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EVALUATION OF A STEM-BASED EDUCATIONAL PROGRAM FOR REDUCING THE GENDER GAP IN SCIENTIFIC AND TECHNOLOGICAL CAREERS

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ABSTRACT

Gender inequality in scientific and technological disciplines remains a constant challenge for education systems and equity policies around the world. Despite progress in access to education, the presence and retention of women in science, technology, engineering, and mathematics (STEM) fields is still lower than that of men, especially at advanced levels of training and in the transition to professional and academic careers. Within this framework, this study sought to systematically examine the most recent scientific output on STEM-focused educational programs that aim to reduce the gender gap in these disciplines. systematic review of the literature was conducted, following the PRISMA protocol guidelines. The research was carried out in the Scopus and Web of Science databases, initially finding 60 articles published during 2025. After eliminating duplicates and applying inclusion and exclusion criteria, 17 studies were selected to form the final set analyzed. The qualitative synthesis focused on identifying intervention strategies, educational levels addressed, impact variables, and main trends and gaps in the research. The findings indicate that STEM education programs can help reduce the gender gap if they incorporate inclusive pedagogical approaches, promote psychoeducational variables such as self-efficacy and STEM identity, and use support mechanisms such as mentoring. However, it is also noted that the effect of these interventions is variable and conditioned by context, educational level, and program structure. Furthermore, evidence suggests that gender inequality persists beyond the educational environment, especially when entering the labor market and pursuing academic careers, which limits the impact of isolated educational efforts. It is concluded that in order to achieve a sustainable reduction in the gender gap in science and technology careers, STEM educational programs are needed that are designed as comprehensive strategies, aligned with institutional policies, and evaluated using robust and longitudinal methods. This review provides significant evidence for the design of educational programs, the formulation of public policies, and the promotion of future research with a focus on gender equity in STEM.

KEYWORDS: STEM Education; Gender Gap; Science and Technology Careers; Systematic Review; Gender Equity.

RESUMEN

La desigualdad de género en las disciplinas científicas y tecnológicas sigue siendo un reto constante para los sistemas educativos y las políticas de equidad en todo el mundo. A pesar de los progresos en el acceso a la educación, la presencia y retención de mujeres en los campos de ciencia, tecnología, ingeniería y matemáticas (STEM) es aún menor que la de los hombres, sobre todo en niveles de formación avanzados y en la transición a carreras profesionales y académicas. En este marco, este estudio buscó examinar de manera sistemática la producción científica más reciente sobre programas educativos enfocados en STEM que tienen como meta reducir la brecha de género en estas disciplinas. Se llevó a cabo una revisión sistemática de la literatura, siguiendo las pautas del protocolo PRISMA. La investigación se realizó en las bases de datos Scopus y Web of Science, inicialmente encontrando 60 artículos publicados durante el año 2025. Después de eliminar los duplicados y aplicar criterios de inclusión y exclusión, se eligieron 17 estudios que conformaron el conjunto final analizado. La síntesis cualitativa se enfocó en identificar estrategias de intervención, niveles educativos tratados, variables de impacto y principales tendencias y lagunas en la investigación. Los hallazgos indican que los programas educativos en STEM pueden ayudar a disminuir la brecha de género si incorporan enfoques pedagógicos inclusivos, fomentan variables psicoeducativas como la autoeficacia y la identidad STEM, y utilizan mecanismos de apoyo como la mentoría. Sin embargo, también se nota que el efecto de estas intervenciones es variable y está condicionado por el contexto, el nivel educativo y la estructura del programa. Además, la evidencia señala que la desigualdad de género persiste más allá del entorno educativo, especialmente al entrar en el mercado laboral y en la trayectoria académica, lo que limita el impacto de esfuerzos educativos aislados. Se concluye que para lograr una reducción sostenible de la brecha de género en las carreras científicas y tecnológicas, se necesitan programas educativos en STEM que sean concebidos como estrategias integrales, alineadas con políticas institucionales y evaluadas con métodos robustos y longitudinales. Esta revisión ofrece evidencia significativa para el diseño de programas educativos, la formulación de políticas públicas y el impulso de futuras investigaciones con un enfoque en la equidad de género en STEM.

Palabras clave: Educación STEM; Brecha De Género; Carreras Científico-Tecnológicas; Revisión Sistemática; Equidad de Género.

1. INTRODUCTION

Gender inequality in science, technology, engineering, and mathematics (STEM) has been reaffirmed as one of the most entrenched challenges in current education systems, not only because of its implications for social justice, but also because of its effect on the scientific, technological, and economic progress of societies. Despite global achievements in education and the increase in women's participation at various educational levels, the presence of women tends to decrease as one move toward more specialized scientific and technological disciplines, especially in fields such as engineering, computer science, and the physical sciences. This lack of representation has been widely evidenced in international research, which agrees that gender inequality in STEM is not a temporary or isolated phenomenon, but rather the result of social, cultural, and educational processes that accumulate throughout life (Wang and Degol, 2017; Cheryan et al., 2017).

