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EDITED BY
Stella L. Smith,
Prairie View A&M University, United States

REVIEWED BY
Judit García-Martín,
University of Salamanca, Spain
Miloš Krstić,
University of Nis, Serbia

*CORRESPONDENCE
Natalia Salas-Guzmán
nsalas@uft.cl

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STEM and gender gap: a systematic review in WoS, Scopus, and ERIC databases (2012–2022)

Francisca Beroíza-Valenzuela[1,2] and Natalia Salas-Guzmán[3]*

[1]Universidad Metropolitana de Ciencias de la Educación, Ñuñoa, Chile, [2]Universidad de Chile, Santiago, Chile, [3]Centro de Investigación en Psicología, Educación y Familia (CIPEF), Universidad Finis Terrae, Santiago, Chile

Introduction: This article offers a thorough examination of relevant literature in the WoS, Scopus, and Eric databases for the period 2012–2022, utilizing the PRISMA model (2020) to address STEM and gender gap factors.

Methods: A comprehensive search of the Web of Science, Scopus, and Eric databases spanning the years 2012 to 2022 was conducted. Employing the PRISMA (2020) model, inclusion and exclusion criteria were applied to identify pertinent studies that examined the relationship between STEM education and the gender gap. After rigorous evaluation, 24 articles that adhered to the established criteria were selected. These articles were thoroughly analyzed to extract relevant information pertaining to the factors contributing to the gender gap in STEM fields and educational interventions designed to alleviate these disparities.

Results: This analysis hinges on two fundamental dimensions. The first addresses the factors that contribute to the gender gap in STEM fields, while the second focuses on educational interventions crafted to mitigate bias. These interventions include activities aimed at enhancing skills in science, mathematics, engineering, and technology as well as fostering a growth mindset. The findings of this review suggest that research on gender and STEM predominantly emphasizes key issues using quantitative methodologies; however, it is recommended to explore other methodologies as well.

Discussion: The practical implications of this research relate to identifying critical areas in need of attention to address the identified gap and recognizing the necessity of diversifying the methods and tools used for gathering information to explore new factors that could account for gender biases in scientific fields. The study's limitations lie in its exclusive focus on the binary gender gap between women and men without considering other relevant factors. Future analyses should incorporate the intersectionality perspective.

KEYWORDS

stereotypes, stem, gender gap, education, academic performance

Introduction

The promotion gender equality in education is an ongoing global challenge in the twenty-first century, due to persistent disparities between men and women (Fernandez et al., 2023). Unfortunately, a gender-based culture that differentiates expectations, skills, and life projects continues to prevail. One area of particular concern is the limited access given to women in scientific disciplines such as science, technology, engineering, and mathematics, collectively referred to as STEM (OECD, 2016). This situation reveals a troubling scenario of social inequality that educators and policymakers worldwide must address.

According to a recent report by UN Women, at the current pace of progress, it may take 286 years to eliminate existing gaps (United Nations Women, 2022). Advancing toward achieving these goals is crucial because providing education for all increases social resilience, mobility, and economic progress. For this reason, the agenda 2030, approved by the United Nations General Assembly in September 2015, is of utmost relevance. It includes 17 Sustainable Development Goals (SDGs), among which Goal 4 stands out, referring to quality, inclusive, and equitable education that promotes lifelong learning opportunities for all. Additionally, SDG 5 addresses gender equality, empowering women, and ending all forms of violence (Economic Commission for Latin America and the Caribbean, 2020). In this regard, according to OECD Indicators (2021), men strongly dominate STEM-related fields, highlighting the need to focus on this issue as it demonstrates the loss of talent by not effectively including women.

STEM is an interdisciplinary approach that emerged in the United States after World War II, driven by the need for technological progress. Its development was further propelled by the historical context of the Cold War, particularly with the launch of the R-7 rocket carrying the Sputnik 1 satellite, which had a significant impact on American politics (Razi and Zhou, 2022). Its educational orientation was established by the National Science Foundation (NSF) and subsequently promoted and adopted worldwide. Its objectives are to provide students with critical thinking skills for creative problem-solving and, ultimately, to make them more marketable in the workforce (White, 2014). In this way, the STEM approach contributes to higher-order skills and provides a foundation for innovation, influencing the economic well-being of nations (Barakos et al., 2012).

