

Gender Gaps and Female Participation in STEM: A Bibliometric Analysis of the Literature

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Abstract

This article presents a bibliometric analysis aimed at mapping scientific output on gender gaps and women's participation in STEM between 2023 and 2025. The methodology is grounded in the PRISMA model for systematic reviews and the Science Mapping Workflow for bibliometric analysis, employing tools such as Bibliometrix and Biblioshiny within the R environment. The search was conducted exclusively in the Web of Science database, retrieving a total of 2,117 records. After removing duplicates and applying thematic filtering, 1,400 articles were included in the final analysis.

Among the main findings, an annual growth rate of 56% was observed between 2023 and 2024. The most frequent keywords were gender equality, STEM education, and inclusion. The United States, Brazil, Mexico, Spain, and China led scientific production. Academic collaboration networks showed high density in Latin America, Western Europe, and East Asia. However, only 26.4% of authorship corresponded to women, highlighting persistent gender inequality. Conceptual, intellectual, and social maps revealed five thematic clusters focused on digital inclusion, higher education, and technological ethics.

This study provides empirical evidence to strengthen institutional strategies that promote gender equity in technology-related fields. Furthermore, it proposes a replicable approach for assessing the evolution of gender-focused scientific agendas in Latin American contexts.

Keywords

Gender gap in STEM, bibliometrics, inclusive higher education, PRISMA, co-occurrence analysis, inclusive software design, women in computing, international academic collaboration,

1. Introduction

The gender gap in Science, Technology, Engineering, and Mathematics (STEM) disciplines remains a persistent challenge within higher education systems and global scientific production. Despite numerous institutional and academic efforts to foster the inclusion of women in technology-related fields, inequalities persist in both access and authorship representation in scientific publications, particularly in areas such as computer science, engineering, and educational innovation [1], [2].

In Latin America, this issue is especially relevant given the growing interest in implementing institutional policies with a gender perspective and in highlighting the contributions of female researchers to digital transformation processes, inclusive software design, and STEM pedagogies [3]. The Latin American Women in Computing Conference (LAWCC) has played a key role in documenting and disseminating experiences, research, and initiatives that promote equity in academic and technological environments [4].

This article presents a bibliometric study analyzing the evolution of scientific literature between 2023 and 2025, focusing on gender gaps, women's participation in STEM, educational inclusion, and gender-sensitive technologies. The systematic review was based on the PRISMA methodology [5] and the Science Mapping Workflow model [6], using the Web of Science (WoS) database as the primary source. Initially, 2,117 records were retrieved, of which 1,400 articles met the established inclusion

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criteria. The analysis was conducted using Bibliometrix and Biblioshiny tools, enabling the visualization of thematic, intellectual, and social structures within the field.

The findings provide quantitative evidence on country-level distribution, authorship patterns, frequent keywords, and collaboration networks, as well as the low participation of women as lead authors (26.4%). Additionally, the study identifies emerging thematic areas and offers recommendations to strengthen gender equity in academic production. The applied approach is replicable across other regions or disciplines and contributes to building a more inclusive and evidence-based scientific agenda.

2. Literature Review

Female participation in STEM disciplines remains constrained by structural barriers, affecting access, retention, and leadership within academia and industry [7], [8], [9]. Recent studies have documented multiple initiatives aimed at reversing this situation, ranging from mentoring programs and institutional policies to diagnostic models that assess gender equity in university settings [10], [11], [12].

In the Latin American context, LAWCC conferences have established a platform for disseminating research on gender and computing. A bibliometric analysis of papers presented between 2008 and 2023 reveals sustained thematic growth in areas such as accessibility, artificial intelligence, digital diversity, and inclusive education [4].

Bibliometric studies have proven to be effective tools for examining the evolution of scientific communities, collaboration networks, and thematic structures. A recent investigation on process management in indexed journals employed the Science Mapping Workflow model to represent structural and dynamic aspects of scientific knowledge [6]. This methodology has been complemented by systematic review models such as PRISMA, widely used to define search, filtering, and inclusion criteria for academic literature [13], [5].

The use of tools such as Bibliometrix, developed in the R environment, enables automated analysis of co-occurrences, social networks, conceptual evolution, and co-citation in scientific sources [14], [15]. These methodologies and resources have been successfully applied in studies on inclusion, educational innovation, and women's representation in STEM careers, which justifies their adoption in the present research.

This article aligns with that line of work by conducting a bibliometric analysis of academic literature indexed in WoS between 2023 and 2025, focusing on gender gaps, inclusion in higher education, and the design of technologies with an equity-oriented approach.

