Mapping Scientific Education in Rural Latin America: Insights into STEM Access and Disciplinary Trends

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Abstract*– This study presents a bibliometric analysis of peer-reviewed literature on STEM education in rural Latin America to identify publication trends, thematic structures, and international collaboration patterns. Despite growing policy interest in expanding scientific education in underserved areas, little is known about how this agenda has been reflected in academic production. A comprehensive search was conducted in Scopus and Web of Science, using a triple-block strategy that combined terms related to rural education, Latin American countries, and scientific disciplines. A total of 193 documents published between 1977 and 2025 were analyzed using Bibliometrix, with a keyword cleaning process to enhance thematic precision. The results reveal a marked increase in publications since 2015, led by Brazil, Colombia, and Mexico. However, international collaboration remains limited and uneven, with a small number of countries dominating both output and authorship. Thematic analysis shows strong emphasis on educational technology, curriculum design, and teacher training, while gaps remain in conceptual integration and territorial representation. This study offers an overview of the scientific landscape and underscores critical challenges related to regional asymmetries, disciplinary fragmentation, and collaboration deficits. The findings provide a foundation for future research and policy efforts aimed at strengthening inclusive science education in rural Latin America.

Keywords*-- STEM education, Rural education, Latin America, Bibliometric review, Science access

I. INTRODUCTION

In recent years, scientific education has gained visibility as a tool for promoting social equity and sustainable development. The latter is particularly relevant in rural Latin America, where persistent inequalities in infrastructure, connectivity, and institutional support continue to limit access to quality STEM education [1-9].

Rural communities often face compounded barriers, such as a lack of specialized teachers, limited laboratory resources, and minimal exposure to scientific culture. Expanding STEM education in these areas is therefore not only academically valuable but also essential for empowering youth, fostering innovation, and reducing socioeconomic gaps. The adoption of digital tools—such as mobile platforms, low-cost kits, and community labs—has created new opportunities for reaching underserved populations [10-18].

Despite national and regional efforts to improve science education in rural contexts, it remains unclear how these initiatives have translated into academic output. While some studies explore global trends in science education or digital learning, few focus specifically on rural Latin America [8, 19-24]. Moreover, the literature lacks a comprehensive mapping of scientific production that addresses both disciplinary focus and collaboration patterns.

Unlike previous bibliometric reviews—such as [25,26] on SDGs and education in Latin America or [27] on global educational innovation—this study uniquely explores the intersection between scientific education, rurality, and territorial inequality across Latin America. While most prior works address either global trends [28-30] or general educational categories [24, 31-34], none of them concentrate specifically on STEM access in rural contexts. Furthermore, the present review differs methodologically by combining Scopus and Web of Science, applying a triple-block search strategy, and implementing rigorous keyword cleaning procedures to eliminate thematic noise—an approach not found in earlier studies. Additionally, this review incorporates a territorialized analysis of international collaboration and conceptual maturity using thematic maps, providing a critical lens on the uneven distribution of research efforts and potential areas for future development.

In light of these gaps, a key question emerges: How has scientific production on STEM education in rural Latin America evolved, and to what extent does it reflect regional disparities, disciplinary focus, and international collaboration? To address this, the present study conducts a bibliometric review of peer-reviewed publications, examining trends in output, geographic distribution, collaboration networks, and thematic structures. This evidence-based analysis offers insights into how the academic community has engaged with the challenges and possibilities of advancing science in rural territories—providing a foundation for educational policy, research agendas, and strategies to reduce scientific and technological inequalities.

II. METHODOLOGY

This bibliometric study implemented a systematic search strategy to examine scientific education within rural contexts across Latin America, with a specific focus on disciplines related to STEM. Following the PRISMA method [35], the primary objective was to identify and analyze trends in publication output, disciplinary distribution, and regional dynamics as reflected in the peer-reviewed scientific literature.

A. Search Strategy

The bibliographic search was conducted in Scopus and Web of Science, two of the most comprehensive databases for scientific literature. The search equation was designed to capture the intersection between rural education, scientific disciplines, and Latin American geography. The terms were grouped into three conceptual blocks:

- Group 1: Educational and geographic context
  ("rural schools" OR "rural teachers" OR "rural education" OR "rural students" OR "rural learners")

- Group 2: Regional focus
  ("Latin America" OR "South America" OR "Central America" OR Argentina OR Bolivia OR Brazil OR Chile OR Colombia OR "Costa Rica" OR Cuba OR "Dominican Republic" OR Ecuador OR "El Salvador" OR Guatemala OR Honduras OR Mexico OR Nicaragua OR Panama OR Paraguay OR Peru OR Uruguay OR Venezuela OR Haiti)

- Group 3: Scientific and disciplinary fields
  (science OR sciences OR "natural sciences" OR STEM OR "science education" OR physics OR chemistry OR biology OR mathematics OR Maths OR engineering OR technology OR "environmental science" OR astronomy OR "earth sciences")

The search was restricted to the title, abstract, and keywords fields in Scopus and to the "Topic" field in Web of Science, containing publications up to July 2025.

B. Data Collection and Screening

The search generated 162 documents from Scopus and 73 from Web of Science, for a total of 235 records. After removing 36 duplicates, the final combined dataset consisted of 199 unique documents. From these, the following document types were excluded due to limited empirical or analytical value: Books (n = 1), Conference reviews (n = 1), and Review articles (n = 4).

The remaining 193 documents were retained for full analysis, distributed as follows: Articles (n = 144), Article early access: 2, Proceedings paper: 1, Book chapters: 7, Conference papers: 39.

The screening process is illustrated in Figure 1, the PRISMA flowchart.