However, women have been relegated from STEM objectives due to societal gender stereotypes, which shape a shared set of beliefs about the attributes that are characteristic of members of a social category (Greenwald and Banaji, 2017). These beliefs can be implicit or explicit in individuals. By implicit we state thoughts and beliefs that are not commonly recognized but influence our explicit actions toward these objectives. This situation influences the expectations that humans have about their own capabilities. Lippmann (1922) defined stereotypes as mental images of different social groups, with their utility lying in simplifying perception and cognition. One of the most widely accepted definitions is provided by Ashmore and Del Boca (1981), who conceive stereotypes as a set of beliefs about the personal attributes of a group of individuals.

Human beings develop generalized stereotypes related to specific disciplinary areas from an early age, which become an integral part of their developmental system (Fine, 2018). These stereotypes influence their identity, that is, what they believe about themselves, their future, their interests, and their motivation to learn (Meltzoff and Cvencek, 2019). In this regard, women encounter stereotypes with negative consequences for their interest and academic performance, necessitating efforts to attract and retain them in the STEM workforce to maximize innovation, creativity, and competitiveness (Hill et al., 2010; Gaweł and Krstić, 2021). Thus, the educational space, as a socializing agent, is a structure that gives rise to interactions contributing to the reinforcement of stereotypes, which leads to the reproduction of symbolic violence (Bourdieu and Passeron, 2018). Stereotypes describe and proscribe, inducing behavior as individuals conform to the norms attributed to them by society, which are further reinforced through educational institutions. The issue of the STEM education gap presents significant challenges for women, as they are hindered by stereotypes imposed by educational contexts regarding their own creative abilities (Rippon, 2019), thereby limiting their access to careers in these fields.

When investigating the potential causes of the gender gap and biases in STEM, one can explore the most relevant theories and approaches that explain behaviors related to gender stereotypes, providing a suitable theoretical and empirical foundation for the study. These are summarized in Figure 1.

In the first group of the so-called "conventional" theories, we have Spence's gender identity theory (Spence, 1993), which presents a multifactorial approach to gender-associated attributes. Individuals adopt interests and behaviors expected of their gender, conforming to conventional roles. Additionally, the stereotype threat theory by Steele and Aronson (1995) reinforces and introduces new elements. It highlights the risk of confirming a negative stereotype about one's own group, which can affect performance on specific tasks. In line with this, women are often associated with weaker mathematical skills compared to men, which influences their performance and interest. However, this does not align with their actual level of ability, as studies indicate that women achieve higher grades in this area (Perez-Felkner et al., 2017; Lundberg, 2020).

In the group of established theories, we have Tajfel and Turner's social identity theory of intergroup behavior (Tajfel and Turner, 1979), which highlights the impact on individuals' behavior when they perceive themselves as members of social categories. This theory involves three psychological processes: social categorization, identification, and social comparisons. Another theory in this group is the social cognitive career and academic interest theory (SCCT) proposed by Lent et al. (1994). SCCT focuses on self-efficacy, outcome expectations, goal mechanisms, and how they can interact with gender, contextual support systems, and experiential learning factors (Lent et al., 1994). Eccles and Wigfield's expectancy-value theory (Eccles and Wigfield, 2002) is a theoretical model that introduces other relevant variables. It addresses the theoretical pathway through which stereotypes affect students' academic outcomes, choices, and the role of motivation as a change agent (Wigfield et al., 2015). While it emphasizes the role of motivation in addressing the gender gap, it overlooks contextual barriers. It is not only through motivation and elevated expectations that individuals achieve their goals, but social, economic, and personal interferences also play a role. In this regard, identity emerges as a crucial aspect. Finally, we have Eagly and Wood (2012), which aims to explain the behavior of women and men, as well as the relevant stereotypes, ideologies, and attitudes related to sex and gender.

In the emerging approaches, the contributions of Greenwald and Banaji (1995) are noteworthy. They had already introduced the concept of implicit social cognition to address the influences of stimuli that impact individuals outside of conscious control. Later, Baron et al. (2014) incorporated this concept and focused on social cognition to address stereotypes, emphasizing that it is a cognitive process that develops throughout an individual's life, including elements such as social association, the assigned gender identity, and self-concept (Meltzoff and Cvencek, 2019). In a similar vein, the nascent proposal of Master and Meltzoff (2020), called STEMO (Stereotypes, Motivation, and Outcomes), integrates aspects of educational research, human development, and social psychology to understand the mechanisms contributing to gender gaps. Their hypothesis describes the ways in which female STEM students encounter negative stereotypes, leading