3. Methodology

The systematic review process was structured according to the PRISMA methodology, ensuring traceability, transparency, and rigor in the selection of analyzed articles [5].

During the identification phase, a total of 2,117 records were retrieved from the WoS database, considering publications indexed between 2023 and 2025 in Spanish and English, as shown in Table 1. The search was conducted using an advanced strategy with Boolean operators and thematic identifiers related to gender gap, STEM, software design, and access to higher education, aligned with the Sustainable Development Goals (SDGs) 4, 5, 8, 10, and 16 [16]. The temporal delimitation was based on the specific interest of this study in evaluating recent trends in the literature on gender gaps in STEM fields, particularly in the post-pandemic context and in response to the growing international focus the topic has received over the past three years. This interval was selected to capture an updated and relevant sample that allows identifying recent changes and initiatives with potential influence on current academic production.

During the initial screening phase, 117 duplicate records were removed, leaving 2,000 unique documents for analysis. Subsequently, in the preliminary selection phase, 500 articles were excluded for not meeting the thematic criteria defined in abstracts and keywords, such as lack of direct relation to

Table 1
Search String in the Database

Element	Content
Database	Web of Science Core Collection
USearch URL	https://www.webofscience.com/wos/woscc/summary/c8b2aa4a-6db0-4ad8-9b71-559b546e848d-01645318c0/relevance/1
Search String	Gender Gap (Topic) OR STEM (Keyword Plus®) OR "Software Design" (Keyword Plus®) AND "Higher Education Access" (Keyword Plus®) AND STEM (Author Keywords) OR "Software Design" (Author Keywords) OR "Higher Education Access" (Author Keywords) AND 2025 OR 2024 OR 2023 (Publication Years) AND Article (Document Types)
WoS Indexes	Gender Gap (Topic) OR STEM (Keyword Plus®) OR "Software Design" (Keyword Plus®) AND "Higher Education Access" (Keyword Plus®) AND STEM (Author Keywords) OR "Software Design" (Author Keywords) OR "Higher Education Access" (Author Keywords) AND 2025 OR 2024 OR 2023 (Publication Years) AND Article (Document Types)
Languages Included	English, Spanish
Document Type	Scientific Articles (Article)
Publication Years	2023, 2024, 2025
Sustainable Development Goals	SDG 05 Gender Equality, SDG 04 Quality Education, SDG 10 Reduced Inequalities, SDG 16 Peace, Justice and Strong Institutions, SDG 08 Decent Work and Economic Growth
Selected Research Areas	Education, Psychology, Sociology, Public Health, Science and Technology, Women's Studies, Engineering, Demography, Mathematical Methods in Social Sciences, Family Studies, Computer Science, Public Administration, Social Work, Regional Studies, Telecommunications, Construction Technology, Robotics
Excluded WoS Categories	Multidisciplinary Chemistry, Clinical Psychology, Social Psychology, Developmental Psychology, Educational Psychology, Applied Psychology, Biomedical Social Sciences, Psychiatry

gender equity in technological higher education or absence of focus on academic inclusion in STEM environments.

In the eligibility evaluation phase, full-text documents were reviewed. An additional 100 records were excluded for not meeting the established methodological criteria, such as lack of empirical evidence, absence of a solid theoretical framework, or misalignment with the study objectives.

A classification of authors' gender was performed, revealing that 133 authorships (equivalent to 3.9% of the total) did not provide explicit information on the author's gender. To ensure the accuracy of the bibliometric analysis and avoid biases derived from uncertainty, the methodological decision was made to exclude these cases from gender-specific analyses, while retaining them for keyword-based analyses. Consequently, quantitative analysis and gender comparisons were conducted exclusively on the set of authors identified as male or female.

Finally, 1,400 scientific articles were included in the bibliometric analysis, forming the documentary base on which conceptual, intellectual, and social mapping techniques were applied using the Bibliometrix tool [15].

4. Results of the Bibliometric Analysis

This section presents the findings obtained from the bibliometric analysis of the corpus comprising 1,400 publications indexed in WoS during 2023–2025. It is important to note that, since the data collection process was carried out on May 30, 2025, the results for that year reflect only the scientific output from