In this context, specialized research has shown that gender differences in the choice of STEM careers cannot be simplified to differences in cognitive abilities or academic performance. Instead, numerous studies indicate that girls and young women achieved performance levels like those of their male counterparts, especially in the early stages of education. However, factors such as gender stereotypes, differentiated social expectations, socialization early in life, and the lack of visible female role models in scientific fields significantly affect the formation of academic and professional aspirations (Eccles, 2014; Wang and Eccles, 2013). These influences, often subtle, shape perceptions of belonging and the feasibility of pursuing a career in STEM.

The continuity of these elements has been explained in the literature through metaphors such as "leaky pipeline" or "gender filter," which describe the progressive decline of women at various stages of education and employment. However, more recent studies question the notion of voluntary or natural attrition, arguing that these "leaks" are the result of educational and cultural environments that foster biases, exclusionary practices, and unfavorable climates for the retention of women (Blickenstaff, 2005; Cheryan et al., 2017). From this perspective, gender inequality in STEM is presented as a structural phenomenon that requires intentional, sustained, and evaluated interventions within the educational sphere.

In this context, STEM-focused education has gained importance as a strategy to change the conditions that have historically restricted the inclusion of women in scientific and technological fields. The STEM approachmathematics as an interdisciplinary fusion of science, technology, engineering, and mathematics, favors active methodologies, real-world problem solving, and contextual learning, making it an appropriate space for challenging stereotypes and increasing educational opportunities (Bybee, 2013). Therefore, STEM educational programs aim not only to develop technical skills, but also to create more inclusive attitudes, identities, and expectations.

Data-based information shows that STEM programs that integrate a gender equality approach can have a favorable impact on fundamental aspects related to the choice and continuity of scientific and technological careers. Among these aspects, academic confidence, lasting interest in science, a sense of belonging, internal motivation, and the intention to pursue studies in STEM disciplines stand out. Long-term and comparative research indicates that the participation of female students in meaningful educational activities—such as mentoring, project-based learning, interaction with female role models, and supportive environments—increases the likelihood of considering and pursuing a career in these fields (Wang et al., 2023; Wang and Eccles, 2013).

However, despite the steady growth of initiatives aimed at closing the gender gap in STEM, scientific output reveals remarkable diversity in conceptual approaches, methodological designs, and evaluation criteria. There are many discrepancies in how the gender gap is defined, in the indicators used to evaluate impact, and in the theoretical frameworks underpinning the interventions. This variety, while reflecting the complexity of the phenomenon, complicates the comparison of results and the identification of consistent patterns of effectiveness across different educational programs (Verdugo-Castro et al., 2022).

In addition, it has been noted that a considerable portion of the studies do not provide sufficient details on the specific elements of the STEM programs evaluated, such as duration, intensity, target population, or expected mechanisms of change. This lack of information limits the possibility of replicating successful experiences and transferring good practices to other educational settings. Therefore, it is essential to organize and systematize the available information through rigorous systematic reviews that allow for the synthesis of findings and offer a comprehensive overview of the state of knowledge.

In this regard, the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) methodology has been established as an international standard for conducting systematic reviews that are transparent, reproducible, and methodologically rigorous. The PRISMA 2020 update emphasizes the importance of clarity in the processes of identifying, selecting, and including studies, as well as explicitly justifying exclusions, which is especially relevant in interdisciplinary areas such as STEM education and gender studies (Page et al., 2021). Its use reinforces the reliability of results and facilitates comparison with previous research.

Existing systematic reviews and meta-analyses have provided evidence that educational interventions focused on gender equity in STEM can have moderate positive effects, particularly on attitudinal and motivational aspects. However, they also indicate that results differ according to educational level, type of intervention, and sociocultural context, highlighting the need for more specific and up-to-date studies to better understand these variations (Yu et al., 2024; Wang and Degol, 2017).

From this perspective, examining recent academic publications is of great importance, as it facilitates the identification of new trends, innovative methods, and unexplored areas of research. The year 2025 is characterized by international agendas that promote gender equality and a growing institutional interest in fostering inclusion in the fields of science and technology, which translates into an increase in studies on STEM educational programs with a gender perspective.

Based on the above, the aim of this study is to conduct a systematic review of the literature, based on the PRISMA methodology, to evaluate STEM-focused educational programs aimed at reducing the gender gap in scientific and technological disciplines. The search was conducted in the Scopus and Web of Science databases, chosen for their international prestige and academic rigor, which ensures the quality and relevance of the sources examined.

The identification process initially yielded 60 articles; after applying temporal criteria, eliminating duplicates, and analyzing thematic and methodological relevance, 17 studies were ultimately selected to comprise the corpus of analysis. This method ensures that the synthesis presented is based on current, relevant, and methodologically sound evidence, in accordance with international standards for systematic review.

