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IDENTIFYING TRENDS IN THE STUDY OF GENDER IN SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS (STEM) PROGRAMS

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ABSTRACT

In recent years, Science, Technology, Engineering, and Mathematics (STEM) education has gained increasing importance in response to changes driven by evolving social dynamics, emphasizing the need for professionals equipped with skills and knowledge to navigate the demands of modern society. However, the gender gap in STEM fields remains a widespread concern, primarily due to the underrepresentation of women. To address this, different strategies have been developed to encourage greater female participation in these areas. These strategies include promoting a greater representation of female mentors, implementing measures to eliminate discrimination, fostering a balance between personal life and work, and ensuring equitable conditions in promotions and salary allocation. Against this backdrop, the present study aims to identify research trends in STEM from a gender perspective by conducting a bibliometric analysis using the PRISMA 2020 methodology. The results reveal an exponential increase in scientific output on this topic, with a peak in publications occurring in 2022. Among the key themes emerging from the literature are persistent gender disparities, the relevance of self-efficacy, and the role of intersectionality in shaping women's participation in STEM. Understanding why more women—and especially women of color—do not pursue or work in STEM disciplines is a concern from the standpoint of global diversity, particularly in the United States, where significant inclusion gaps remain. Furthermore, despite improvements in female representation, barriers related to retention and professional advancement persist. Overall, this analysis provides new insights into the thematic evolution and emerging directions of research at the intersection of gender and STEM.

Keywords: STEM; inclusion, science; engineering; gender

INTRODUCTION

In today's knowledge-based society, cultural, academic, economic, and social changes have driven progressive advancements (AISC, 2020). In this context, Industry 4.0 demands professionals with technological skills, particularly in the fields of Science, Technology, Engineering, and Mathematics (STEM) (Christie et al., 2017). Notably, the significance of STEM programs has been widely recognized for their role in addressing global challenges—such as improving healthcare and food access—fostering innovation, and enhancing technological competitiveness (Ho et al., 2020; Tam et al., 2020).

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In alignment with these objectives, the STEM approach aims to provide interdisciplinary education, integrating rigorous academic concepts with real-world applications (Domínguez et al., 2019). This integration not only seeks to reduce the stigma that often discourages young people from choosing STEM careers but also aligns education with current needs, thereby promoting the development of solutions to social and economic issues (Priya et al., 2015). As such, STEM education has an impact across various sectors, including education, healthcare, environmental sustainability, and employment (Lupiáñez & Ruiz-Hidalgo, 2016).

Importantly, the relationship between science, technology, and engineering within STEM is not arbitrary. Science builds the groundwork for critical thinking and knowledge organization (Lupiáñez, 2018), while technology and engineering enable the creation of practical solutions for complex problems. In today's labor market, STEM education plays a crucial role, as evidenced in a study from PageGroup (2019) examining the number of STEM graduates in Latin America. According to the report, Chile leads with 45% of its graduates in STEM fields, followed by Mexico (42%), Argentina (41%), and Colombia (34%). Notably, only three out of every ten Colombian graduates come from STEM disciplines. Additionally, the Organization for Economic Co-operation and Development (OECD) projects that, by 2030, approximately 80% of current jobs will be replaced by STEM-related occupations (Gottfried & Williams, 2013).

Despite the growing demand for STEM professionals, a persistent gender gap remains a concern. This disparity is largely attributed to cultural stereotypes that hinder women's participation, ultimately resulting in a significant loss of talent in fields deemed crucial for technological progress (Kuchynka et al., 2022). Although women's enrollment in higher education has increased, most tend to pursue careers in education, health sciences, and economics, whereas their representation in STEM fields remains low. In 2018, women made up seven out of ten graduates in education, health sciences, and economics in Colombia, and they also accounted for 60% of graduates in the social sciences and humanities (ONU et al., 2020). In Latin America, 40% of researchers are women; in Colombia, however, this figure drops to 38.1%, where significant disparities persist in terms of scientific production and salary compared to their male counterparts (World Economic Forum, 2020).

Beyond labor market considerations, STEM education also plays a key role in achieving the United Nations' Sustainable Development Goals (SDGs) outlined in the 2030 Agenda (Ramírez & Basto, 2022; UNICEF et al., 2022). Specifically, its impact is evident in reducing poverty (SDG 1) and driving economic growth (SDG 8) by equipping individuals with the skills necessary for jobs in Industry 4.0. Moreover, it contributes to improving the quality of education (SDG 4) and fostering gender equality (SDG 5) by promoting women's access to technological careers. It also supports industrial innovation (SDG 9) and enables sustainable development in areas such as water and sanitation (SDG 6), climate change (SDG 13), and environmental conservation (SDGs 14 and 15).

Within this framework, STEM careers have gained prominence as drivers of sustainable development, particularly thanks to the potential of artificial intelligence, automation, and data science to optimize processes and increase productivity (SELA, 2020). Nonetheless, significant challenges persist, including the low female representation and the urgent need to strengthen STEM education through inclusive approaches that can be applied to the current socio-economic realities.