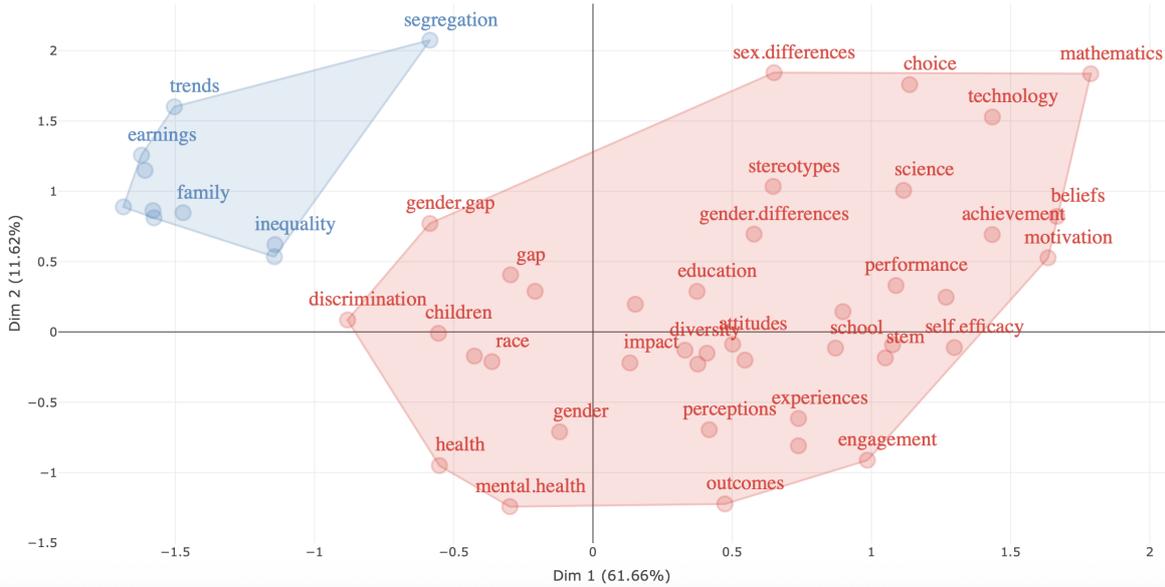


Figure 2: Multiple Correspondence Factor Analysis of Key Terms (2023–2025)

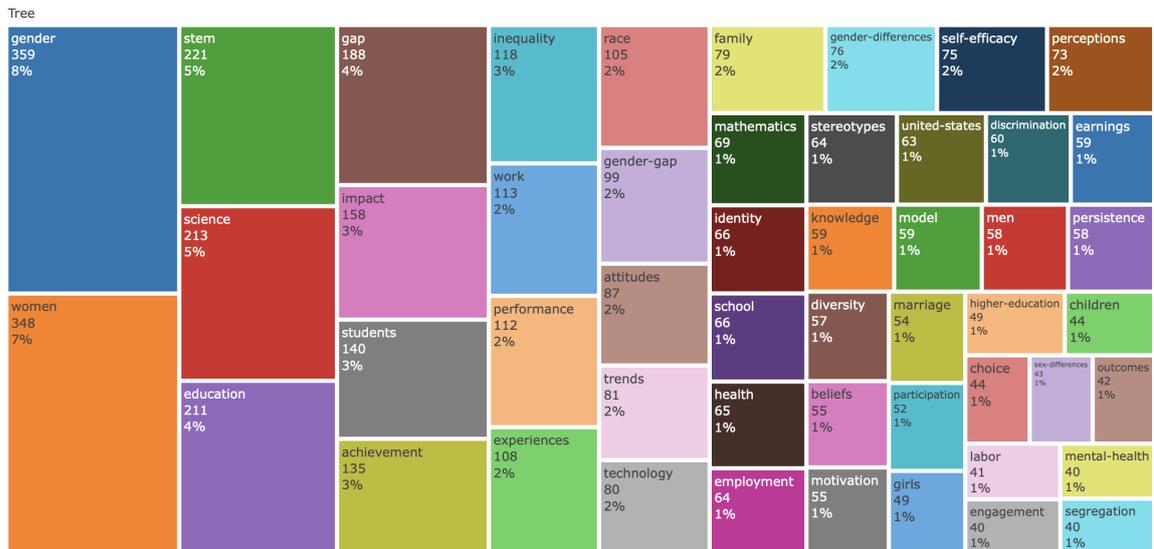


Figure 3: Treemap of the Most Frequent Keywords in the Corpus (2023–2025)

psychosocial and identity cluster covers 28% of the terms, addressing topics such as mental health, self-efficacy, and discrimination. This segmentation confirms a complex thematic structure consistent with the results of the factorial analysis in Figure 2.

The chart in Figure 5 illustrates the cumulative evolution in the frequency of the 10 most relevant terms in the analyzed corpus between 2023 and 2025. A sustained increase is evident in concepts such as “impact” (over 340 mentions), “students” (330), and “science” (280), followed closely by “education” (270) and “STEM” (260), reflecting a strong orientation toward educational, scientific, and formative dimensions. Likewise, terms such as “inequality,” “gap,” and “women” show constant growth, reaching between 160 and 200 occurrences.