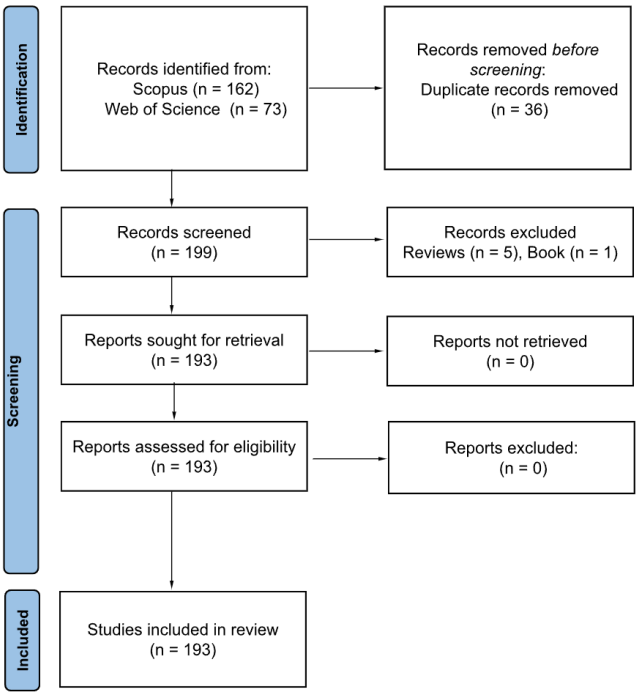

Figure 1: PRISMA flowchart.

The included documents were published in three languages: English (133 documents), Spanish (40 documents), and Portuguese (20 documents).

C. Data Processing and Keyword Cleaning

The dataset was processed using Bibliometrix (R package) and its web-based interface Biblioshiny [36]. In order to enhance the precision of the keyword co-occurrence analysis and the robustness of the thematic mapping, a set of non-discriminative and semantically redundant terms was systematically excluded. These excluded terms comprised broad descriptors such as: *students, student, education, educational institutions, school, schools, rural schools, rural school, rural education, rural areas, rural area, rural population, rural community, rural learners, rural students, rural youth, teaching, learning, learning process, teaching and learning, female, male, adolescent, adult, children, child, boys, girls, article, human, humans, saliva, health survey, prevalence, electric utilities, sanitation, urban population, epidemiology.*

This cleaning step ensured more precise identification of thematic structures and relevant disciplinary intersections.

III. RESULTS

A. *Temporal Evolution*

The evolution of scientific production reflects a markedly uneven historical trajectory, characterized by a long period of minimal output followed by an exponential increase in recent decades.

Between 1977 and 2000, the output remained marginal, with fewer than 3 publications per year, and several years showing no publications at all. During the aforementioned stage, the topic appeared sporadically, with isolated contributions in 1977 (1 article), 1981 (1 article), 1982 (1 article), and 1994 (2 articles), indicating a lack of research activity, as shown in Figure 2.

A gradual upward trend began to emerge after the year 2000, with annual outputs ranging from 1 to 4 articles, until a more pronounced increase became visible from 2005 onward. Between 2010 and 2015, publication levels began to stabilize at a higher range, fluctuating between 4 and 10 articles per year. The year 2015 marks a key inflection point, with 10 publications, likely linked to the growing interest in inclusive education, digital technologies, and science literacy in underserved regions.

From 2020 on, the trend accelerates significantly. The years 2020 (19 articles), 2021 (17 articles), 2022 (20 articles), 2023 (19 articles), and especially 2024 (25 articles) represent the peak of scientific productivity in the field. Despite 2025 data being partial (only up to July), the year has already yielded 12 articles, suggesting continued momentum.

The cumulative trajectory, represented by the black line in Figure 2, clearly demonstrates this exponential pattern of growth, particularly from 2015 to 2024. This sharp increase suggests a growing regional and international recognition of the importance of scientific education in rural contexts and its implications for equity, inclusion, and development.

This temporal dynamic sets the stage for further analysis of geographic distribution, as it is important to understand which countries have contributed most to this expansion and how research efforts are spatially concentrated or distributed across the region.

B. *Geographic Distribution*

The regional distribution reveals a strong concentration in a few Latin American countries, with notable disparities across the region. As shown in Figure 3, Brazil leads by a significant margin, contributing 95 documents, nearly half of the total output. It is followed by Colombia with 67, Chile and the United States with 39 each, and Mexico with 31.