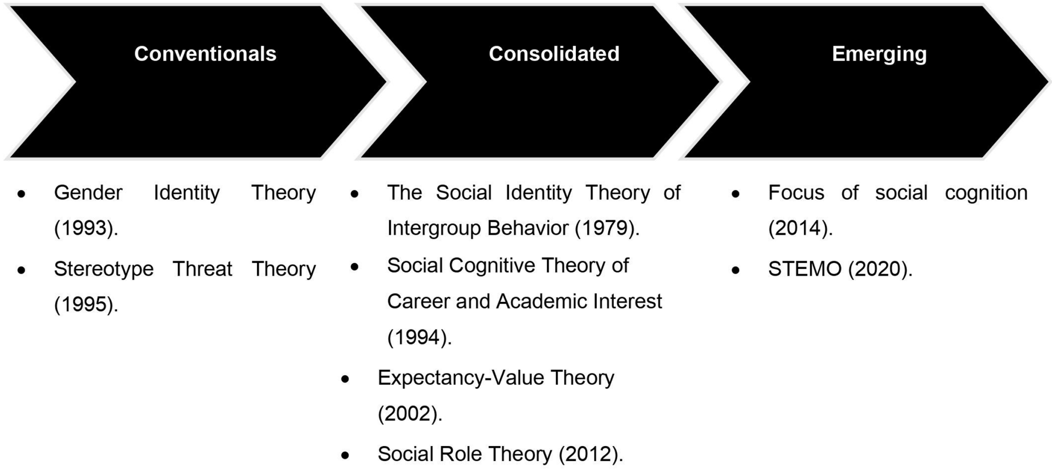

FIGURE 1
Theoretical models explaining stereotyped behaviors.

to biased self-representations regarding their group membership and consequent effects on their interest and academic performance.

The current debate in empirical studies on gender stereotypes in STEM revolves around the differences in preferences and interests between men and women. In this regard, findings indicate that stereotypical images persist and apply to all areas. Given the limited number of studies, it is still risky to make comparisons or inferences (Master and Meltzoff, 2020). On the other hand, some lines of research have focused on the preschool stage and the effect of math stereotypes on teacher-student interaction networks (Ortega et al., 2021). Similarly, research on the role of implicit and explicit beliefs related to mathematics in primary school students, in connection with the influence of parents on their behavior, is noteworthy (Siani and Dacin, 2018). From another perspective, studies have focused on considering the socioeconomic and cultural profiles of female high school students who intend to pursue STEM careers (Kızılay et al., 2020). Meanwhile, recent research addresses the experiences of female graduate students in STEM careers regarding gender gaps and the challenges they face (Lim et al., 2021).

Studies on STEM education have progressively increased in recent years, delineating different scientific trends (Bogdan and García-Carmona, 2021). Therefore, it is essential to identify the approaches that have been developed and envision research gaps for the advancement of new perspectives. Hence, this systematic review follows the PRISMA 2020 guidelines (Page et al., 2021) and aims to describe the scope of research on STEM and the gender gap in primary, secondary, and tertiary education between the years 2012 and 2022. The following questions will help us address this objective:

- What are the most frequently addressed research topics? (Q1).
- What are the most widely used theories that guide research? (Q2).
- How are the topics addressed in the studies? (Q3).
- What is the most developed research method in the studies? (Q4).

The following section delineates the methodological criteria and search strategies employed in this study. After this, the systematic review's findings are elucidated, leading into discussions, conclusions, and the acknowledgment of limitations, ultimately culminating in a comprehensive compilation of bibliographic references utilized in this study.

Methods

This Systematic Review follows the PRISMA (2020) criteria. The research incorporates empirical scientific articles published in open access journals from 2012 to 2022, using the search engines Scopus, Eric, and WoS, recognized as those that compile the highest number of multidisciplinary scientific publications. The purpose is to gather knowledge advancement in a specific subject. The search date for this review was June 21, 2022, and the following English keyword combinations were used: STEM Education AND gender gap, STEM AND gender gap, and STEM AND education AND gap AND gender.

This study is structured based on pre-established criteria for selection/exclusion on this matter, such as the temporal dimension and the object of study. Additionally, the scientific mapping considered five stages: (1) study design, (2) data collection, (3) data analysis, (4) data visualization, and (5) interpretation. In the study design stage, the guiding question was: "What were the results of publications on STEM education and the gender gap indexed in the Scopus, Eric, and WoS databases for the period 2012–2022. The data collection stage consists of three sub-stages: (1) data gathering, (2) data screening, and (3) data cleaning. Table 1 condenses the research protocol criteria that represent the search filters.