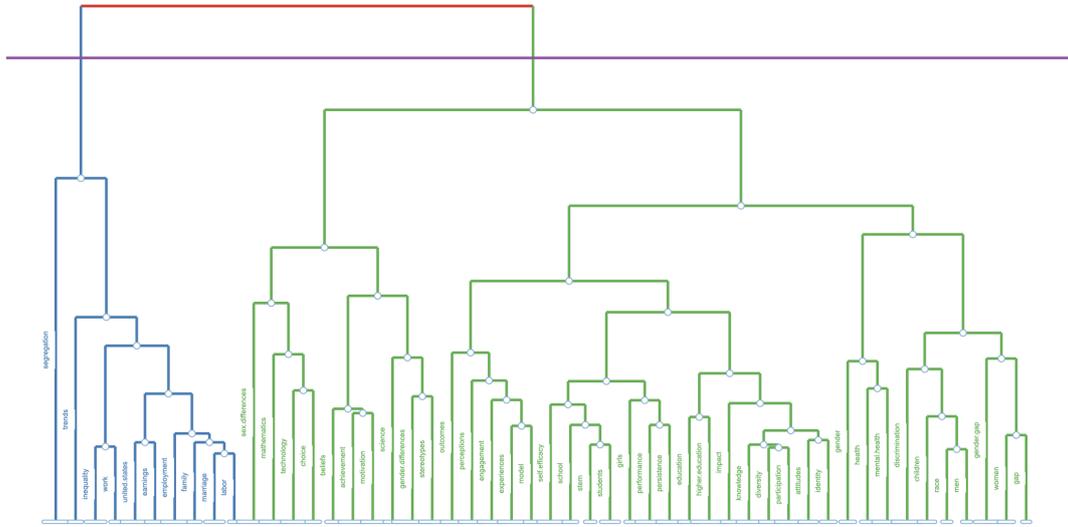


Figure 4: Hierarchical Dendrogram of Thematic Co-occurrence (2025)

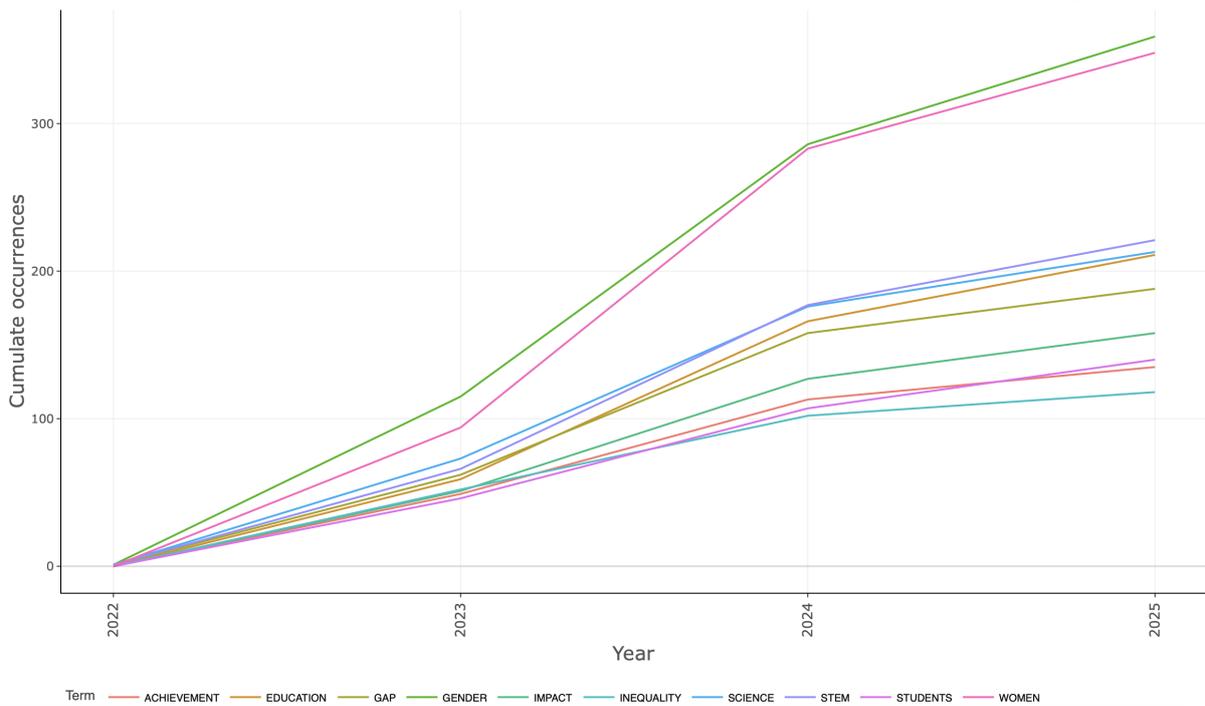


Figure 5: Cumulative Temporal Evolution of the Main Key Terms (2023–2025)