The gender gap in STEM entrepreneurship has emerged as a major barrier to economic development by depriving societies of women's valuable contributions (Agboola, 2021; Chowdhury et al., 2022; Idris et al., 2024). While diversity and inclusion are widely acknowledged as crucial for attracting top talent capable of addressing today's complex challenges, women—despite comprising half of the global population—continue to be significantly underrepresented in engineering and scientific fields. This underrepresentation, observed worldwide with few exceptions, limits both innovation and economic potential.

Studies from several Asian countries reveal that women's participation in engineering has historically depended on economic needs, political ideologies, and government policies. Given the vital role that STEM programs play in tackling global issues such as climate change and health crises, closing this gender gap is imperative (Anaya et al., 2022; Kuchynka et al., 2022).

One key factor sustaining women's underrepresentation in STEM fields is societal stereotypes regarding their abilities in these domains. To overcome this, it is crucial to integrate essential STEM skills early into curricula, facilitating a deeper comprehension and engagement with

STEM over time (Piva & Rovelli, 2022). Additionally, educational institutions should foster inclusive learning environments that support students of all genders and ethnicities, thereby helping to build a diverse and innovative workforce (Stupurienė et al., 2022). Adopting a gendered perspective allows for a more nuanced understanding of the complex barriers women face in STEM, which often lead to professional inequities (Ong et al., 2020).

Moreover, research on gender discrimination in STEM frequently draws on the theory of implicit or unconscious bias, which posits that women are less competent in science and mathematics than men (Main et al., 2022). Yet, as Perez-Felkner et al. (2020) have noted, variations in gender disparities within STEM have not been sufficiently explored.

Ultimately, the persistent gender gap in STEM continues to impede women's access, retention, and professional advancement in these fields. Despite global efforts to promote gender equity, empirical evidence indicates that women graduates in STEM fields still encounter social and economic barriers in the labor market, particularly in the Global South. For instance, a recent study by Yizengaw (2025) revealed qualitative differences in the job search process between male and female graduates. Based on mixed-method data from 161 engineering graduates, 18 employers, and 16 faculty members, the study found that female graduates are more likely to secure employment in the private sector compared to their male counterparts. However, it also reported that limited institutional support in higher education remains a significant challenge, as existing structures do not adequately consider gender-specific needs.

Efforts to bridge the gender gap in STEM education have been analyzed across various institutional contexts. For example, Gatera et al. (2025) examined the role of IPRC Tumba in fostering STEM education among Rwandan female students. Their study, involving 105 participants, showed that while 54.3% of students disagreed with the notion of male superiority in STEM, 45.7% still acknowledged the influence of social stereotypes on perceptions of gender competence. Despite these challenges, 70.48% of female students at IPRC institutions chose STEM fields, and 87% expressed confidence in successfully pursuing STEM careers while managing family responsibilities. These findings reflect a gradual shift in gender norms within STEM education but also highlight the need for sustained institutional support to help female students overcome gender biases.

In light of the 2030 Agenda for Sustainable Development, collaboration has emerged as a key competency for future workforce success (Maeda & Socha-Dietrich, 2021; Schleicher, 2021; World Economic Forum, 2023). Effective collaboration in STEM settings requires collective intelligence (Malone & Woolley, 2019), which is shaped by cognitive and problem-solving skills, as well as social aspects (Wechsler, 1946 ; Burt, 1973).

In this regard, Beroíza-Valenzuela et al. (2025) explored gender dynamics in teamwork and their impact on collective intelligence in STEM higher education. They found that although collaboration enhances group performance, gendered patterns continue to influence team dynamics. This underscores the importance of targeted interventions to promote inclusive teamwork, thereby ensuring that collaboration in STEM is equitable and supportive of diverse perspectives. These insights provide a preliminary foundation for the present study, which aims to analyze the evolution of gender-focused STEM research and identify key trends influencing women's participation and success in these fields (Woolley & Gupta, 2024; Beroíza-Valenzuela et al., 2025).

It is, therefore, essential to highlight the gender disparities that persist across STEM disciplines, as these gaps serve as the starting point for identifying ongoing challenges in the literature. One such gap was pointed out by Meoli et al. (2024), who explored the characteristics of university education among recent STEM graduates and concluded that, in general, women are less likely than men to secure STEM-related occupations shortly after graduation. According to their findings, while participation in internships or study abroad programs help narrow the gender gap, these programs tend to reduce men's high likelihood of obtaining STEM jobs rather than increase women's already low probability of securing them.

In a similar vein, Barra et al. (2024), in their study on the adoption of information technologies in developing countries, identified various mechanisms and factors that influence technology adoption in gender-specific ways. Notably, their analysis revealed a positive relationship between digital skills, willingness to use technology in entrepreneurial activities, and entrepreneurial orientation—though social influence was not found to be significant. These findings indicate that, although the gender gap may narrow under specific conditions (participation in internships, study abroad experiences, or the development of digital skills), gender disparities in STEM employment and technology adoption persist. This underscores the need for a deeper investigation into the factors driving these inequalities.