Before proceeding with the selection of articles, the following inclusion and exclusion criteria were defined:

Inclusion criteria

1. Open-access empirical scientific articles that are available in databases, and peer-reviewed, published in the last 10 years.
2. Studies that link the analysis of standardized assessment databases with other attitudinal, cognitive, and social variables from governmental and non-governmental entities.
3. They must be empirical studies with educational implications and case studies.
4. The studies that address STEM and the gender gap in primary, secondary, or tertiary education.

Exclusion criteria

1. Book chapters, conferences, theoretical articles, systematic reviews, and meta-analyses.

TABLE 1 Research protocol summary.

Item	Description
Topic	STEM and gender gap
Keywords	STEM, education and gender gap
Temporal dimension	Last 10 years (2012–2022)
Spatial dimension	National e international
Selection criteria	Open-access empirical scientific articles published, available in databases, and peer-reviewed
Language	English and Spanish
Methodological procedure for article search	Three scientific databases are defined: WoS, Scopus, and Eric. The keywords associated with the Boolean operator "AND" are entered. Repetitions of articles from the WoS and Scopus databases are removed using R software. Duplicates from Eric are eliminated through a manual procedure in the Excel suite program of Microsoft Office software.

2. Studies only focused on the database analysis published, prior to 2012 of this systematic review, on standardized assessments.
3. Database studies on academic performance analysis without linkage to other attitudinal, cognitive, and social variables from governmental and non-governmental entities.
4. Studies focused on the topics of ethnicity, race, graduate students, and practicing professionals in STEM.
5. Studies that mainly address the implementation of other guidelines, with STEM and gender gap not being their focus of analysis.
6. Once the systematic review protocol outlined in the PRISMA model (2020) proposed by Page et al. (2021) was applied to the WoS, Scopus, and Eric databases, a total of 24 scientific articles that met the inclusion and exclusion criteria were obtained, corresponding to the primary units of analysis for the research. The process is presented in the following flowchart (Figure 2).

Results

A synthesis of the selected research results is presented in the following table organized by authors, theory, sample, methodology, and results. The analysis that will be conducted next follows the