In summary, this systematic review aims to enrich the field of STEM education and gender studies through a critical and organized evaluation of recent academic production. By identifying methods, results, and areas for further research, the study seeks to provide valuable information for researchers, educators, educational program designers, and public policy makers who wish to promote more equitable and sustainable participation of women in scientific and technological disciplines.

2. GENERAL OBJECTIVE

To systematically analyze the scientific output published in the Scopus and Web of Science databases during 2025 on STEM-based educational programs aimed at reducing the gender gap in scientific and technological careers, in order to identify intervention approaches, impact variables, educational levels addressed, and main trends and research gaps, using the PRISMA methodology.

3. METHODOLOGY

This research was developed as a systematic review of the literature, following the guidelines established in the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol, with the purpose of rigorously identifying, organizing, and analyzing scientific production related to the evaluation of STEM-based educational programs aimed at reducing the gender gap in science and technology careers. The adoption of this methodological approach ensured the transparency, systematicity, and reproducibility of the process of searching, selecting, and analyzing the included studies, strengthening the validity of the work and its compliance with international standards for scientific publication.

The literature search was conducted in the Scopus and Web of Science databases, selected for their international recognition, multidisciplinary coverage, and editorial quality requirements through peer review processes. These databases are widely used in systematic reviews due to their reliability in retrieving high-impact scientific output in the fields of education, gender studies, and applied sciences. The search strategy was designed considering combinations of key terms in English, given that this language accounts for most of the scientific output indexed on these platforms.

The keywords used included expressions such as: "STEM education," "STEM programs," "gender gap," "gender inequality," "women in STEM," "female participation," and "STEM careers." These were combined using Boolean operators (AND/OR) and applied to the title, abstract, and keyword fields in order to maximize the retrieval of relevant studies. No restrictions were placed on the institutional affiliation or country of origin of the authors; however, the studies were required to explicitly address the relationship between STEM educational programs and the reduction of the gender gap in access to, retention in, or choice of science and technology careers.

The inclusion criteria considered for the selection of studies were as follows:
(i) scientific articles published during 2025 in peer-reviewed journals indexed in Scopus or Web of Science;
(ii) empirical, theoretical, or review research evaluating STEM-based educational programs, strategies, or interventions with a focus on reducing the gender gap;
(iii) studies written in English or Spanish; and
(iv) availability of the full text for detailed analysis.

On the other hand, exclusion criteria were established to ensure the relevance and quality of the analyzed corpus. The following were excluded:
(i) documents that had not been peer reviewed, such as theses, technical reports, books, book chapters, and conference proceedings;
(ii) studies that address STEM education without explicitly considering the gender dimension;
(iii) research focused solely on theoretical or descriptive aspects unrelated to educational programs or impact assessment; and
(iv) duplicate records identified in both databases.

The initial search process identified a total of 60 potentially relevant records. Duplicates were then removed, resulting in 42 unique documents, which underwent an initial selection phase involving a review of titles and abstracts. At this stage, studies that did not meet the established thematic or methodological criteria were discarded.

In the final phase, the selected texts were read in full, strictly applying the previously defined inclusion and exclusion criteria. As a result of this process, 17 articles were selected, which make up the final corpus for analysis in this systematic review. These studies were examined qualitatively, taking into account variables such as the type of STEM educational program, educational level, gender approach, methodology used, and main results reported.

The entire process of identification, screening, eligibility assessment, and final inclusion of studies is documented using the PRISMA flow diagram, which is presented in Figure 1. This diagram provides a clear and detailed representation of the procedure followed, ensuring the traceability of the methodological process and facilitating its replication in future research.