Along the same lines, other studies have investigated how gender disparities manifest in the development of specific competencies. For example, Bahtiar et al. (2022) assessed scientific literacy skills using PhET simulation-assisted science teaching materials and found notable differences between genders: female students demonstrated higher scientific literacy skills (80) compared to their male peers (77.95). Additionally, certain subtopics were dominated by female students (electric charge, Coulomb's law, and electroscope), while others were dominated by male students (static electricity and atoms).

Likewise, the study by Sepriyanti et al. (2022) on 21st-century learning highlights that gender partially influences the development of higher-order thinking skills and numerical literacy. Their study, involving students from nine public Islamic universities in Indonesia, identified a low but significant correlation. Taken together, these findings reinforce the notion that gender differences are not only evident in workforce transition or technology adoption but also in academic performance and competence levels, emphasizing the need to analyze how pedagogical and sociocultural factors contribute to these disparities.

Despite the extant research, much of the information remains fragmented, and there is a lack of comprehensive synthesis that clearly maps current research trends. This absence of consolidated data hinders the efficacy of policies designed to promote gender equality in STEM programs. Consequently, the present study aims to examine research trends in STEM from a gender perspective by focusing on aspects like research quality, development over time, leading authors, contributing countries, and key terms. The intention is to support the results from previous studies. To this end, the study poses the following guiding questions:

- Which years have seen the highest volume of studies on STEM education from a gender perspective?
- What growth patterns can be observed in the number of scientific publications addressing STEM education from a gender perspective?
- Who are the main research contributors in the field?
- How has the thematic focus evolved in STEM research from a gender perspective?
- What are the main thematic clusters in the field?
- Which keywords are emerging or gaining prominence in STEM research from a gender perspective?
- What themes stand out as central to shaping a research agenda in the field?

To answer these questions, the methodology section outlines the literature review process and the analytical framework used to extract and interpret the findings. Then, the results are discussed, highlighting the key insights relevant to the study's objectives.

The novelty and contribution of this study lie in its comprehensive and systematic approach to identifying trends in gender-related studies within STEM fields. By integrating findings from diverse disciplinary, regional, and methodological contexts, it addresses existing gaps in the literature. Unlike previous research, which often focuses on isolated aspects such as workforce transitions, technology adoption, or academic performance, this work provides a holistic analysis that connects these dimensions. In doing so, it reveals broader patterns and underlying factors influencing gender disparities in STEM. Moreover, by synthesizing data from various reputable international sources, this analysis not only maps the evolution of gender-related challenges in STEM but also offers a framework to guide future research and inform policy efforts aimed at reducing disparities in these fields.

METHODS

To achieve this study's objectives, a bibliometric analysis was performed, enabling the examination of scientific publications using secondary sources of information. The process began with a review of metadata—such as titles and keywords—because metadata helps unify information across different databases (González et al., 2018). As a result, articles containing important insights into STEM studies from a gender perspective were identified.

The research methodology followed the updated PRISMA 2020 guidelines (Page et al., 2021), which provide a structured framework for conducting systematic reviews and meta-analyses. These guidelines ensure methodological rigor and transparency in the selection and reporting of data. Moreover, the study adhered to the PRISMA 2020 criteria regarding eligibility, information sources, and selection processes—standards widely recognized for their robustness in literature reviews.

Following the PRISMA 2020 statement, eligibility criteria were divided into inclusion and exclusion criteria. Inclusion criteria were based on key terms such as "woman," "education," "science," "technology," "mathematics," and "engineering," ensuring that selected articles were relevant to gender studies in STEM education.

In line with PRISMA 2020 recommendations, the exclusion process was structured into four distinct phases to guarantee transparency and reproducibility (Page et al., 2021):

Identification phase: Articles that lacked proper indexing or contained misleading metadata were excluded.

Screening phase: Documents that were inaccessible due to paywalls or database restrictions were removed.

Eligibility phase: Articles that, after abstract and full-text screening, did not align with the research focus were discarded.

Final selection phase: Conference proceedings and non-peer-reviewed literature were excluded to ensure the quality of the scientific evidence.

To gather relevant scientific and academic literature on STEM studies from a gender perspective, searches were conducted in the multidisciplinary databases Web of Science and Scopus. In addition to covering a large number of journals and disciplines, these databases were selected for their value in analyzing and evaluating scientific work (Page et al., 2021).