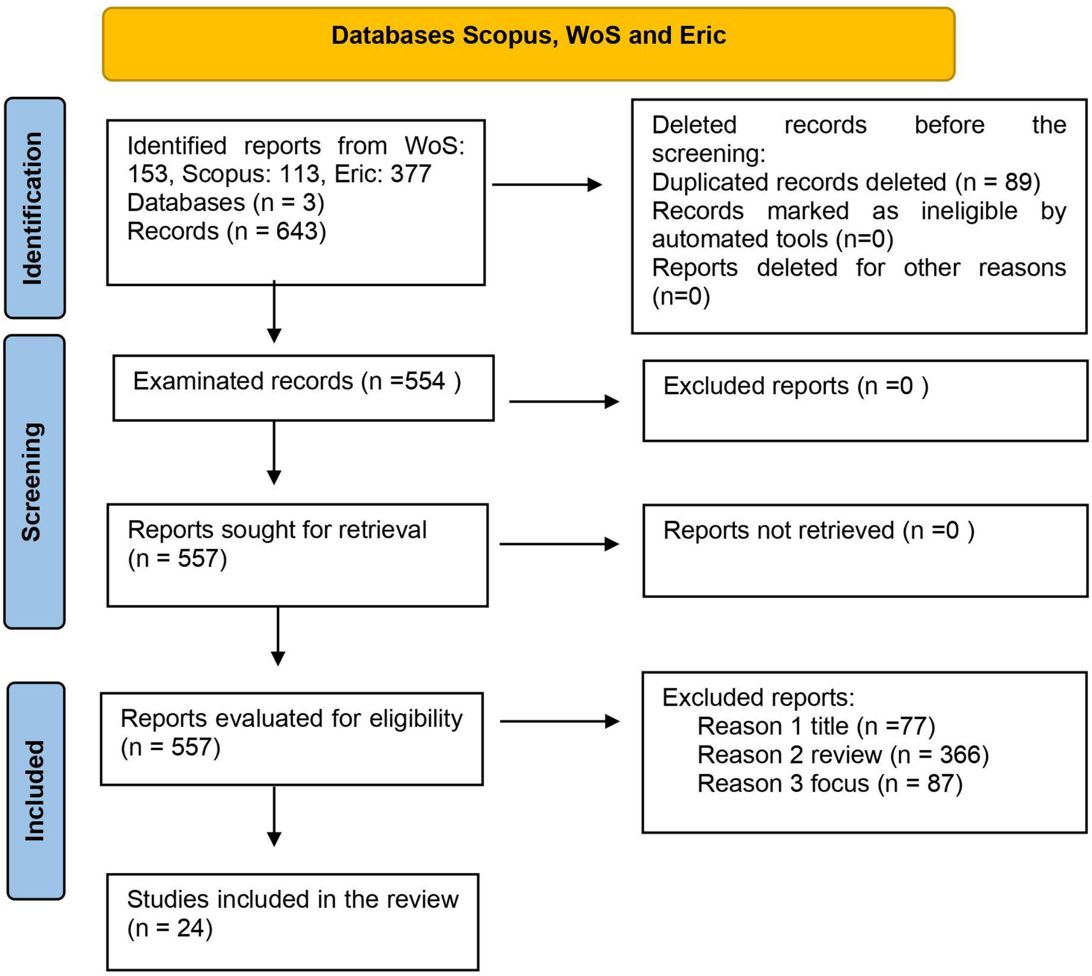

FIGURE 2
Flowchart of scientific article search.

projected order that is most relevant for facilitating understanding and integration of the findings. Table 2 shows a summary of the analyzed studies.

The results have been organized into two dimensions derived from the analysis of the articles found: factors influencing the gender gap in STEM and learning experiences to overcome the gender gap in STEM. Under the factors influencing the gender gap in STEM, categories such as self-efficacy, motivation, expectations, social support, gender roles, identity, teaching roles, anxiety, skills, interests, goals, confidence, stereotype attribution bias, value beliefs, occupational aspirations, burnout, well-being, academic performance, self-perceived skills, influence of the job market, and peer influence emerge. In this regard, four factors that dominated the reviewed research are highlighted: beliefs, self-efficacy, motivation, and expectations. In the realm of learning experiences to overcome the gender gap in *STEM*, a growth mindset is emphasized.

Similarly, the quantitatively most studied focus has been the discipline of mathematics, even though STEM also encompasses other areas such as chemistry, physics, biology, engineering, astronomy, among others.

Discussion

Gender gap in STEM is a challenge that involves combined factors such as stereotypical beliefs, self-efficacy, expectations, and motivation. Overcoming biases should be directed toward various aspects, such as university and government support, financial assistance, assertive teacher interaction (Wang, 2013), and, of course, meaningful scientific learning experiences (Rundgren et al., 2019).

The analysis of factors and strategies to address and detect inequalities imposed by biases is limited and should consider other variables. It has mostly focused on studies that gather personal perceptions from each subject, without examining the underlying relationship that governs gender social inequalities between men and women, such as power dynamics and collaborative work. Exploring these aspects would provide alternative perspectives to the issue and contribute to the retention of individuals in STEM fields.

Research has focused on the use of the social cognitive career theory, as there is an interest in understanding the social, cognitive, and psychological factors that influence women's choices in STEM fields. However, they have not considered the brain structures involved in the adoption of stereotypes.

Furthermore, although significant progress has been made in research on STEM and the gender gap (Le Thi Thu et al., 2021), studies have predominantly focused on the development of quantitative methodologies, highlighting the limited presence of qualitative and mixed methods studies. Moreover, surveys and databases have been commonly used as research tools. The use of database analysis reveals serious issues due to the lack of familiarity and control over the data structure (Bryman, 2016). Therefore, it would be advisable to diversify the methods and tools for gathering information in order to explore new factors that could explain gender biases in scientific fields.

Factors that affect the gender gap in STEM

Gender stereotypes are unconscious and conscious beliefs that underpin the gender gap in STEM and are in line with the *status quo*, as they depend on who is stereotyping and who is being stereotyped to generate an implicit and explicit response in their cognition that translates into social behavior. The factors influencing the gender gap in STEM education are addressed in various studies and can be grouped into three types: psychological, contextual, and sociocultural. However, the boundaries between these factors are blurred, as there is an interactive and dynamic relationship among them.

