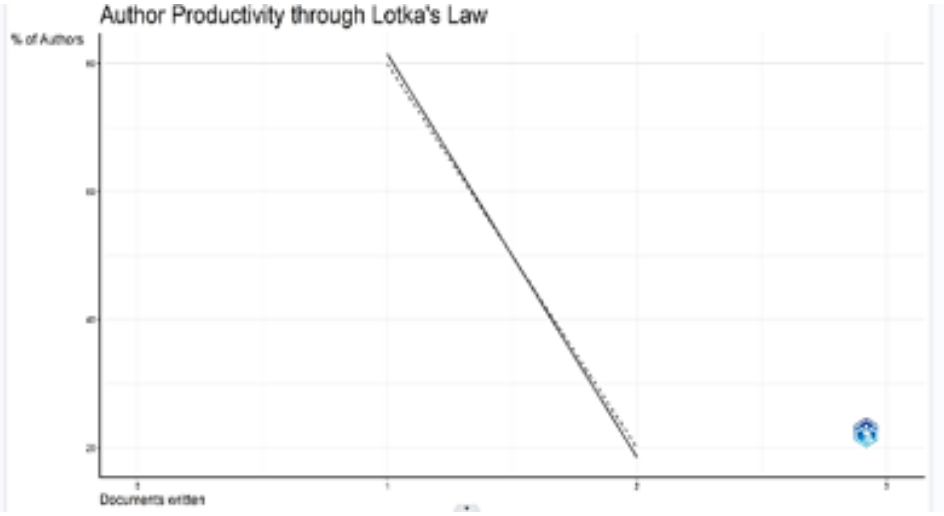


Figure 5. Lotka's Law of Scientific Productivity

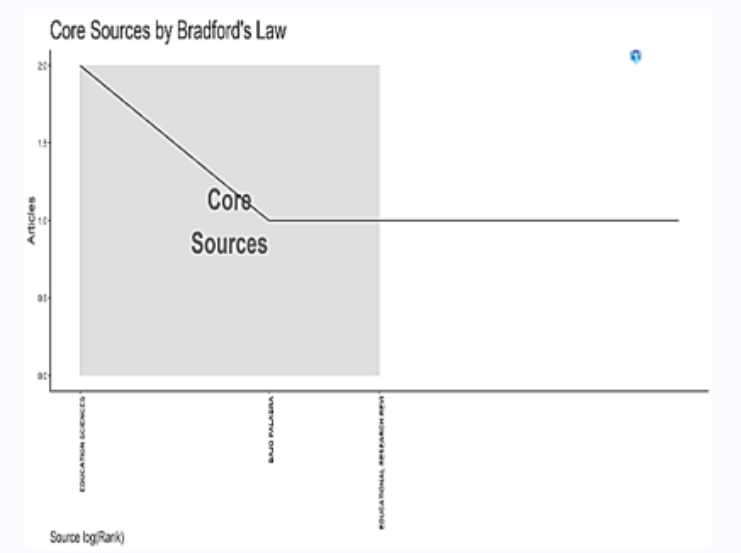


Note: Figures were generated using the Bibliometrix software.

The analysis of the indicator 2 (Research Impact: fig.6) revealed a marked increase in scientific output during the final years of the study period. From a geographical perspective, Spain emerged as the leading contributor, increasing its annual scientific production from one publication in both 2020 and 2021 to four publications in 2022, and reaching seven publications in 2024. This upward trend demonstrates Spain's sustained expansion and growing leadership in research on neurodidactics applied to learning assessment, highlighting its increasingly prominent role in advancing this emerging field of study.

According to Bradford's Law, the scientific literature is concentrated within a relatively small core of specialized journals. In this study, Education Sciences and Educational Research Review emerged as the journals with the highest editorial centrality. This concentration indicates that research on neurodidactics and learning assessment is primarily disseminated through a limited number of high-impact journals specializing in education, educational research, and neuroscience, underscoring their pivotal role in shaping and advancing knowledge within this interdisciplinary field.

Figure 6. Bradford's Law: Distribution of Core Journals.



Note: The figures were generated using VOSviewer.

The analysis of Indicator 3 (Scientific Collaboration: fig.7) was based on a co-authorship network analysis conducted using VOSviewer. The results revealed a highly centralized scientific collaboration network, characterized by a well-defined core of interconnected researchers. The network map identifies Arango-Posada, J.C. as the author with the highest level of connectivity and the most strategically positioned node within the collaboration network, suggesting a high degree of betweenness centrality and a pivotal role in facilitating scientific collaboration and knowledge exchange among researchers.

Furthermore, the high density of connections observed within the network reflects strong and recurring collaborative relationships among authors. The absence of fragmented subnetworks indicates a cohesive research community, demonstrating thematic consistency, sustained collaboration, and continuity in scientific production within the field of neurodidactics and early childhood learning assessment.