To guarantee an efficient search process, two similar search equations were created but adapted to the interface requirements of each database. As emphasized by the PRISMA 2020 statement, correctly defining the search criteria and keywords is essential to ensure that all of this information is found in the articles to be analyzed. For this reason, the following search equations were used:

- Web of Science: TI= (women OR woman OR gender) AND TI= (STEM OR engine* OR science* OR mathema* OR technolog*) AND TI=(education*)

- Scopus: TITLE (women OR woman OR gender) AND TITLE (STEM OR engine* OR science* OR mathema* OR technolog*) AND TITLE (education)

After implementing the search strategy in the selected databases, a total of 950 publications were obtained: 699 from Scopus and 251 from Web of Science. All of these documents addressed STEM education from a gender perspective, with publication dates ranging from 1964 to 2023. The records were compiled in Microsoft Excel®, where the previously defined exclusion criteria were applied. After filtering, a total of 518 publications remained for further analysis.

To facilitate data analysis, VOSviewer, a free software tool, was used to generate graphs of bibliometric indicators.

To reduce selection bias, an exhaustive review was carried out during the selection and analysis of the publications. Each article was independently selected by each author, following the PRISMA 2020 statement. Additionally, to resolve any discrepancies during the exclusion process, articles were carefully re-examined to identify similarities or convergences.

Figure 1 presents a flow chart that summarizes the study's methodological design based on the PRISMA 2020 statement.

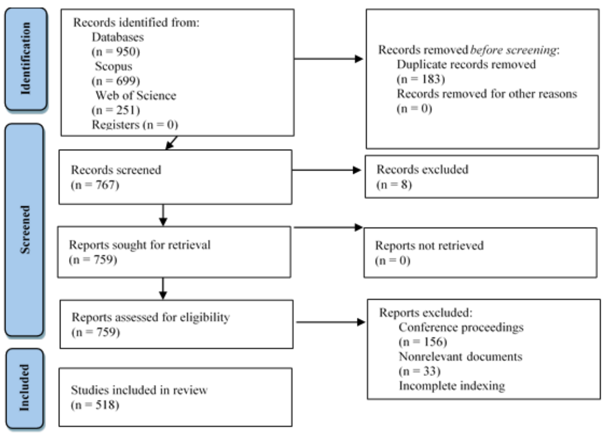

Figure 1. PRISMA Fow Chart. Source: Created by the authors using data from Scopus and Web of Science

In accordance with PRISMA 2020 recommendations, the study combined bibliometric analysis with quantitative and qualitative synthesis. The following methods were used:

Bibliometric indicators: Network mapping of co-citation relationships using VOSviewer.

Thematic trend analysis: Identification of recurring themes in gender studies in STEM education.

Descriptive statistics: Analysis of publication trends and citation impact.

This methodological framework ensures alignment with PRISMA 2020 standards and strengthens the study's validity and replicability.

RESULTS AND DISCUSSION

This research begins with a bibliometric analysis examining annual publication trends in STEM studies from a gender perspective. The data show a steady increase in publications from 1954—the year the first paper on the topic was published—through 2023, with an overall exponential growth of 99.41%. As illustrated in Figure 2, publication activity peaked in 2022, with the publication of 62 studies. Many of these studies explore gender disparities in STEM and highlight that women are statistically less likely than men to pursue STEM careers. Additionally, the findings suggest that women who choose STEM careers often do so with strong familial support, indicating that they may face greater challenges in their career development compared to men (Codina et al., 2020).

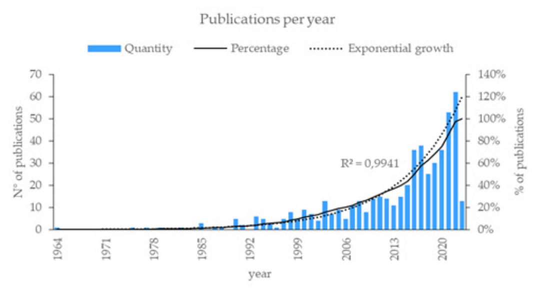

Figure 2. Percentage of Publications Per Year. Source: Created by the authors using data from Scopus and Web of Science

Among a total of 53 publications in 2021, one notable article was "*What Lies Beneath Sustainable Education? Predicting and Tackling Gender Differences in STEM academic success.*" The study critically examined the academic performance of students across genders in terms of educational content and suggested strategies to motivate women to pursue research careers in STEM (Tandrayen-Ragoobur & Gokulsing, 2022). Figure 3 presents further analysis axploring the citation impact and publication volume of individual authors. The analysis highlights authors with high citation counts despite a limited number of publications, as well as those with a substantial body of work addressing gender perspectives in STEM studies.