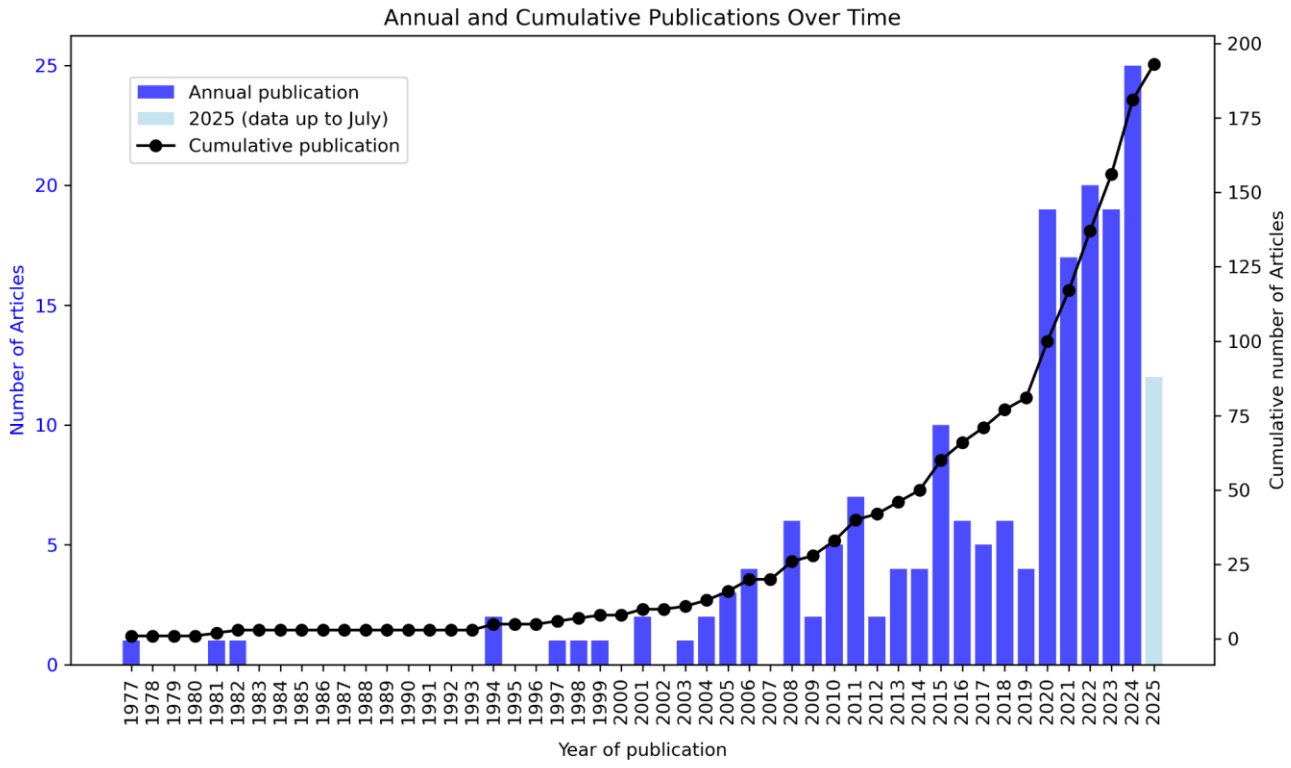

Figure 2: Annual and cumulative number of publications from 1977 to 2025 (July)

A second group includes Peru (20), Argentina (12), and Ecuador (6), showing moderate engagement. Other contributors, such as Honduras (4), El Salvador (1), and Bolivia (1), have marginal presence, reflecting structural research gaps and limited publication capacity in those settings.

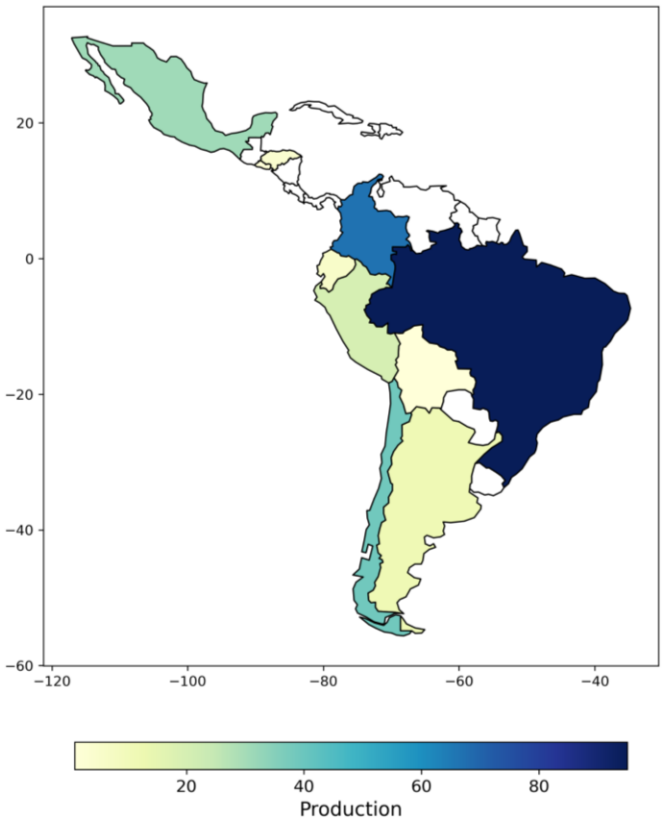

Figure 3: Geographic distribution of publications across Latin America

The presence of non-Latin American countries such as the USA (39), UK (10), Spain (8), and Canada (7) suggests active international collaboration. These countries often appear as co-authors or sponsors of research conducted in Latin America, especially through development programs or university partnerships.

This distribution indicates that while scientific production is growing regionally, it remains unequal. The dominance of Brazil and Colombia suggests centralized academic production, which may influence research agendas and the visibility of less represented contexts. The following section explores this further through an analysis of international collaboration networks, highlighting the relational dynamics between countries.

C. *International Collaboration Networks*

The geographic patterns described previously (Figure 3) are further illuminated by analyzing international collaboration networks, shown in Figure 4. While scientific production remains highly concentrated in Brazil, Colombia, Chile, Mexico, and Peru, international partnerships reveal a more nuanced picture of cooperation dynamics and leadership roles.

Figure 4 illustrates two distinct clusters of collaboration. The first is centered on Brazil and includes regional partners such as Colombia, Chile, and Mexico, forming a predominantly Latin American network. The second is led by the United States, which maintains strong ties with Peru, Canada, the United Kingdom, and several Asian partners, including Vietnam and Sri Lanka. Notably, Peru emerges as a strategic bridge between these two clusters, with visible connections to both the U.S.-centric and Latin American spheres.

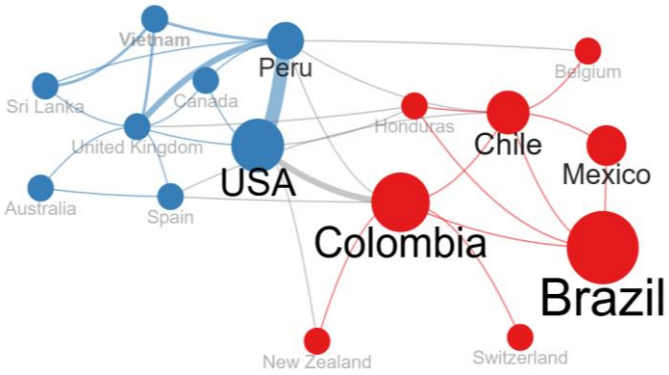

Figure 4: International Collaboration Network

A more detailed view of scientific leadership emerges when analyzing the countries of corresponding authors, shown in Figure 4. Brazil leads with 35 documents (18.1%), all of which are single-country publications (SCP), indicating an entirely domestic production profile. Colombia follows with 20 articles (10.4%), of which 4 (20%) involve international co-authorship (MCP). The United States ranks third with 18 articles (9.3%), showing slightly lower collaboration (MCP = 2; 11.1%).