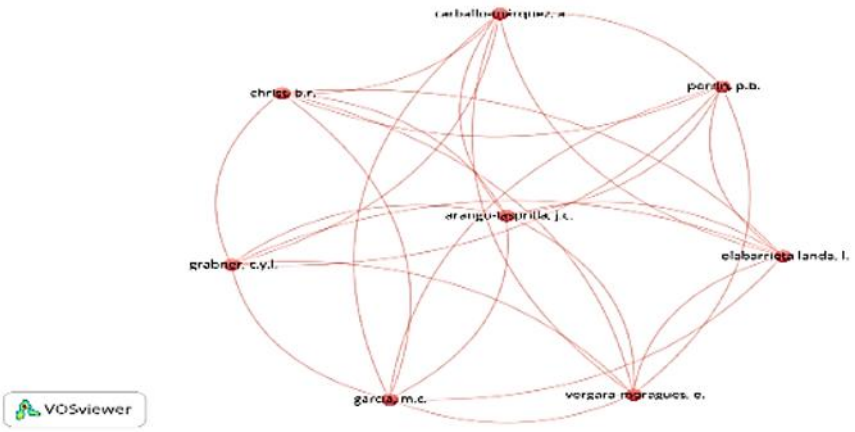
From a structural perspective, the configuration of the collaboration network suggests a well-established scientific ecosystem in which interactions among researchers facilitate the co-creation of knowledge and the effective exchange of intellectual contributions within the principal cluster. The close proximity between nodes, together with the high density of collaborative

links, reflects a complete and cohesive research network, likely supported by shared research projects, long-term institutional partnerships, or consolidated research lines.

This collaborative structure enhances the group's academic visibility, promotes the dissemination of scientific knowledge, and contributes to the production of high-impact research. Such a pattern is consistent with the characteristics of internationally recognized research communities and aligns with the publication standards of journals indexed in leading databases such as Scopus.

The network illustrates the relationships among terms based on their frequency of co-occurrence within the analyzed scientific publications.

Figure 7. Co-authorship network



Note: The figures were generated using VOSviewer.

The analysis of indicator 4 (Thematic Analysis: fig.8), based on the keyword co-occurrence network generated with VOSviewer, revealed a well-defined thematic structure composed of several interconnected clusters. The term neuroeducation emerged as the central node linking the different thematic networks, highlighting its pivotal role within the scientific literature. The network demonstrates a strong convergence among key research domains, including neuroscience, teaching, cognitive development, artificial intelligence, and brain-based learning. This convergence confirms the interdisciplinary nature of neurodidactics and reflects the broad range of educational applications supported by neuroscience.

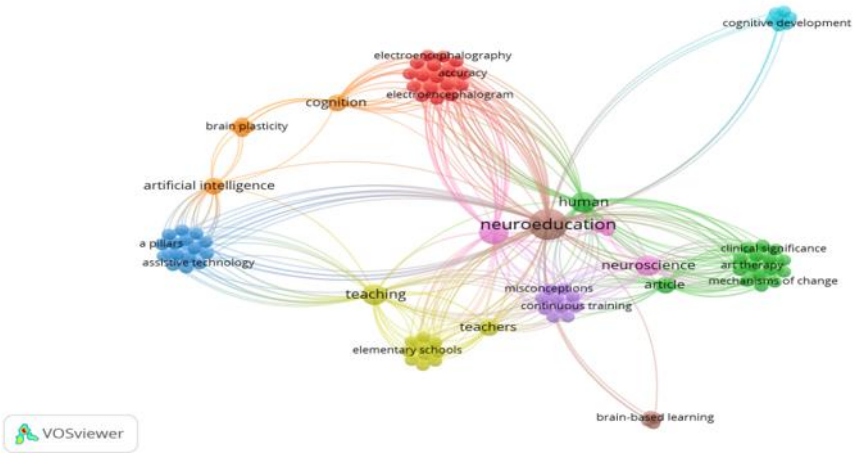
The close proximity of nodes and the high density of links indicate a strong integration of concepts from neuroscience and education. Prominent connections were identified among terms such as brain-based learning, mechanisms of change, and cognitive development, suggesting a gradual transition from theoretical frameworks toward practical educational applications.

The color-coded clusters further reveal distinct thematic subfields within neurodidactics. Cluster 1 is primarily associated with neurophysiological foundations, including electroencephalography and electrophysiology. Cluster 2 focuses on educational processes, encompassing themes such as teachers, primary schools, and teaching practices. Cluster 3 is centered on emerging technologies, particularly artificial intelligence and educational technology.

In addition, the term frequency analysis, visualized through a word cloud generated with Bibliometrix in the R environment, corroborates these findings by identifying neuroeducation as the most prominent and frequently occurring concept in the dataset. Supporting terms such as education, learning, neuroscience, and cognitive development also appeared with high frequency, reinforcing their central role in the current scientific landscape of neurodidactics. The word

cloud visualizes the most frequently occurring terms in the analyzed literature, with word size proportional to the frequency of occurrence across the selected publications.

Figure 8. Keyword co-occurrence network



Note: The figures were generated using the Bibliometrix software.