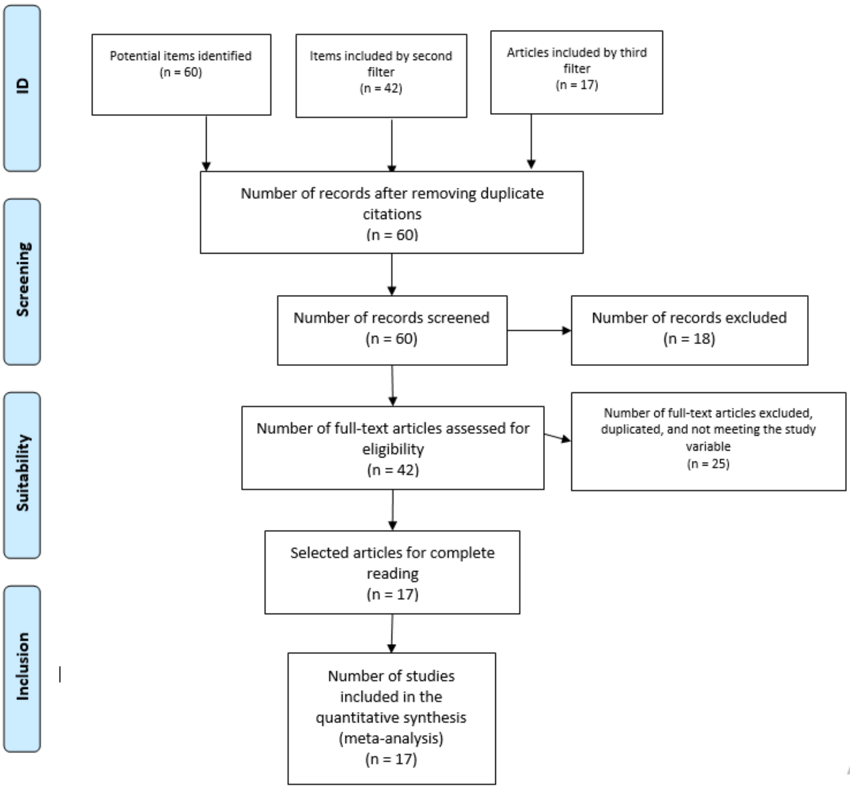

Figure 1. Flowchart of systematic review conducted using the PRISMA technique (Moher, Liberati, Tetzlaff, Altman, & Group, 2009)

Source: Own elaboration; Based on the proposal of the Prisma Group (Moher, Liberati, Tetzlaff, Altman, & Group, 2009)

4. RESULTS

Table 1 shows the results after applying the search filters related to the methodology proposed for this research, after recognizing the relevance of each of the referenced works.

Table 1. List of articles analyzed

No.	RESEARCH TITLE	AUTHOR/YEAR	COUNTRY	TYPE OF STUDY	INDEXING
1	*Underrepresentation of Hispanic women in science, technology, engineering, mathematics, and medicine*	Gencel-Augusto, J., Minaya, N. J., Johnson, D. E., & Grandis, J. R. (2025).	UNITED STATES	QUALITATIVE	SCOPUS
2	*Educational strategies to reduce the gender gap in the self-efficacy of high school students in STEM teaching*	Brage-del-Río, M., Martin-Núñez, J. L., & Pablo-Lerchundi, I. (2025, May).	SPAIN	QUALITATIVE	SCOPUS
3	*Unequal access, equal outcomes? Gender differences in the relationship between university-led STEM program factors and undergraduates' career commitment in STEM*	Guo, C., Wu, W., Hu, T., & Gao, T. (2025)	CHINA	QUALITATIVE	SCOPUS
4	*Participation of Latin American women in metrology: Challenges and opportunities in industry and research/academia*	López-Canchola, C. C., Sierra-Ferreyra, K., & Purata-Sifuentes, O. J. (2024).	IRAN	QUALITATIVE	WOS
5	*Tackling the Gender Gap in Cybersecurity Education*	Korolchuk, O., Gaievska, L., Klymkova, I., Lozovetska, V., & Bodnar, K. (2024)	MEXICO	QUANTITATIVE	SCOPUS
6	*Using AI Tools to Enhance Educational Robotics to Bridge the Gender Gap in STEM*	Voutyrakou, D. A., & Skordoulis, C. (2025).	GREECE	QUALITATIVE	SCOPUS

7	*Reverse Gender Gap in STEM Disciplines at Qatar University: The Impact of Family Influence and Educational Support*	Al-Thani, M. A. N., & Ashour, S. (2025)	QATAR	QUALITATIVE	SCOPUS
8	*Bridging the gap: gender-specific preferences in STEM occupations in vocational education and training*	Gutfleisch, T., & Nennstiel, R. (2025).	GERMANY, SWITZERLAND	QUANTITATIVE/QUALITATIVE	SCOPUS
9	*Factors influencing the lower number of women in STEM compared to men: A case study from Kosovo*	Prebreza, R., Beqiraj, B., Prebreza, B., Krypa, A., & Krypa, M. (2025)	KOSOVO	QUALITATIVE	SCOPUS
10	*A critical examination of the underlying causes of the gender gap in STEM and the influence of computational thinking projects applied in secondary school on STEM Higher Education*	González-Gallego, S., Hernández-Pérez, M., Alonso-Sánchez, J. A., Hernández-Castellano, P. M., & Quevedo-Gutiérrez, E. G. (2025, March)	SPAIN	QUALITATIVE	SCOPUS
11	*Armenian Women in Science: An Analytical and Bibliometric Study of Current Trends*	Sargsyan, S., Maisano, D. A., Shakhatuni, A., Sargsyan, H., Mirzoyan, A., Ohanyan, M., ... & Gzoyan, E. (2025)).	ARMENIA	QUALITATIVE	WOS
12	*Continuing education of academic women in STEM: perspectives on mentoring and professional roles*	García-Silva, E., Perez-Suarez, S., Zavala-Parrales, A., Meléndez-Anzures, F. E., & Dominguez, A. (2025, February).	SPAIN, MEXICO, CHILE	QUALITATIVE	WOS
13	*Examining gender impact on the selection and persistence of STEM careers in a Uruguayan university without access barriers*	Bruzzese, M. M. G., Cedréz, M. C., & Aguerre, T. F. (2025).	URUGUAY	QUANTITATIVE	WOS
14	*Filling the gap between career choice and academic variables: gender comparisons in STEM and social sciences*	Diniz, A. M., Alfonso, S., Conde, Á., García-Señorán, M., Ares-Ferreiros, M., & Almeida, L. S. (2025).	PORTUGAL, SPAIN	QUANTITATIVE	WOS
15	*Putting the pieces of the puzzle together in modeling gendered educational choices*	Schwerter, J., Lauermann, F., Doebler, P., & Fokkema, M. (2025).	GERMANY, NETHERLANDS	QUANTITATIVE	WOS
16	*Sex differences in research productivity among doctoral students in Sweden: A quantile regression approach*	RLindahl, J., Danell, R., Litson, K., & Feldon, D. F. (2025).	SWITZERLAND, UNITED STATES	QUANTITATIVE	WOS
17	*Where the Women Are: Gender Imbalance in Computing and Faculty Perceptions of Theoretical and Applied Research*	Kleinberg, S., & Marsh, J. K. (2025)	UNITED STATES	QUALITATIVE	WOS