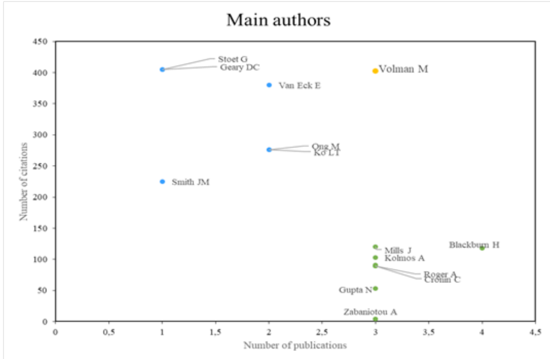

Figure 3. Leading authors per year. Source: Created by the authors using data from Scopus and Web of Science

Volman received the highest number of citations (403) for her research on gender differences in STEM education, with a focus on information technology (Pilotti, 2021). Stoet G and Geary DC also made a significant impact with a publication demonstrating that women have comparable aptitude to men in STEM disciplines at the university level despite their persistent underrepresentation (Volman & an Eck, 2001).

Blackburn has authored the most publications on gender in STEM, addressing critical issues such as women's experiences, gender stereotypes, and classroom biases that hinder diversity in STEM fields (Stoet & Geary, 2018). The study also assessed journals across the field, highlighting variations in citation impact.

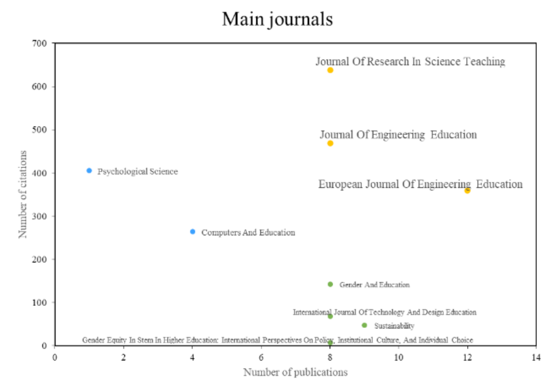

Figure 4. Prominent Journals. Source: Created by the authors using data from Scopus and Web of Science

The *Journal of Research in Science Teaching* is the most cited journal in the field, with 638 citations across eight publications. A key article published in the journal is "*Counterspaces for Women of Color in STEM Higher Education: Marginal and Central Spaces for Persis-*

tence and Success." It examines the systemic challenges women of color face in STEM fields and highlights how the historical dominance of white male scientists continues to shape educational structures (Blackburn, 2017). Although it is not primarily focused on gender in STEM, *Psychological Science* is also highly cited, with 405 citations. A seminal 2011 study in this area, "*Boys and Girls in STEM: A Meta-Analysis of Gender Differences in University STEM Fields*," by Smith, found that girls often outperform boys in STEM fields at the university level.

Sustainability, with nine publications, has shown significant engagement with gender and STEM issues, including studies on how technological integration in science education influences gender disparities (Palomares-Ruiz et al., 2020). Additionally, a bibliometric analysis identified countries with high productivity and impact in gender-focused STEM research, as well as countries with fewer publications but higher citation rates and vice versa.

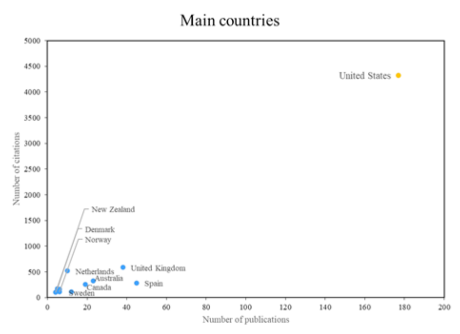

Figure 5. Key Contributing Countries. Source: Created by the authors using data from Scopus and Web of Science

The United States has the highest publication volume and citation count gender-related STEM research, with 4,322 citations and 177 publications. Among these publications is the manuscript "*The Gender-Equality Paradox in Science, Technology, Engineering, and Mathematics Education*," which analyzes girls' performance in STEM fields. The results showed that girls perform as well as or better than boys in science, and suggest that, in countries with less gender equality, societal pressures on quality of life may encourage more girls and women to pursue STEM education (Volman & van Eck, 2001).

The United Kingdom ranks second, with 39 publications and 585 citations. Among these publications is "*Women Into Science and Engineering? Gendered Participation in Higher Education Stem Subjects*," which examines gender dynamics in students' learning trajectories in university STEM pathways. While more women are enrolling in STEM programs, the study highlights that their participation remains disproportionately low in fields such as physics and engineering (Volman et al., 2005).

Finally, the Netherlands is one of the countries with the fewest STEM publications from a gender perspective, yet it has a relatively high total citation count of 517. One of its most cited articles is "*New Technologies, New Differences: Gender and Ethnic Differences in Pupils' Use of ICT in Primary and Secondary Education.*" The study examines the ICT skills of ethnic minority students and finds that they are generally less proficient than their majority peers. The study offers recommendations to improve ICT-related policies that favor access and support for these students (Palomares-Ruiz et al., 2020).

Key research themes in gender-focused STEM studies have evolved over time, as shown in Figure 6. In 1993, social class was a central topic, with studies highlighting the trials and tribulations faced by university students in the Netherlands. Efforts to transform education led to increased participation by women. While most female students completed their degrees, they often criticized the academic content and structure (van Drenth & van Essen, 2003).