4.2. Academic and Geographic Collaboration Networks

Figure 6 illustrates the international collaboration network in the field of gender and STEM, showing geographic nodes and bilateral connections. The United States leads scientific collaborations with more than 180 foreign institutions, followed by Spain (≈ 150) and Brazil (≈ 140). Latin America stands out with Mexico, Chile, Colombia, and Costa Rica as active countries in co-authorship networks. This collaboration pattern confirms the growing internationalization of the field, particularly in inclusive agendas and educational policies. In line with [4] and [6], these patterns reflect both the academic maturity of certain regions and their institutional priorities regarding gender equity in STEM.

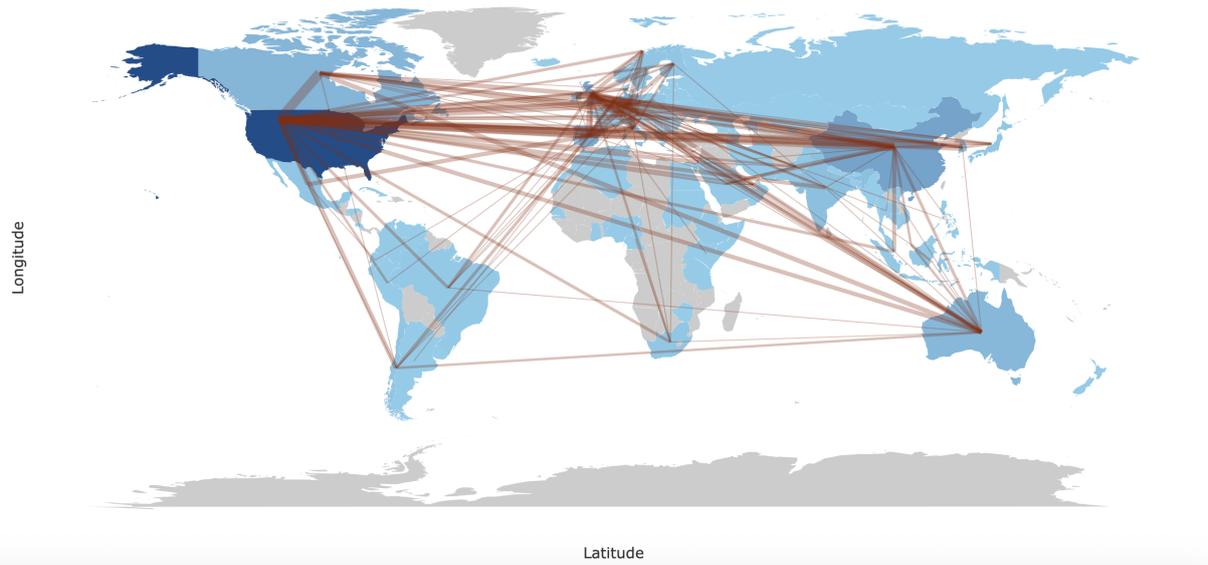


Figure 6: World Map of Scientific Collaboration Between Countries

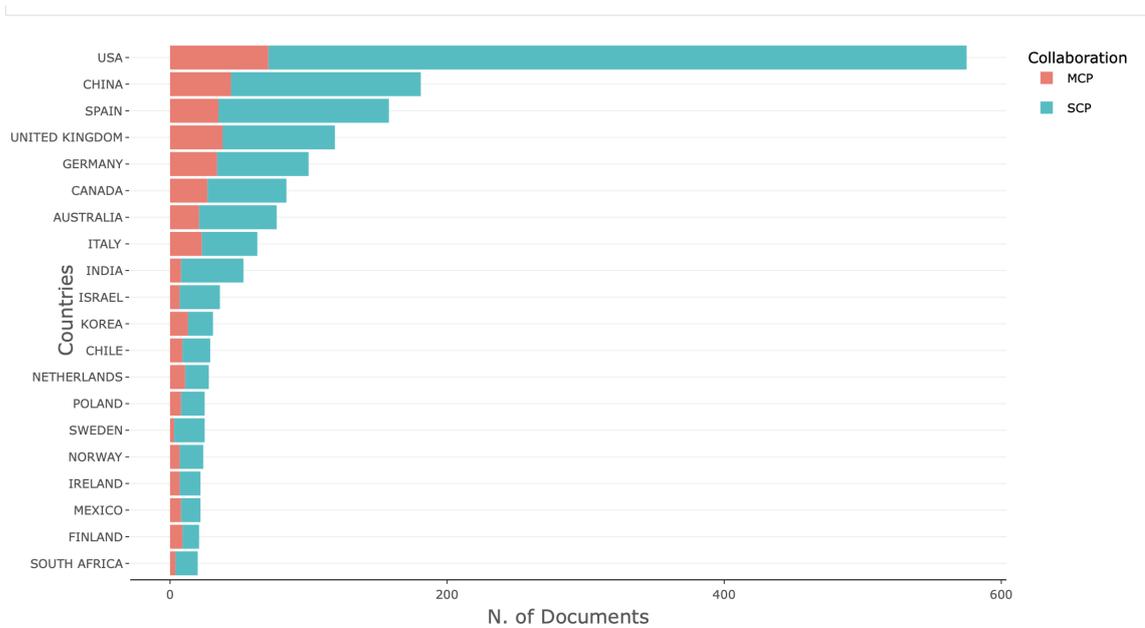


Figure 7: Comparison Between National and International Publications by Country (SCP/MCP)