Source: Own elaboration

The scientific research reviewed consistently shows that gender inequality in scientific and technological disciplines should not be considered an isolated phenomenon or attributed solely to individual choices, but rather is the result of educational trajectories influenced by structural, cultural, institutional, and psychoeducational factors that interact throughout the educational process. In this context, the studies analyzed confirm that the lack of female representation in STEM is observed in initial access as well as in continuity, career commitment, and academic and professional advancement, highlighting the need to evaluate STEM educational programs from a global and long-term perspective.

Several studies in the set analyzed indicate that the gap begins to establish itself at an early age due to educational socialization processes that affect female students' self-efficacy, academic perception, and expectations of success. In this context, the research conducted by Brage-del-Río et al. shows that certain educational strategies in secondary education can help reduce differences in self-efficacy in STEM, a variable that is widely recognized as an indicator of the choice of scientific careers. This finding is consistent with the literature on motivation, which argues that perceived competence and the importance given to the task play a crucial role in educational decisions, especially in traditionally male-dominated environments.

In line with this idea, González-Gallego et al. critically examine the underlying causes of the gender gap in STEM and highlight the importance of computational thinking projects in secondary education as tools that could change attitudes, interests, and predispositions toward scientific and technological studies in higher education. These findings reinforce the notion that STEM educational programs seeking to close the gender gap must go beyond simply imparting technical knowledge, incorporating meaningful pedagogical experiences that allow students to develop a positive and lasting STEM identity.

At the university level, evidence suggests that access to STEM programs alone does not ensure a reduction in the gender gap if factors affecting commitment and persistence in the field are not considered. In this context, Guo et al. show that, although there are differences in access to certain elements of STEM programs at universities, levels of career commitment can be similar between men and women. This finding presents a key aspect for the analysis of STEM educational programs: the need to differentiate between equity in opportunities and equity in outcomes, which implies evaluating multiple impact indicators and not limiting oneself to participation rates alone.

Retention and development in STEM disciplines stand out as essential aspects in various studies in the collection. Bruzzese et al. (2025), in a university setting in Uruguay with no formal restrictions on access, demonstrate that women are less likely to select and remain in STEM careers, even though institutional conditions appear to be fair. This finding indicates that educational programs aimed at closing the gap must offer specific academic and psychosocial support that addresses the cumulative disadvantages related to gender, prior educational background, and cultural capital.

On the other hand, Diniz and his team (2025) examine the connection between career choice and academic variables in contexts on the Iberian Peninsula, revealing that gender disparities in STEM manifest themselves in ways that differ from those observed in the social sciences. The researchers highlight the impact of intermediate factors such as family expectations, past school experiences, and academic self-image, reinforcing the importance of STEM programs including a contextualized perspective that recognizes the social dynamics that affect educational decisions.

The corpus also presents important information about gender disparity in technical training environments and in the transition to employment. Research by Gutfleisch and Nennstiel (2025) reveals that inclinations toward certain occupations in technical vocational education are strongly influenced by gender norms, even when academic outcomes are similar. This finding broadens the analysis by showing that closing the STEM gap should not be restricted to the university setting but should also consider the continuity between education and employment, as well as social representations related to certain technological professions.

Regarding the use of educational technologies, Voutyrakou and Skordoulis (2025) demonstrate that incorporating artificial intelligence tools into educational robotics programs can help create more open learning environments, while increasing women's interest and participation in STEM. Such initiatives suggest that technology, when designed with an equitable approach, can act as a driver for reducing bias and expanding educational opportunities, aligning with current trends in pedagogical innovation in STEM disciplines.

From a structural and long-term perspective, various studies in the corpus investigate the gender gap in science and academia. Gencel-Augusto et al. (2025) document the continued underrepresentation of Hispanic women in STEM and medicine, even in environments wher r access to education has improved, highlighting the existence of systemic barriers that impact career advancement. Similarly, Lindahl et al. (2025) point to gender differences in the research productivity of doctoral students, especially at the highest levels of performance, indicating that the gap widens in the advanced stages of the academic career.