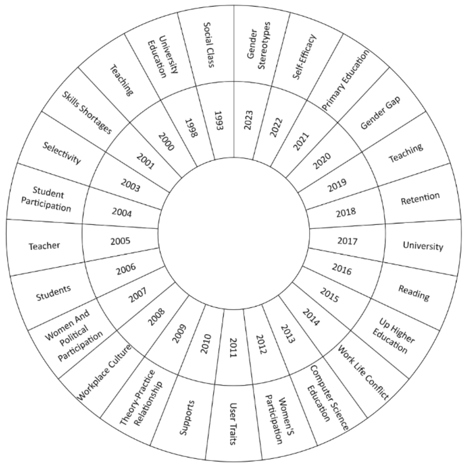

Figure 6. Evolution of Key Research Themes in Gender-Focused STEM Studies. Source: Created by the authors using data from Scopus and Web of Science

In 2003, the central research theme was educational selectivity. This theme revealed similarities between the school traditions of Germany and the Netherlands, as well as the early role of women in U.S. education between 1800 and 1910. While these women helped expand educational opportunities for women, their professional roles were often tied to domestic expectations and were often viewed as a hobby rather than a career (Anaya et al., 2022). By 2021, the focus had shifted to primary education. The study "*Technology-Based Activities at Home and STEM School Achievement*" emphasized the positive impact of students' engagement in digital activities on their STEM performance (Sevilla & Snodgrass Rangel, 2023).

In 2022, research focused on self-efficacy and its role in gender disparities in mathematics performance, as well as the influence of parents' careers in science-related fields on women's decisions to pursue scientific studies at the university level. These findings underscore the critical role of self-efficacy in shaping STEM pathways (de las Cuevas et al., 2022). Currently, gender stereotypes have emerged as the dominant research theme, with studies exploring how these stereotypes affect professional development in STEM fields. This focus reflects the persistent inequality found in technical and professional STEM education, where gender gaps are more pronounced than in other academic fields (Ryan & Deci, 2000a; Xu, 2016).

The publication "*Aspirations and Application for Graduate Education: Gender Differences in Low-Participation STEM Disciplines*" analyzes gender disparities in STEM graduates' aspirations, aiming to explain the underrepresentation of women in these fields. The publication emphasizes the lack of scholarly attention to the role of educational aspirations in women's pursuit of graduate-level STEM education (Craig et al., 1998; Mancl & Lee, 2016; Camacho, 2017). A Cartesian diagram is used to analyze the frequency and relevance of key terms in gender-focused STEM research. The X-axis represents term frequency, and the Y-axis indicates the time periods during which these terms were monitored.

Quadrant IV displays terms that were once frequently used but have since declined in relevance. Notable examples include "gender difference," "equity," and "programming," reflecting a shift in the perception that programming is not a skill that all students need to possess. Conversely, the use of computers as an educational tool has increased significantly and now appears in a diverse range of contexts (Burušić et al., 2021).

Analysis of Quadrant III reveals terms with the lowest frequency of occurrence and the least annualized usage in the reviewed publications. Consequently, these terms are considered less relevant for future STEM research from a gender perspective. These terms include concepts such as *representation*, *science teacher*, *secondary education*, *identity*, *students*, *educational technology*, *teaching*, *reading*, and *race* (Bezak et al., 2019; Gimeno et al., 2019; Main et al., 2022; Mlambo, 2021; Reinoso et al., 2023). Historical, political, and social factors have distanced women from science, placing them at a systemic disadvantage (Ong et al., 2018).

Quadrant II includes terms that have been used infrequently in gender-focused STEM research, but which have gained prominence over time and point out new areas of inquiry. Examples include *gender stereotypes*, *self-efficacy* (Deci & Ryan, 2008; Ryan & Deci, 2000b), *gender perspective*, *women of color*, *primary education*, *textbooks*, *retention*, *standardization*, *diversity*, *gender inequality*, *gender equality*, and *universities*.

In contrast, Quadrant I features high-frequency terms that are considered key concepts in gender-focused STEM studies. In this case, the *gender gap* is the sole term in this category. This concept addresses the persistent underrepresentation of women in STEM careers despite the increasing availability of high-paying job opportunities. Encouraging women to bridge this gap has become a major political and policy concern (Wolffensperger, 1993).

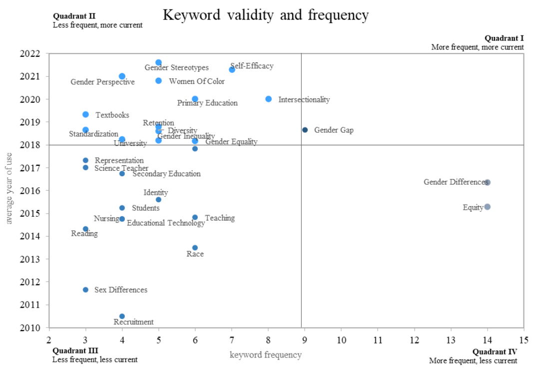

Figure 7. Keyword Co-occurrence Network. Source: Created by the authors using data from Scopus and Web of Science

Figure 8 outlines a research agenda derived from a systematic review. It highlights trending, emerging, and current topics to guide future studies. A total of 518 articles were initially reviewed, following the PRISMA methodology and applying inclusion and exclusion criteria. The 30 most important terms related to gender-focused STEM studies were then identified from these sources. Two aspects were analyzed: (1) the timeframe in which each term gained relevance in the literature, and (2) the year when the term reached its peak in academic production.