A stacked bar chart is presented in Figure 7, differentiating the type of scientific collaboration by country: SCP (Single Country Publications) and MCP (Multiple Country Publications). The United States leads with more than 550 documents and is also the country with the highest proportion of international collaboration publications (around 30% MCP). China and Spain follow, each with more than 250 documents, although with a lower proportion of MCP, indicating a strong capacity for internal production. The prominent presence of Spain, Chile, Mexico, and Brazil among the top 15 countries reflects the growing positioning of Latin America in gender and STEM research.

Figure 8 presents the most cited sources in the corpus analyzed between 2023 and 2025. A high concentration of citations is observed in journals specializing in sociology, psychology, and gender studies. Notable examples include American Sociological Review with 1,139 citations, Journal of Marriage and Family (805), PLOS ONE (760), and Gender Society (738). This pattern confirms the

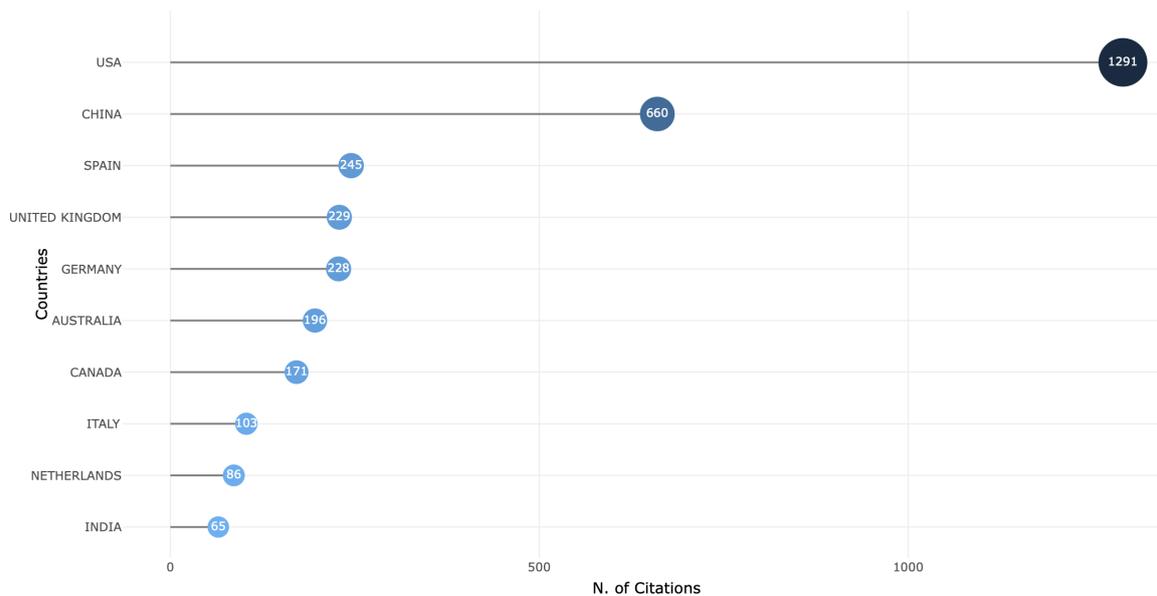


Figure 8: Most Cited Academic Sources in the Bibliographic Corpus (2023–2025)

academic robustness of the corpus and its reliance on high-impact indexed publications, reinforcing the scientific validity of the findings obtained in this research.