Chile and Mexico each contribute 13 documents (6.7%). Chile shows a higher degree of international collaboration (MCP = 3; 23.1%) than Mexico (MCP = 1; 7.7%). Peru, with 6 articles (3.1%), maintains moderate collaboration as well, with one-sixth of its output co-authored across borders.

The United Kingdom and Canada, despite their modest total output (6 and 3 articles respectively), display higher collaborative intensity: 33.3% of their publications are internationally co-authored. Meanwhile, Ecuador (n = 4), Argentina (n = 2), and a group of other countries—Australia, Belgium, Bolivia, China, Germany, Hong Kong, India, and Sweden (each with n = 1)—show exclusively single-country authorship.

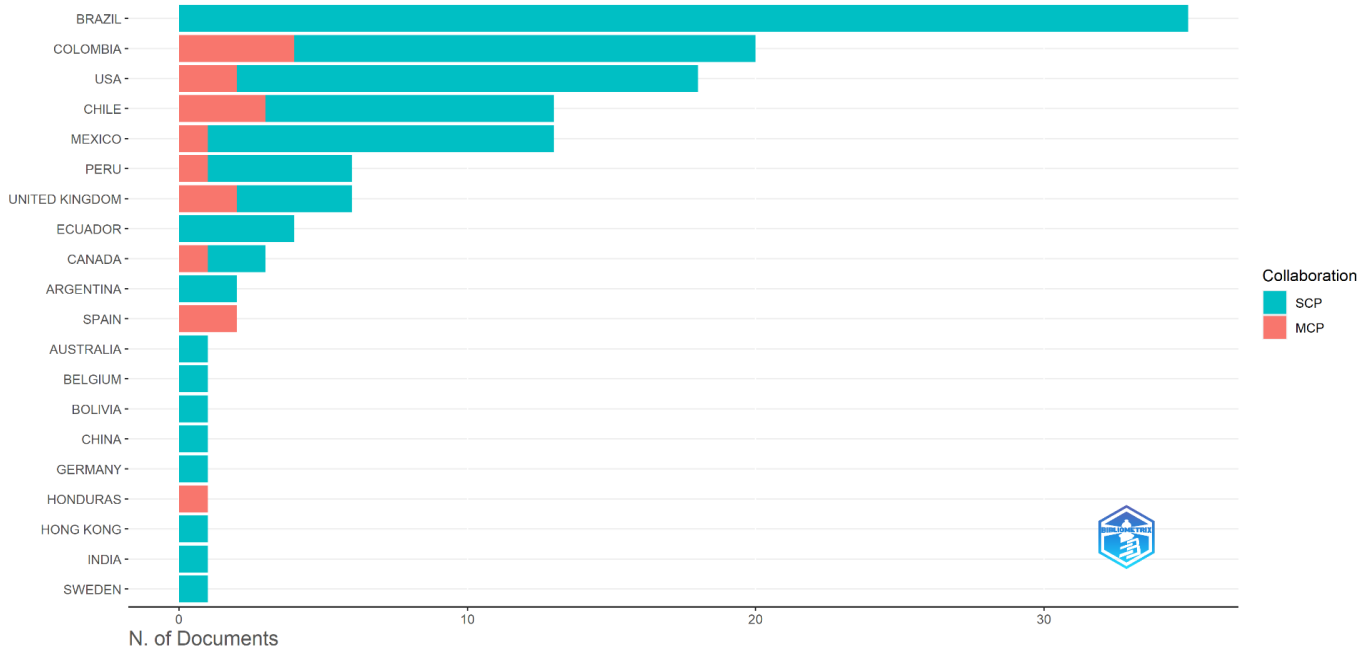

Figure 5: Distribution of Corresponding Authors by Country and Type of Collaboration

In contrast, Spain and Honduras are outliers: both exhibit a 100% international collaboration rate, albeit with only two and one publications, respectively. These cases highlight participation in globally coordinated efforts rather than domestic leadership.

Concurrently, these patterns suggest that volume alone does not equate to network centrality or international visibility. Countries with moderate output but higher MCP rates, such as the UK, Chile, or Canada, demonstrate more integration into global research networks. Meanwhile, dominant producers like Brazil may benefit from strengthening international linkages to amplify regional visibility.

D. Keyword Analysis

The analysis of author-provided keywords and Keyword Plus reveals recurring thematic patterns that reflect both the research priorities and contextual challenges addressed in the literature. In the Keyword Plus cloud, shown in Figure 6, dominant terms such as "*rural education*," "*engineering education*," and "*developing countries*" stand out prominently, indicating a strong focus on educational access and technical training in underserved regions. Additional key terms like "*human-computer interaction*," "*decision making*," "*curricula*," and "*internet*" underscore the influence of digital tools, educational methodologies, and behavioral factors in shaping science engagement.

Meanwhile, the author keyword cloud, depicted in Figure 7, reinforces and complements these trends. Prominent terms include "*developing countries*," "*natural sciences*," "*rural*," "*teacher education*," and "*Mexico*", which reflect a regional and disciplinary grounding. The presence of keywords like "*digital divide*," "*technology*," "*pandemics*," and "*STEM*" indicates concern with both infrastructural and systemic barriers, particularly in the wake of the COVID-19 pandemic. Educational innovations are also a focal point, as seen in "*digital literacies*," "*e-learning*," and "*educational technology*."