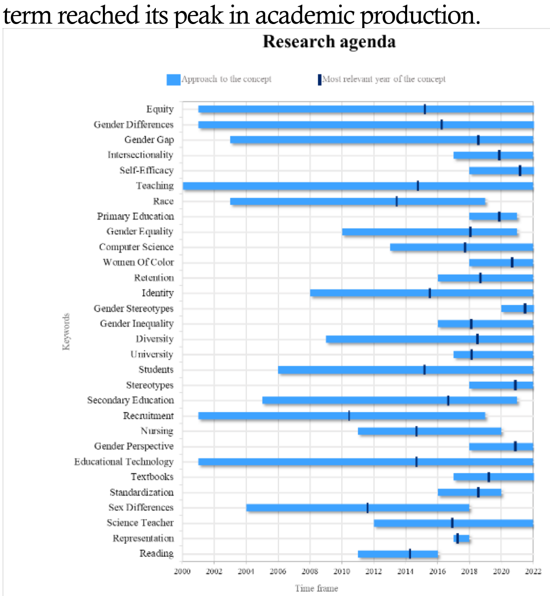

Figure 8. Research Agenda. Source: Created by the authors using data from Scopus and Web of Science

An analysis of the terms reveals that "*teaching*" has shown the greatest longevity, appearing consistently from 2000 to the present. However, the term was most popular in 2014. It remains a key term in gender-focused STEM research due to the critical role education plays in promoting inclusion and equal opportunities in STEM programs (Blackburn, 2017; McLoughlin, 2005; Stonyer, 2002). Future research could explore pedagogical practices that encourage women's participation in STEM; the barriers educators face when implementing inclusive STEM instruction; and how to address these challenges through targeted education policies and training programs (Guillén-Gámez & Rodríguez-Fernández, 2021; Peña et al., 2021; Dulce-Salcedo et al., 2022).

The key terms "*equity*" and "*gender differences*" are the second most frequently used terms in gender-focused STEM research. These terms first appeared in 2001 and remain relevant today, peaking in usage in 2015 and 2016. These concepts are of the utmost importance because a significant gap persists between male and female participation in STEM programs. Future research should delve into contributing factors, such as gender stereotypes, sexual harassment, and the development of skills and aptitudes, that influence the equity gap and women's participation in STEM careers (Sarouphim & Chartouny, 2017; Zahedi et al., 2021; Nasri et al., 2023).

Continuing the analysis, the *gender gap* first appeared in the literature in 2003 and remains highly relevant in gender-focused STEM research. Disparities in women's participation and representation in STEM fields persist, limiting their access to opportunities and resources. This indicates that this concept will continue to be an important concept in future research (Ayalon, 2003; Garcia-Holgado et al., 2018; Perez-Felkner et al., 2020).

One newer, increasingly prominent term is *intersectionality*, which first appeared in 2017 and is still in use today. It examines how overlapping identities—such as gender, race, social class, and sexual orientation—interact to shape an individual's unique and complex experiences of oppression and privilege. Future research could explore how intersectionality influences women of color's access to education and employment opportunities, and their retention in STEM industries (Leyva, 2017; Morton & Parsons, 2018; Ong et al., 2018).

Several terms that emerged between 2013 and 2018 have become increasingly prominent in the literature, including "*computer science*," "*self-efficacy*," and "*women of color*." Self-efficacy, in particular, has been identified as a key predictor of women's success and retention in computer science (Wang et al., 2024), a field in which women have historically been marginalized as well as in other male-dominated STEM fields (Craig et al., 1998; Charleston et al., 2014; Ong et al., 2020; Zahedi et al., 2021). Figure 8 also highlights the emergence of terms such as "*university*," "*gender perspective*," and "*textbooks*" between 2017 and 2018. Though these terms are relatively recent, they are relevant because they reflect growing attention to developing essential skills and knowledge for a successful career and to the persistent issue of gender inequality in academic contexts.

Terms such as "*race*" and "*secondary education*" were central to the development of conceptual frameworks in STEM research from a gender perspective, but they have declined in prominence. These concepts were most relevant when they were important. *Secondary education* is a setting where racial inequalities can be fostered, which may affect students' academic performance (Creamer, 2009; Perez-Felkner et al., 2020; López et al., 2021; Maccaro et al., 2024). Finally, terms such as *standardization* and *reading* played a critical role in creating early frameworks. They influence the overall quality of education and students' academic performance, while also contributing to critical thinking and active citizenship (Bacharach et al., 2003).