The Sankey diagram in Figure 9 illustrates the connection between countries of origin (AU_CO), authors (AU), and the most frequent thematic terms (DE) in the analyzed corpus. Dominant flows are identified from China and the United States toward authors such as Li Y., Zhang X., and Wang J., who address topics such as “gender differences,” “STEM,” and “higher education.” This visualization provides insight into the thematic and geographic distribution of academic production, highlighting the high concentration of authorial leadership in Asia and North America, as well as alignment with topics on gender, equity, and technology. It facilitates the recognition of structural patterns in global academic networks.

5. Discussion

This section interprets the main findings of the bibliometric analysis and contrasts them with previous studies to identify implications, limitations, and opportunities for improvement in the research agenda on gender and STEM.

Between 2023 and 2025, a 56% increase was observed in scientific production on topics related to gender equity, educational inclusion, and technological design with a focus on female authorship. This trend reflects growing institutional and academic attention to these issues, particularly in Latin America, where universities such as the University of Chile and UNAM led in publication volume. However, female participation as lead authors remains limited, representing only 26.4%.

The results are consistent with previous studies presented at LAWCC, such as the mapping conducted up to 2023 of all articles presented at the conference [4], which highlighted similar patterns of thematic concentration and low female co-authorship. They also demonstrated the usefulness of the science mapping approach for visualizing conceptual, social, and intellectual structures in the evolution of fields such as BPM, validating its application in this study for gender-related topics [6].

Affirmative actions are needed to promote women’s participation in STEM research, including mentoring policies, targeted funding, and visibility in scientific spaces. Experiences such as those of Pacheco and Álvarez [17] and Huston et al. [18], focused on institutional initiatives to reduce the gender gap, show that strategic and financial support can positively influence the retention and advancement of

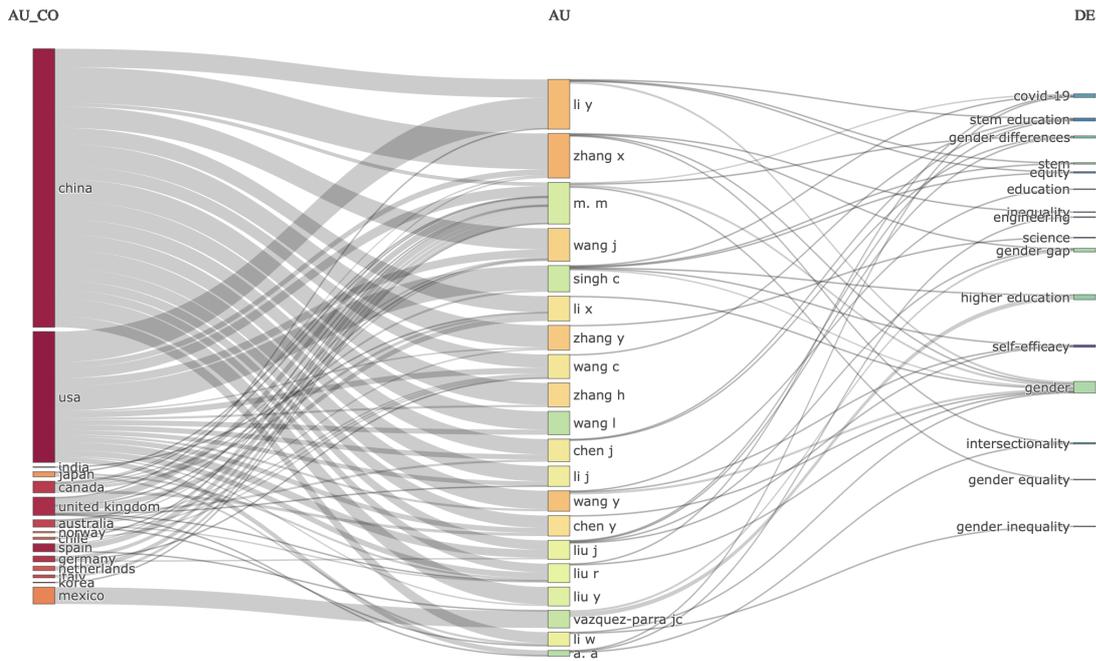


Figure 9: Sankey Diagram of Author–Country–Topic Collaboration (2023–2025)

women in academic and professional careers. In Costa Rica, various initiatives aim to reduce the gender gap in STEM and strengthen female participation in research, such as the national campaign “Deciding My Future,” developed by the Ministry of Public Education, the Inter-American Development Bank, and Innovations for Poverty Action [19], as well as the Women’s Network in Science, Engineering, and Humanities (CIHRED-UCR) at the University of Costa Rica [20].