Kleinberg and Marsh's (2025) study on the presence of women in the field of computing offers a different perspective by showing that segregation occurs not only in the number of women, but also in specific areas and in the institutional recognition of the work they do. This finding is particularly important for the analysis of STEM educational programs, as it suggests that successful initiatives in the early stages may have a limited effect if transformations in academic cultures and professional recognition standards are not implemented.

Similarly, research focusing on specific regional contexts, such as the study by Prebreza et al. (2025) in Kosovo and that by Al-Thani and Ashour (2025) in Qatar, shows that gender inequality in STEM fields manifests itself differently depending on the sociocultural environment, family dynamics, and institutional policies. These findings underscore that STEM educational programs must be developed and analyzed with context in mind, avoiding approaches that are overly general and do not consider local particularities.

On the other hand, analytical and modeling research, such as that of Schwerter et al. (2025), allows us to identify factors that largely explain educational choices based on gender, such as self-perception in mathematics, career goals, and internalized expectations. These findings provide an empirical basis for redirecting the evaluation of STEM education programs toward crucial intermediate aspects, rather than focusing solely on final outcomes such as enrollment or graduation.

Overall, the evidence reviewed supports the view that STEM-based educational programs can help narrow the gender gap in science and technology careers, provided they integrate pedagogical, motivational, technological, and structural aspects. The comprehensive review that has been carried out, in line with the purpose of the study, indicates that the most effective interventions are those that strengthen self-efficacy and identity in STEM, promote inclusive learning, include mentoring and ongoing support, and address institutional barriers that affect women's academic and professional development. These conclusions reinforce the need to create, evaluate, and expand STEM educational programs that have a gender perspective, are based on scientific evidence, and are adapted to specific circumstances.

5. DISCUSSION

The results of this systematic review allow us to address, first, that the gender gap in science and technology careers is not due to a single cause nor can it be resolved with isolated or short-term interventions. On the contrary, the evidence reviewed indicates that it is a multidimensional phenomenon that develops gradually throughout educational and career trajectories, involving individual, pedagogical, sociocultural, and institutional factors. This finding is consistent with the global literature, which warns that gender disparities in STEM persist even in contexts where formal access to education is equitable, calling into question approaches that focus exclusively on enrollment figures or on eliminating obvious barriers (Cheryan et al., 2017; Wang and Degol, 2017).

One of the most significant contributions of the body of research examined is the corroboration of the fundamental role played by psychoeducational variables, such as self-efficacy, academic self-perception, and STEM identity, in the choice and continuation of science and technology careers. Research focused on secondary education and stages prior to higher education shows that gender differences in these variables occur before career choice and significantly affect future decisions. In this context, educational strategies that seek to strengthen self-efficacy and generate positive experiences in STEM are presented as key tools for reducing the gap, aligning with the expectation-value theory ( ), which suggests that academic decisions are based on the perception of competence and the value attributed to the activity (Wang and Eccles, 2013).

However, the results also indicate that progress in motivational variables does not always translate directly into a sustained reduction in the gap at later stages. Some university studies included in the review indicate that, although women enter STEM programs and report similar levels of dedication to their careers, inequalities in continuity, specialization, and career prospects continue to appear. This apparent contradiction suggests that STEM educational programs should be evaluated not only for their immediate effects, but also for their ability to create sustainable trajectories, highlighting the need to take a long-term perspective in assessing their impact.

Discussion of the findings also reveals that the gender gap in STEM does not occur uniformly across disciplines or contexts. Some studies document configurations, such as the so-called "reverse gap" in certain university or cultural environments, where female participation exceeds male participation in specific areas. However, these cases do not negate the existence of inequality but rather highlight the influence of contextual factors such as family support, institutional policies, and differentiated social expectations. This finding emphasizes the need to avoid simplistic generalizations and to design STEM programs that take into account the sociocultural context in which they are implemented.

Another key aspect of the conversation is the persistence of inequality beyond formal education, especially during the transition to employment and in academic trajectories. Research on scientific productivity, the distribution of disciplines, and the institutional valuation of academic work shows that gender inequalities tend to deepen in later stages, even among women who have overcome initial educational obstacles. This implies that, although STEM education programs are indispensable, they are not sufficient on their own to guarantee gender equality, and their impact may be limited unless they are accompanied by structural changes in organizational cultures and professional recognition systems.

In this context, information on mentoring, academic support, and professional development takes on particular importance. The research in the review indicates that mentoring strategies, both formal and informal, help improve retention, professional identity, and opportunities for women in STEM, particularly in university and academic settings. These findings reinforce the need for educational programs with a gender perspective to integrate elements of ongoing support that go beyond the classroom and address key transitions throughout the educational and professional path.