Figure 6: Word Cloud Keywords Plus

Figure 7: Word Cloud Author Keywords

E. Thematic Landscape

With the purpose of further understanding the conceptual structure of the literature, a thematic map was generated based on co-word analysis using Keyword Plus, shown in Figure 8. This strategic diagram classifies themes according to their centrality (relevance to the field) and density (level of internal development), resulting in four quadrants: motor themes, basic themes, niche themes, and emerging or declining themes.

Motor Themes (upper-right quadrant) are both well-developed and highly central to the research field. In this map, keywords such as "*internet*," "*academic performance*," "*adolescent behavior*," and "*learning management system*" are represented. Their position suggests that digital resources and learning technologies, especially in connection with youth behavior and academic outcomes, are pivotal to the literature. The presence of "*Chile*" and "*chilean*" indicates the national specificity of some of these discussions, reflecting regional implementation of educational technologies and frameworks.

Basic Themes (lower-right quadrant) are fundamental to the field but present lower internal cohesion. These include "*rural educations*," "*developing countries*," "*curricula*," "*decision making*," "*educational technology*," and "*engineering education*." Despite being less developed internally, these themes form the backbone of research on accessible science and innovation in Latin America, especially in underserved or structurally vulnerable contexts. Also appearing here are "*human-computer interaction*," "*animation*," and "*e-learning*," pointing to the foundational role of digital interfaces and pedagogical media.

Niche Themes (upper-left quadrant) are well-developed but have low centrality. Terms such as "*public relations*," "*cosmic rays*," "*extensive air showers*," and "*societies and institutions*" fall into this category. These areas, although internally strong and possibly related to specific institutional or scientific case studies (e.g., physics education or science outreach), have limited connection with the broader discourse on sustainable innovation or educational transformation. Similarly, topics like "*cost engineering*," "*spatial analysis*," and "*school of engineering*" suggest isolated lines of inquiry that may still inform specific technical applications.

Emerging or Declining Themes (lower-left quadrant) show low values in both centrality and density. Themes such as "*calcium*," "*elementary*," "*science*," "*arsenic*," and "*nutrition*" fall into this group, alongside geographical identifiers like "*Peru*" and "*South America*." Their positioning may reflect either nascent research lines—still gaining traction—or declining interest within the corpus analyzed. Nevertheless, their presence is valuable for identifying underexplored areas with potential for future growth.

These thematic clusters offer a structured overview of the intellectual organization of the field, where digitalization, rural inclusion, and science education emerge as central pillars, while region-specific themes provide contextual grounding.

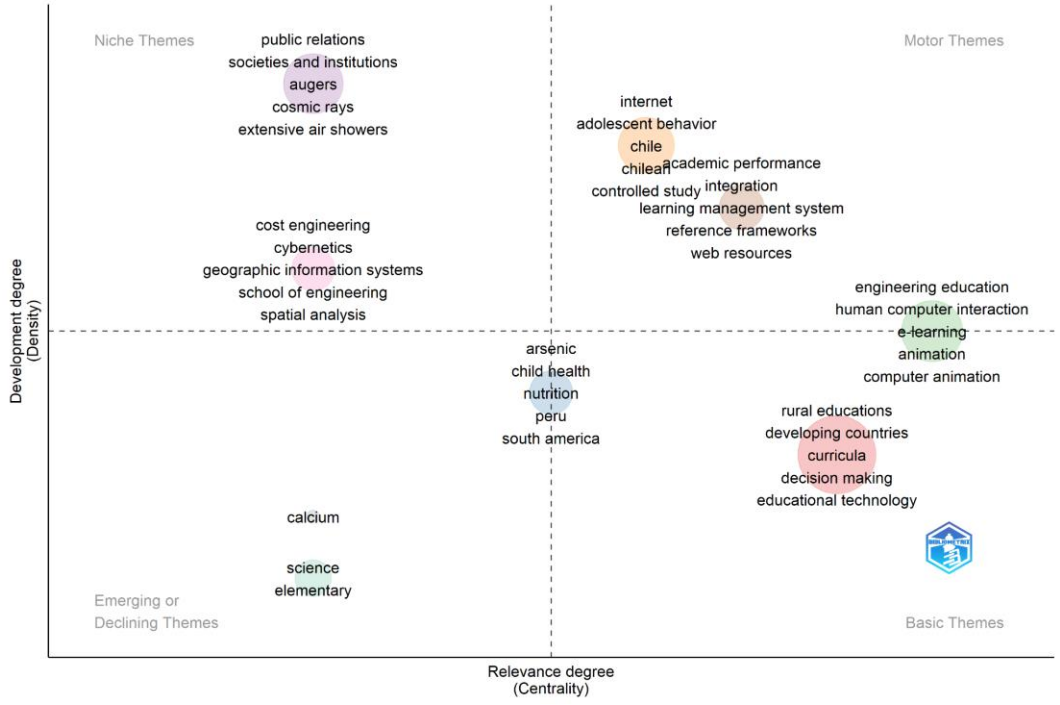

Figure 8: Thematic map Keyword Plus

IV. DISCUSSION

A. Main Findings

The results of this bibliometric review underscore a growing but uneven scientific interest in the development of STEM education in rural Latin America. The exponential rise in publications observed over the last decade confirms that this topic has gained traction within academic and policy-oriented agendas, particularly in connection with digital transformation, equity in education, and sustainable development.

The dominance of countries such as Brazil, Colombia, and Mexico in terms of publication volume reflects the presence of consolidated academic ecosystems and targeted policy initiatives. However, the limited output from other nations, especially in Central America and parts of the Andean region, reveals persistent structural asymmetries in research capacity and access to publication systems. These geographic disparities mirror broader patterns of educational inequality across the region and reinforce the need for inclusive research funding and transnational collaboration programs.