This analysis was based exclusively on articles indexed in WoS, excluding gray literature and other relevant repositories in the Latin American context. Furthermore, the review was limited to the period 2023–2025, considering publications up to May of the last year. Future research could expand the temporal scope and combine quantitative approaches with qualitative methods for a deeper analysis.

It is recommended to apply this bibliometric approach to other scientific disciplines or geographic regions to identify emerging patterns with a gender perspective. Incorporating altmetric analyses and evaluating social impact indicators would also be pertinent, as well as exploring mentoring networks and female leadership in science and technology. The replicability of the methodology applied in this study constitutes a significant contribution to the systematization of inclusive scientific agendas. Despite the increase in scientific production on gender and STEM topics, significant structural gaps persist in female participation and leadership, even in institutional contexts that promote equity.

Recent studies show that, in Latin America, mentoring strategies, institutional support, and role models significantly influence the reduction of gaps, although they do not completely overcome historical barriers [4].

6. Conclusions

This bibliometric study enabled a rigorous analysis of the recent evolution of scientific production related to the gender gap in STEM, inclusive software design, and equitable access to higher education between 2023 and 2025. Based on a systematic review using the PRISMA methodology and the Science Mapping Workflow model, 2,117 publications were identified, of which 1,400 met the inclusion criteria and were processed using the Bibliometrix and Biblioshiny tools.

The results show sustained growth in scientific output, with a 56% increase between 2023 (366 articles)

and 2024 (572 articles). This rise reflects greater academic attention to the issue of gender inequality in scientific and technological environments. The most frequently addressed topics included gender equality, STEM education, higher education, women in computing, and inclusion, representing more than 70% of the most common keywords. Five thematic clusters were identified, with the densest clusters related to digital inclusion, gender-focused public policies, and educational innovation.

Despite these advances, a low representation of women in authorship was confirmed, with only 26.4% of the total 3,412 identified authorships. In contrast, 69.7% corresponded to men, and 3.9% could not be classified. This finding confirms the persistence of structural gender gaps, even in research addressing equity-related topics.

Regarding geographic distribution, the United States led production with 198 publications, followed by China (156), Brazil (212 total publications), Mexico (187), and Spain (174). Costa Rica, although with a smaller volume, contributed 38 publications in international collaboration, positioning itself as an emerging actor in the region.

Co-authorship networks revealed active participation of Latin American institutions, although collaboration density among female researchers was low. The proportion of publications with international collaboration (MCP) was notable in countries such as the United States (69 MCP publications) and China (44 MCP), evidencing their capacity for global scientific articulation.

This article proposes replicating the applied approach as a strategic tool for monitoring institutional policies and shaping scientific agendas with a gender perspective. Strengthening mentoring programs, targeted funding, and affirmative actions to enhance female participation in academic publications is recommended. Furthermore, future research could integrate qualitative and altmetric analyses to capture broader dimensions of the impact of gender-focused science.

7. Future Work

For future research, the aim is to expand bibliographic sources by incorporating databases such as AMC, EBSCO, Google Scholar, IEEE Xplore, RedALyC, ScienceDirect, Scopus, and SciELO, with the objective of improving regional coverage and reducing geographic and disciplinary bias resulting from the exclusive use of WoS.

This article proposes replicating the applied approach as a strategic tool for monitoring institutional policies and shaping scientific agendas with a gender perspective. Strengthening mentoring programs, targeted funding, and affirmative actions to enhance female participation in academic publications is recommended. Furthermore, future studies could integrate qualitative and altmetric analyses to capture broader dimensions of the impact of gender-focused science.

Based on this study, several future research lines are proposed, aimed at evaluating the impact of digital systems on institutional efficiency, their replicability in other university campuses, and the integration of these developments into training processes with an applied learning approach. Additionally, it is suggested to deepen strategies that promote women's participation in technological projects and to develop gender-sensitive metrics to monitor their academic contribution. Comparative studies between campuses or universities are also recommended to validate the results obtained and enrich the proposed intervention models. Finally, these future works could serve as input for designing university policies aligned with the Sustainable Development Goals, particularly regarding gender equality (SDG 5), quality education (SDG 4), institutional innovation (SDG 9), and capacity building in public management (SDG 16).

Declaration on Generative AI

During the preparation of this work, the authors used ChatGPT for grammar and spelling correction, and Copilot for translation. After using these tools, the authors reviewed and edited the content as necessary and assume full responsibility for the content of the publication.

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