A key finding of this study is the evolving discourse on gender equity in STEM education. This discourse has shifted from broad advocacy for women's participation to more targeted strategies that address structural barriers and long-term retention. Earlier studies largely focused on enrollment disparities (Codina et al., 2020), whereas current studies increasingly emphasize the importance of mentorship, inclusive curricula, and institutional support as key factors in women's success in STEM fields.

The growing prominence of terms such as "self-efficacy," "retention," and "diversity" (Figure 7) indicates a shift from binary gender comparisons to a more nuanced understanding of the systemic conditions that promote long-lasting gender inclusion in STEM careers. These findings highlight the need for future research evaluating the long-term impact of intervention programs, particularly in underrepresented STEM fields, such as physics and engineering, where gender disparities persist despite rising enrollment rates.

This study also highlights the evolving intersection between gender research in STEM and the broader context of digital transformation and technological innovation. The increased use of terms such as "*computer science*," "*digital inclusion*," and "*artificial intelligence*" in recent gender-focused STEM literature (Figure 8) indicates a growing awareness of how technological advancements are reshaping participation dynamics. While earlier research focused on traditio al STEM fields (Wolffensperger, 1993), more recent studies examine the influence of digital literacy, algorithmic bias, and automation on gender equity in STEM careers (Wang et al., 2024). This shift marks a broader paradigm in gender-focused STEM research—one that moves beyond access and representation to critically assess how digital transformation creates opportunities and challenges for women in technology-driven industries.

Future research should explore how emerging technologies can either reduce or reinforce gender disparities to ensure that advancements contribute to a more inclusive and equitable STEM ecosystem rather than perpetuate existing inequalities.

The analysis reveals significant findings that deepen our understanding of gender disparities in STEM. The Women in STEM 2024 (*Mujeres en STEM 2024*) report highlights that, in Spain, low self-confidence, math anxiety, and negative early educational experiences significantly shape girls' academic trajectories, often discouraging them from pursuing STEM careers (Cobreros et al., 2024). These findings are consistent with those of Liang et al. (2023), who observed that students' sense of belonging and perceptions of success are closely tied to early exposure to non-stereotypical learning environments and the development of resilience toward failure.

Regarding the effectiveness of public policies, regional research in Asia and Africa reveals notable contrasts. The UNDP report for the Asia-Pacific region highlights progress in women's STEM education, yet notes that it has not translated into equal employment opportunities, largely due to cultural biases and rigid labor structures (UNDP, 2024 C.E.). Similarly, a UNESCO study on Southern Africa finds that despite high female enrollment in higher education, women's participation in STEM programs and leadership positions remains limited. This is due to gender norms, insufficient career guidance, and a lack of inclusive institutional policies (UNESCO, 2024). These findings suggest that, while interventions exist, their long-term impact remains understudied, particularly in contexts beyond Europe and North America.

Moreover, most high-impact bibliometric studies originate from developed countries, which limits the representation of diverse global contexts. Nevertheless, studies such as the analysis of gender inequality in engineering programs in Colombia's Caribbean region show that structural barriers remain despite increasing female enrollment. These findings call for comprehensive, context-specific policies, including retention strategies and the promotion of female role models in STEM fields (Carrillo Lanzabal et al., 2024). The findings also underscore the importance of fostering research that incorporates intersectional and regional perspectives and of expanding the research agenda to examine how gender, geography, and access intersect to shape opportunities in science and technology.

CONCLUSION

This study reveals a growing global interest in gender dynamics within STEM, with research activity increasing significantly after 2000 and accelerating sharply after 2016. This trend is partly influenced by broader gender equity movements. Despite this surge in scholarly attention, persistent challenges remain, including limited access to higher education, social and political influences, and enduring gender gaps in STEM careers. Notably, recent gender-focused STEM research is predominantly authored by women, affiliated with institutions in the United States and Europe, underscoring regional disparities in research engagement.

Thematic shifts indicate a move toward intersectionality, gender stereotypes, and the lived experiences of women of color—highlighting ongoing concerns about racial and social inequities in STEM education. Conversely, interest in topics such as secondary education and gender in STEM teaching has declined, suggesting an evolution in research priorities. These findings highlight the need for further studies that incorporate male perspectives on gender equity and evaluate the long-term effectiveness of inclusion policies and professional training programs.

These findings not only contribute to academia but also offer institutions and policymakers a roadmap for designing data-driven interventions that enhance women's retention and progression in STEM. Future research should address gender inclusivity in higher education and professional STEM settings to ensure that diversity efforts result in lasting, systemic change. The evolving research agenda must examine the intersection of gender identity, diversity, stereotypes, and retention strategies with technological and pedagogical innovations to foster a more inclusive and equitable STEM ecosystem.

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