Similarly, the incorporation of new technologies, such as artificial intelligence and educational robotics, is presented in literature as an opportunity to create more inclusive learning experiences. However, the findings indicate that the effect of these technologies is neither automatic nor neutral: their ability to narrow the gap depends on pedagogical design, inclusive intent, and the ability to detect and correct biases in learning spaces. Thus, technology can function both as a driver of equity and as a reproducer of existing inequalities, presenting significant challenges for the evaluation of technology-mediated STEM programs.

The debate also highlights a recurring tension between deficit-focused and transformative approaches. While some programs seek to "fix" students perceived individual shortcomings (e.g., lack of confidence or interest), the evidence reviewed suggests that the most effective interventions are those that challenge and transform the structural and cultural conditions that generate exclusion. This observation is consistent with critical perspectives that warn that blaming students alone for the gap can obscure institutional biases and exclusionary pedagogical practices (Blickenstaff, 2005; Cheryan et al., 2017).

From a methodological perspective, the results of the review highlight the diversity of designs, indicators, and methods used to evaluate STEM education programs from a gender perspective. Although this diversity reflects the complexity of the issue, it also complicates the direct comparison of results and the identification of patterns of effectiveness. Therefore, there is a clear need to move toward more integrated evaluation frameworks that simultaneously consider cognitive, motivational, contextual, and structural variables and allow for the capture of the short-, medium-, and long-term effects of interventions.

Regarding the purpose of this study, the discussion of the findings reaffirms that the evaluation of STEM-focused educational programs aimed at reducing gender inequality requires a broad and multidimensional approach. The results indicate that the most successful programs are those that integrate inclusive teaching methods, the strengthening of self-confidence and STEM identity, ongoing support through mentoring, and clear attention to the institutional and cultural contexts in which they are developed. Therefore, the systematic review provides evidence that can guide the design, implementation, and evaluation of future educational initiatives that seek gender equity in STEM.

Finally, the discussion reveals the presence of significant gaps in research, especially in relation to long-term evaluations, comparative studies between different contexts, and analyses that explicitly integrate education with the transition to the labor market. Addressing these gaps is crucial to achieving a more comprehensive understanding of the true impact of STEM education programs and to creating evidence-based policies and practices that contribute in a sustainable way to closing the gender gap in scientific and technological careers.

6. CONCLUSIONS

The conclusions of this systematic review confirm that gender inequality in science and technology is a structural and long-standing problem that requires a comprehensive approach to understanding and resolving it, going beyond simplistic explanations or those that focus solely on individual performance. The scientific evidence reviewed shows that gender differences in STEM develop through cumulative processes that begin in the early years of schooling and are perpetuated throughout secondary and higher education and professional life, affected by psychoeducational, sociocultural, and institutional factors. Therefore, reducing this gap cannot be achieved through isolated actions, but rather requires continuous and consistent educational strategies over time.

Regarding the main objective of the study, the analysis of scientific output published in Scopus and Web of Science during 2025 reveals that STEM educational programs have great potential to help reduce the gender gap, if they are designed and implemented with a clear focus on equity. The studies reviewed show that the most effective interventions not only increase students' exposure to scientific or technological content, but also focus specifically on key intermediate variables, such as academic self-efficacy, self-concept, STEM identity, sense of belonging, and expectations of success. These variables are essential mediators between educational experience and choice, perseverance, and projection in scientific and technological careers.

Furthermore, the results indicate that the effectiveness of STEM programs is strongly influenced by the educational level at which they are implemented and their connection to crucial transitions in the educational system. In the early stages, interventions that seek to create positive experiences and challenge gender stereotypes help to broaden the academic options that girls and adolescents perceive. However, in higher education and graduate school, the results suggest that it is essential to complement pedagogical strategies with support systems, mentoring, and institutional backing that promote retention, career commitment, and professional development. This distinction by level shows that STEM educational programs should be conceived as part of integrated educational trajectories and not as isolated initiatives.

Another important point that emerges from the review is that gender disparity in STEM is not limited to the field of education but extends to the transition to the world of work and academic trajectories, where inequalities tend to increase. The persistence of differences in scientific productivity, institutional recognition, and access to leadership roles suggests that the benefits of educational programs may be insufficient if they are not accompanied by structural transformations in organizational cultures, evaluation systems, and merit criteria. In this context, the findings underscore the need to connect STEM educational programs with institutional and labor policies that seek gender equity.

From a pedagogical and technological perspective, the review leads to the conclusion that the adoption of innovative tools, such as educational robotics and artificial intelligence, can increase the impact of STEM programs in reducing the gender gap, provided that these technologies are incorporated based on an inclusive and critical design. Evidence indicates that technology is not impartial and that its potential to promote equity depends on pedagogical intent, teacher training, and consideration of possible biases in learning environments. Therefore, the integration of technology into STEM programs must be accompanied by thoughtful strategies that ensure its effective contribution to inclusion.

From a methodological perspective, the conclusions highlight the need to strengthen the evaluation methods of STEM education programs with a gender perspective. The variety of designs, indicators, and methodologies found in the literature complicates the comparison of results and the generalization of conclusions. Therefore, the importance of moving toward more integrated evaluation frameworks that simultaneously consider cognitive, motivational, contextual, and structural dimensions is emphasized, as well as the conduct of longitudinal studies that allow for the examination of the impact of interventions in the medium and long term.