In conclusion, all the indicators revealed that the scientific literature on neurodidactics is predominantly concentrated in Europe. Spain emerged as the leading contributor, accounting for the highest volume of publications related to the central topic of this study. In Latin America, Ecuador demonstrated a modest but growing scientific presence, with authors contributing between one and two publications each. Although this indicates emerging research activity in the region, the overall scientific output remains substantially lower than that of European countries. This geographical imbalance highlights both a current limitation of the field and a significant opportunity to strengthen research capacity and scientific production across Latin America.

4. Discussion

The discoveries of this bibliometric analysis indicate that neurodidactics applied to the comprehensive assessment of learning in early childhood is an emerging yet increasingly consolidated research field. The sustained growth in scientific production observed since 2020 reflects the expanding interest in integrating neuroscience with educational processes. These findings are consistent with those reported by Rodríguez Dueñas et al. (2026), who argue that neuroscience has become a central framework for the design and improvement of educational practices.

The geographical concentration of scientific production, particularly in Spain and several other European countries, demonstrates that research activity remains unevenly distributed. This pattern is consistent with the distributions predicted by Lotka's Law and Bradford's Law, whereby scientific productivity is concentrated among a relatively small number of highly productive authors and specialized journals. Consequently, the development of the field continues to depend heavily on established research groups and a limited set of high-impact journals specializing in neurodidactics and educational neuroscience. Such concentration may constrain both the thematic diversity and the international dissemination of knowledge. The continued support of organizations such as the European Commission and the National Science Foundation further reflects the sustained investment in neuroscience-based research on child development.

The analysis of the co-authorship networks revealed a cohesive scientific community characterized by strong collaborative relationships among researchers. However, these collaborations remain largely concentrated within

the European context, indicating limited international diversification. This lack of geographical diversity may restrict the transfer and adaptation of neurodidactic knowledge to educational systems outside Europe. These results are consistent with Walsh et al. (2024), who emphasize that translating neuroscience into educational practice requires broader and more diverse international collaboration networks capable of addressing different educational and cultural contexts.

The thematic analysis identified neuroeducation as the conceptual core of the field, closely associated with cognitive development, brain-based learning, and artificial intelligence. This interconnected thematic structure demonstrates the increasingly interdisciplinary nature of neurodidactics and suggests that the field is evolving from theoretical foundations toward evidence-based educational applications. This transition aligns with the educational models proposed by Granado De La Cruz et al. (2025) and Gkintoni et al. (2025), both of whom advocate for pedagogical approaches grounded in neuroscientific evidence.

Despite this scientific progress, a substantial gap persists between research production and its implementation in educational practice. In particular, there remains a shortage of validated neurodidactic assessment instruments specifically designed for children aged 2–6 years. Londoño Vega et al. (2024) similarly identify the disconnect between theory and classroom practice as one of the principal barriers to transforming assessment systems in early childhood education.

The limited availability of well-established research groups and funding opportunities in Latin America represents both a challenge and an opportunity. Expanding research capacity in the region would facilitate the development of culturally responsive neurodidactic models that integrate neuroscientific principles with local educational and social realities (Zhumabayeva et al., 2025). Consequently, the findings of this study have important implications for teacher education, curriculum design, and educational policy development.

Overall, the available evidence highlights the need to incorporate neurodidactic principles into educational assessment systems. Future assessment models should move beyond the exclusive measurement of cognitive performance to include emotional development, social interaction, and motor competencies (Villacís-Macías et al., 2025). Accordingly, future research should prioritize the design, validation, and implementation of neurodidactic assessment instruments for early childhood while strengthening studies conducted in Latin American contexts. Particular attention should be given to the integration of emerging technologies, including artificial intelligence, to develop more comprehensive, equitable, and context-sensitive assessment models.

5. Conclusion

This bibliometric analysis identified a sustained increase in scientific production on neurodidactics applied to comprehensive assessment in early childhood, particularly from 2020 onward, indicating that the field entered a stage of emerging consolidation by 2022. The analysis also confirmed a strong geographical concentration of scientific production in Europe, especially in Spain, together with an authorship distribution consistent with Lotka's Law and an editorial concentration in accordance with Bradford's Law. These findings reveal limited international diversification, particularly within Latin American research contexts.

The collaboration network analysis further demonstrated the existence of highly centralized research structures dominated by a relatively small group of influential authors, suggesting that scientific production remains dependent on established academic hubs. The thematic analysis identified neuroeducation as the central conceptual axis of the field, exhibiting strong connections with cognitive development, neuroscience, and artificial intelligence, thereby confirming the interdisciplinary character and applied orientation of contemporary neurodidactics.

Overall, the findings reveal a significant gap between scientific knowledge and its

implementation in educational practice, particularly regarding the validation of neurodidactic assessment instruments for children aged 2–6 years. Although neurodidactics offers considerable potential to transform educational assessment, its full consolidation will require stronger teacher preparation, the development and validation of evidence-based assessment tools, and increased investment in context-specific research that bridges scientific evidence with the educational realities of diverse learning environments, particularly in Latin America.

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Author Declaration

- Confirm originality of work
- State no conflicts of interest