Collaboration data further emphasizes this imbalance. While Brazil is the top contributor in terms of total documents, its scientific production is almost entirely domestic. In contrast, countries like Chile, Peru, and Colombia show moderate but growing levels of international collaboration, often through partnerships with institutions in the United States, the United Kingdom, and Canada. These findings underscore the importance of international networks not only for increasing visibility but also for expanding methodological diversity and knowledge exchange. Countries with fewer resources may benefit from fostering co-authorship strategies that allow them to participate in global research circuits.

Thematic analyses indicate a strong presence of basic but underdeveloped themes—such as rural education, educational technology, and curricula—suggesting that while these issues are central, they remain fragmented in terms of theoretical depth and interdisciplinary integration. The emergence of terms like e-learning, human-computer interaction, and animation within this cluster reveals an increasing concern with technological mediation, but often from an implementation rather than a critical or evaluative perspective.

At the same time, motor themes such as academic performance, learning management systems, and adolescent behavior reflect ongoing concerns with digital environments and learner outcomes. These themes suggest a partial convergence between educational psychology, ICT integration, and rural development. However, the coexistence of isolated or niche topics—e.g., cosmic rays, cost engineering, or public relations—raises questions about the thematic coherence of the field and may reflect cross-disciplinary noise or fragmented research scopes.

Finally, the presence of several terms in the "emerging or declining" quadrant, particularly those linked to public health (nutrition, arsenic, child health), highlights broader intersections between science education and environmental or health literacy—domains that may offer fertile ground for future integrative studies.

In sum, this review reveals a dynamic but unevenly distributed field, where foundational themes are gaining visibility but still lack conceptual consolidation. Advancing this area will require more inclusive, cross-border collaboration, thematic integration, and sustained investment in rural scientific infrastructure and teacher training.

B. Limitations

This study presents several limitations that should be considered when interpreting the findings. First, the review is based exclusively on documents indexed in Scopus and Web of Science, which—although highly reputable—may exclude relevant publications from regional databases (e.g., SciELO, RedALyC) or grey literature sources that are particularly significant in Latin American contexts. As a result, valuable contributions published in non-indexed national journals or institutional reports might be underrepresented.

Second, the search strategy, while carefully constructed and iteratively refined, inherently shapes the scope of the results. Despite efforts to balance specificity and breadth, some relevant studies may have been omitted due to variations in terminology or metadata inconsistencies. Conversely, the inclusion of general terms like science or technology—even after manual filtering—may have introduced thematic noise, especially from health or engineering domains not directly linked to STEM education in rural areas.

Third, the language distribution of the dataset favors publications in English, which represented over two-thirds of the corpus. Although Spanish and Portuguese-language documents were included, linguistic biases in indexing and visibility may skew the representation of local or community-based research initiatives that often publish in native languages.

Fourth, the bibliometric approach, by its nature, emphasizes quantitative trends (e.g., publication counts, keyword frequency, collaboration metrics) and does not capture the depth, quality, or contextual richness of the research content. The aforementioned limits the capacity to evaluate pedagogical approaches, implementation outcomes, or community impact described within individual studies.

Finally, the analysis reflects the state of the literature up to July 2025, and any publications indexed after that date are not

captured. Given the rapid evolution of digital education and science policy in the region, particularly in response to post-pandemic restructuring, some emerging developments may be missing.

Despite these limitations, the study offers a valuable overview of the scientific landscape and contributes a structured baseline for future, more in-depth qualitative or mixed-methods reviews.

C. *Future Perspectives*

The findings of this review open several avenues for future research and strategic development. First, there is a need to expand the empirical depth of the field through qualitative and mixed-method studies that explore how STEM education is implemented, adapted, and experienced in rural settings. While bibliometric indicators reveal thematic concentrations and gaps, they do not capture the pedagogical dynamics, teacher agency, or community engagement processes that shape educational outcomes on the ground.

Second, longitudinal and comparative studies could offer insights into the evolution of STEM education in different rural subregions—such as the Andean highlands, the Amazon basin, or Central American border zones—highlighting both common structural barriers and context-specific innovations. Such analyses would help to move beyond national aggregates and better reflect territorial diversity.

Third, the field would benefit from greater integration with related areas, including environmental education, indigenous knowledge systems, and digital inclusion policies. Interdisciplinary research that links science education with sustainability, health literacy, or climate resilience could amplify both the academic relevance and societal impact of rural STEM initiatives.

Fourth, there is an opportunity to enhance regional collaboration and research visibility, particularly by involving institutions and researchers from underrepresented countries. Supporting open-access publishing, regional journals, and multilingual dissemination strategies would contribute to more equitable knowledge production and circulation.

Finally, the emergence of technologies such as low-cost digital laboratories, mobile science kits, virtual simulations, and AI-assisted tutoring tools opens promising paths for innovation in low-resource educational environments. Future research should examine not only the adoption of such tools, but also their cultural appropriateness, pedagogical integration, and long-term sustainability in rural Latin America.

These future directions point toward the construction of a more inclusive and context-sensitive research agenda that aligns educational innovation with territorial realities and scientific equity.

V. CONCLUSIONS

This review provides a wide mapping of the scientific production related to STEM education in rural Latin America. The findings reveal an accelerated growth of scholarly output over the past decade, reflecting increasing academic and institutional attention to educational equity, technological inclusion, and territorial development.

The analysis identified Brazil, Colombia, Chile, Mexico, and Peru as the primary contributors, although international collaboration remains irregular. While some countries exhibit strong domestic leadership, others depend on transnational partnerships to participate in the global research ecosystem. These dynamics highlight the relevance of expanding regional cooperation and promoting inclusive research policies.