In addition, the review shows the existence of significant research gaps, especially in non-Western settings, in comparative analyses between educational levels, and in studies that explicitly link STEM education with labor market entry and retention. Addressing these gaps is vital to broadening understanding of the phenomenon and developing more effective educational programs that are sensitive to the diversity of sociocultural contexts. It also points to the need for greater clarity in reporting program components and expected mechanisms of change, with the aim of facilitating replication and transfer of good practices.

In summary, this systematic review provides compelling evidence that STEM-focused education programs can have a key impact on reducing gender inequality in science and technology, provided they are designed as comprehensive, context-appropriate interventions and rigorously evaluated. By incorporating inclusive teaching methods, promoting motivational variables, offering ongoing support, and addressing structural barriers, these programs can help not only to increase women's participation in STEM, but also to foster more equitable and sustainable academic and professional trajectories. Thus, the study provides valuable information for the creation of educational policies, the design of institutional initiatives, and the promotion of future research focused on gender equity in science and technology.

7. RECOMMENDATIONS

Based on the findings of this systematic review, a series of suggestions are proposed to improve the design, implementation, and evaluation of STEM-based educational programs that consider gender equity. These suggestions should not be understood as rigid rules, but rather as guidelines supported by the scientific evidence studied, with the aim of assisting in informed decision-making in the educational, institutional, and research spheres.

First, it is advisable that STEM-related educational programs clearly incorporate a gender approach from the conception phase. The evidence reviewed shows that the most effective interventions not only focus on teaching scientific or technological content, but also address important psychoeducational aspects, such as academic self-efficacy, self-concept, STEM identity, and sense of belonging. Thus, it is essential that programs include pedagogical strategies that challenge gender stereotypes, give visibility to female figures in science and technology, and create learning experiences that strengthen female students' perception of competence and legitimacy in these fields.

In addition, it is suggested that STEM programs implement active and context-adapted methodologies, such as project-based learning, real-world problem solving, and teamwork, as these strategies promote continuous participation and greater engagement with learning. Evidence indicates that real educational experiences, connected to relevant social and professional contexts, help to increase female students' academic aspirations and consolidate their interest in scientific and technological careers. Therefore, it is recommended that programs avoid uniform or context-disconnected approaches that reproduce exclusionary dynamics or reinforce established inequalities.

From an institutional perspective, it is advisable for STEM educational initiatives to be linked to ongoing support mechanisms, such as mentoring programs, academic tutoring, and peer support networks. The review shows that the retention and advancement of women in STEM depend largely on the availability of ongoing support, especially at critical moments such as the transition from secondary to higher education, or from university to the labor market or academic career. Therefore, educational institutions should view STEM programs as part of comprehensive equity strategies and not as isolated or temporary actions.

With regard to teacher training, there is a need to strengthen teacher training in STEM education approaches with a gender perspective. The evidence analyzed suggests that teaching practices, teacher expectations, and the classroom environment have a significant impact on female students' participation and performance in STEM areas. In this regard, it is essential to promote training processes that enable teachers to identify and reduce implicit biases, design inclusive activities, and apply formative assessments that recognize the diversity of learning trajectories and styles.

Regarding the use of technologies in education, it is suggested that the incorporation of tools such as artificial intelligence, robotics in teaching, and interactive digital environments be carried out from a critical and inclusive perspective. Although these technologies provide opportunities to innovate in STEM education and improve student participation, data indicate that their effect on reducing the gender gap depends on pedagogical intent and how learning experiences are designed. Therefore, it is advisable to conduct a systematic assessment of potential biases related to the use of technologies and ensure that they truly contribute to equity rather than perpetuating inequalities.

In the field of educational policy, it is suggested that links between STEM educational programs and institutional and national strategies aimed at gender equality should be promoted. The review shows that the benefits of educational interventions may be limited if they are not accompanied by policies that address structural barriers, such as segregation in disciplines, unequal valuation of academic work, and differences in access to professional development opportunities. Thus, it is important that public policies integrate STEM education as a key element in equality and sustainable development agendas.

Finally, with regard to future research, it is recommended to move towards more robust and comparable evaluation methodologies for gender-focused STEM education programs. The evidence analyzed presents a notable variety of methodologies, which complicates the synthesis of results and the identification of transferable good practices. Therefore, it is proposed that longitudinal studies be developed to examine the effect of interventions in the medium and long term, as well as research that combines educational indicators with results in labor market incorporation and academic careers. In addition, it is essential to expand research in varied and underrepresented contexts, with the aim of creating more inclusive and contextualized evidence.

Taken together, these recommendations seek to guide the design and evaluation of STEM-based educational programs toward more comprehensive, equitable, and sustainable approaches, thereby contributing to the effective reduction of the gender gap in science and technology disciplines and the strengthening of more just and inclusive education systems.

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