Thematic analyses reveal a concentration around digital technologies, teacher training, and curricular design—topics essential for advancing STEM engagement in underserved areas. However, the presence of underdeveloped or fragmented themes indicates the need for deeper theoretical integration and more context-sensitive approaches. Additionally, the emergence of public health and environmental keywords points to interdisciplinary opportunities that remain underexplored.

In sum, this study offers a structured overview of a growing but still asymmetrical field. It contributes to the academic understanding of rural science education and provides a foundation for future investigations that aim to strengthen the role of science and technology in promoting social inclusion and sustainable development across Latin America.

REFERENCES

[1] Martín Bascopé y Kristina Reiss, “Place-Based STEM Education for Sustainability: A Path towards Socioecological Resilience,” Sustainability, vol. 13, no. 15, Art. no. 8414, 17 p., Jul. 2021.

[2] J. Çolakoğlu, A. Steegh, and I. Parchmann, “Reimagining informal STEM learning opportunities to foster STEM identity development in underserved learners,” Front. Educ., vol. 8, Art. no. 1082747, 2023.

[3] K. N. Kuteesa, C. U. Akpuokwe, and C. A. Udeh, “Gender equity in education: Addressing challenges and promoting opportunities for social empowerment,” Int. J. Adv. Res. Soc. Sci., vol. 6, no. 4, Apr. 2024. [Online]. Available: https://doi.org/10.51594/ijarss.v6i4.1034

[4] R. J. Albarracín Vanoy, “STEM education as a teaching method for the development of XXI century competencies,” Metaverse Basic Appl. Res., vol. 1, Dec. 2022. [Online]. Available: https://doi.org/10.56294/mr202221.

[5] R. Paucar-Curasma, L. P. Cerna-Ruiz, C. Acra-Despradel, K. O. Villalba-Condori, L. A. Massa-Palacios, A. Olivera-Chura, and I. Esteban-Robladillo, “Development of computational thinking through STEM activities for the promotion of gender equality,” Sustainability, vol. 15, no. 16, Art. no. 12335, 2023. [Online]. Available: https://doi.org/10.3390/su151612335.

[6] L. Y. Florido Gómez and M. R. Raquel Alcoce, “Fortalecimiento en el desarrollo del pensamiento matemático de los escolares en la educación rural colombiana: Estudio del caso en el Municipio Yacopí –

Cundinamarca," Cienc. Lat. Rev. Cienc. Multidiscip., vol. 7, no. 3, pp. 2051–2074, 2023. [Online]. Available: https://doi.org/10.37811/cl_rcm.v7i3.6332.

[7] A. Castro, J. Medina, C. A. Aguilera, M. Ramirez, and C. Aguilera, "Robotics education in STEM units: Breaking down barriers in rural multigrade schools," Sensors, vol. 23, no. 1, Art. no. 387, 2023. [Online]. Available: https://doi.org/10.3390/s23010387.

[8] V. Silva, S. Peña, and M. Saucedo, "STEM education as a strategy to move from the new structural economy to the endogenous and sustainable growth model in Latin America," Labor et Educatio, no. 2020, pp. 53–71, 2020. [Online]. Available: https://doi.org/10.4467/25439561LE.20.005.12996.

[9] S. Murphy, "Leadership practices contributing to STEM education success at three rural Australian schools," Aust. Educ. Res., vol. 50, pp. 1049–1067, 2023. [Online]. Available: https://doi.org/10.1007/s13384-022-00541-4.

[10] S. Muñoz-Hernández, C. Benac-Earle, A. Herranz Nieva, and M. Gonzalez-McGuinness, "Sustainable methodology for operational and formal digital skills acquisition: A case study of e-health inclusion," Sustainability, vol. 13, no. 17, Art. no. 9698, 2021. [Online]. Available: https://doi.org/10.3390/su13179698

[11] S. Vera-Choqqueccota, B. E. Y. Belmekki, M.-S. Alouini, M. Teodorescu, D. Haussler, and M. A. Mostajo-Radji, "Reducing education inequalities through cloud-enabled live-cell biotechnology," Trends Biotechnol., vol. 43, no. 1, pp. 43–60, Jan. 2025. [Online]. Available: https://doi.org/10.1016/j.tibtech.2024.07.015

[12] D. Song, A. Karimi, and P. Kim, "A remotely operated science experiment framework for under-resourced schools," Interact. Learn. Environ., vol. 24, no. 7, pp. 1706–1724, 2015. [Online]. Available: https://doi.org/10.1080/10494820.2015.1041407

[13] E. D. Kameni and S. C. T. Koumetio, "The role of inclusive educational technologies in transforming African cities into inclusive smart cities," E3S Web Conf., vol. 418, Art. no. 03003, pp. 1–6, 2023. [Online]. Available: https://doi.org/10.1051/e3sconf/202341803003

[14] S. Livingstone et al., "Global perspectives on children's digital opportunities: An emerging research and policy agenda," Pediatrics, vol. 140, suppl. 2, pp. S137–S141, Nov. 2017. [Online]. Available: https://doi.org/10.1542/peds.2016-1758S

[15] S. Casillas-Martín, M. Cabezas-González, and A. García-Valcárcel Muñoz-Repiso, "DigiCraft: A pedagogical innovative proposal for the development of the digital competence in vulnerable children," Sustainability, vol. 12, no. 23, Art. no. 9865, 2020. [Online]. Available: https://doi.org/10.3390/su12239865

[16] D. Bavelier, C. S. Green, and M. W. G. Dye, "Children, wired: For better and for worse," Neuron, vol. 67, no. 5, pp. 692–701, Sep. 2010. [Online]. Available: https://doi.org/10.1016/j.neuron.2010.08.035

[17] L. Holly, B. L. H. Wong, R. van Kessel, I. Awah, A. Agrawal, N. Ndili et al., "Optimising adolescent wellbeing in a digital age," BMJ, vol. 380, Art. no. e068279, 2023. [Online]. Available: https://doi.org/10.1136/bmj-2021-068279

[18] C. J. Sieck, A. Sheon, J. S. Ancker et al., "Digital inclusion as a social determinant of health," NPJ Digit. Med., vol. 4, Art. no. 52, 2021. [Online]. Available: https://doi.org/10.1038/s41746-021-00413-8

[19] A. Narayan, B. Chogtu, M. Janodia et al., "A bibliometric analysis of publication output in selected South American countries," F1000Research, vol. 12, Art. no. 1239, 2023. [Online]. Available: https://doi.org/10.12688/f1000research.134574.1

[20] J. Guerrero-Casado, "Scientific production in Latin America indexed in Scopus in farming sciences: An analysis during the period 1996–2016," Idesia, vol. 35, no. 4, pp. 27–33, 2017. [Online]. Available: http://dx.doi.org/10.4067/S0718-34292017000400027

[21] M. Persson, "La internacionalización de la educación superior a través de las revistas científicas digitales en América Latina," Cuad. Cent. Estud. Diseño Comun., no. 85, 2020. [Online]. Available: https://doi.org/10.18682/cdc.vi85.3758

[22] R. González-Quintero, R. Barahona-Rosales, D. M. Bolívar-Vergara et al., "Technical and environmental characterization of dual-purpose cattle farms and ways of improving production: A case study in Colombia," Pastoralism, vol. 10, Art. no. 19, 2020. [Online]. Available: https://doi.org/10.1186/s13570-020-00170-5

[23] K. R. Finardi, C. França, and F. F. Guimarães, "Ecology of knowledges and languages in Latin American academic production," Ensaio: Aval. Polít. Públicas Educ., vol. 30, pp. 764–787, 2022.

[24] B. S. Lancho-Barrantes and F. J. Cantú-Ortiz, "Science in Mexico: A bibliometric analysis," Scientometrics, vol. 118, pp. 499–517, 2019. [Online]. Available: https://doi.org/10.1007/s11192-018-2985-2

[25] L. Pedraja-Rejas, M. A. Garrido-Tamayo, I. Ortega-Piwonka, et al., "Scientific production in Latin American physics: a bibliometric analysis," Scientometrics, vol. 129, pp. 4189–4230, 2024. [Online]. Available: https://doi.org/10.1007/s11192-024-05035-x

[26] L. Pedraja-Rejas, E. Rodríguez-Ponce, C. Muñoz-Fritis, and D. Laroze, "Sustainable Development Goals and Education: A Bibliometric Review—The Case of Latin America," Sustainability, vol. 15, Art. no. 9833, 2023. [Online]. Available: https://doi.org/10.3390/su15129833

[27] E. Abad-Segura, M.-D. González-Zamar, J. C. Infante-Moro, and G. Ruipérez García, "Sustainable management of digital transformation in higher education: Global research trends," Sustainability, vol. 12, Art. no. 2107, 2020. [Online]. Available: https://doi.org/10.3390/su12052107

[28] L. A. Navarro-Ibarra, O. Cuevas-Salazar, L. L. Acuña-Michel, and J. M. Valenzuela-Ochoa, "Mathematics education and technology: Bibliometric analysis and systematic review (2000–2024)," Eurasia J. Math. Sci. Technol. Educ., vol. 21, no. 3, Art. no. em2607, 2025. [Online]. Available: https://doi.org/10.29333/ejmste/16072

[29] P. Bitzenbauer, "Quantum physics education research over the last two decades: A bibliometric analysis," Educ. Sci., vol. 11, Art. no. 699, 2021. [Online]. Available: https://doi.org/10.3390/educsci11110699

[30] A. Valencia-Arias, L. M. Méndez Velásquez, E. Agudelo-Ceballos, J. T. Cumpa Vásquez, J. A. Jimenez Garcia, and E. Martínez Rojas, "Virtual education in the rural sector: Analysis of scientific literature," Front. Educ., vol. 10, Art. no. 1567733, 2025. [Online]. Available: https://doi.org/10.3389/feduc.2025.1567733

[31] J. A. Morales-Marroquín, R. Solis Miranda, J. B. Pinheiro, and M. I. Zucchi, "Biodiversity research in Central America: A regional comparison in scientific production using bibliometrics and democracy indicators," Front. Res. Metr. Anal., vol. 7, 2022. [Online]. Available: https://doi.org/10.3389/frma.2022.898818

[32] G. Herrera-Franco, N. Montalván-Burbano, C. Mora-Frank, and L. Bravo-Montero, "Scientific research in Ecuador: A bibliometric analysis," Publications, vol. 9, Art. no. 55, 2021. [Online]. Available: https://doi.org/10.3390/publications9040055

[33] W. Medina-Jerez, "Science education research trends in Latin America," Int. J. Sci. Math. Educ., vol. 16, pp. 465–485, 2018. [Online]. Available: https://doi.org/10.1007/s10763-016-9785-z

[34] M. Sili, B. Benítez, and A. Da Ponte Prieto, "Evolution and statement of the rural studies in Latin America: A current bibliographical review," Cuad. Investig. Geogr., vol. 50, no. 1, pp. 123–124, May 2024. [Online]. Available:https://publicaciones.unirioja.es/ojs/index.php/cig/article/view/5919

[35] M. J. Page et al., "The PRISMA 2020 statement: An updated guideline for reporting systematic reviews," BMJ, vol. 372, Art. n71, 2021, doi: 10.1136/bmj.n71.

[36] Aria y C. Cuccurullo, "Bibliometrix: An R-tool for comprehensive science mapping analysis," J. Informetr., vol. 11, pp. 959–975, 2017, doi: 10.1016/j.joi.2017.08.007.