Within the most investigated factors, one can identify self-efficacy, motivation, expectations, social support, gender roles, identity, aspirations, family background, attitudes, socioeconomic context, teaching role, anxiety, skills, interests, goals, confidence, stereotype attribution bias, values beliefs, external support, masculinity, occupational aspirations, burnout, well-being, academic performance, self-perceived skills, influence of the job market, and classmates (Legewie and DiPrete, 2014; Lauermann et al., 2017; Master et al., 2017; Siani and Dacin, 2018; Vázquez and Blanco, 2018; Makarova et al., 2019; Çiftçi et al., 2020; Cotner et al., 2020; He et al., 2020; Lundberg, 2020; Salmela-Aro, 2020; Stearns et al., 2020; Alam et al., 2021; Ashlock et al., 2021; Ayuso et al., 2021; Demir et al., 2021; Mitsopoulou and Pavlatou, 2021; Moè et al., 2021; Anaya et al., 2022; Chan, 2022; Cuevas et al., 2022). In this sense, four gender gap factors stood out from the reviewed research: beliefs, self-efficacy, motivation, and expectations. These factors were quantitatively addressed the most and the study conclusions indicated them as critical elements mediating biases.

Self-efficacy is the mechanism that assist individuals determine their activity and environmental choices (Bandura, 1982). It contributes to the persistence and regulation of emotions, behaviors, and interest in entering or persisting in STEM disciplines (Rundgren et al., 2019). However, self-efficacy is influenced by a multitude of factors, among which learning experiences stand out, whether in primary, secondary, or tertiary education, which, in turn, are influenced by various contextual elements such as social, cultural, and economic factors, and are directly related to stereotypical beliefs (Chan, 2022).

Both motivation and interest in STEM among women are directly related to beliefs about their skills, leading to demotivation and self-doubt, which in turn affects career choices (Chan, 2022). However, what enables women to become interested and motivated in choosing other careers? According to the social cognitive career theory, both supports and barriers influence interests and motivations. Studies indicate that greater interests are expressed by males (Vázquez and Blanco, 2018; Çiftçi et al., 2020). In this regard, according to Mitsopoulou and Pavlatou (2021), the combination of outcome expectations and self-efficacy levels results in interest in STEM. However, beliefs play a crucial role as girls have a lower perception of their skills compared to boys from an early age (Perez-Felkner et al., 2017). Girls may not choose engineering, even if their STEM scores are high (Cuevas et al., 2022), as they are confined to spaces imposed by society through symbolic violence. This situation is further exacerbated by the fact that students' interest in STEM subjects decreases during secondary education (Bailey et al., 2017; Ballen et al., 2018). Therefore, constant opportunities and motivating learning experiences are required.

TABLE 2 Characteristics of the reviewed studies.

Authors	Theory	Methodology	Results
Legewie and DiPrete (2014)	SCCT (Social cognitive career theory).	Quantitative. National education longitudinal study and high school effectiveness study databases. Longitudinal study. High school students.	The high school context reinforces or weakens gender stereotypes
Lauermann et al. (2017)	EVT (Expectancy-Value theory).	Quantitative. Data from the childhood and beyond (CAB) study Longitudinal study. Elementary, high school, and university students.	There are gender differences regarding beliefs related to career and career achievement.
Perez-Felkner et al. (2017)	Stereotype threat theory	Quantitative. Data from the education longitudinal study (ELS) of the USA. Longitudinal database studies of 2002, 2004 and 2012 from 16.200 tenth grade and high school students.	Women have less belief in their math skills compared to men.
Ballen et al. (2018)	SCCT (Social cognitive career theory).	Quantitative. University students.	Class size does not reduce performance gaps in STEM.
Vázquez and Blanco (2018)	SCCT (Social cognitive career theory).	Quantitative. Self-efficacy scale, outcome expectations, aspirations, interests, and social supports and barriers scale. 1,465 non-parametric tests of high school students.	Gender differences in favor of men in all variables
Rundgren et al. (2019)	SCCT (Social cognitive career theory).	Quantitative. Database of the interest and recruitment in science (IRIS) project. 2.372 answers of higher education students.	Male students value informal learning experiences more and exhibit higher levels of STEM interest and self-efficacy than females.
He et al. (2020)	Gender Identity theory.	Qualitative. Semi-structured interview. 6 students from high school.	Factors such as social and cultural norms, teachers, parents, the labor market, media, and peers, as well as the curriculum, influence expectations.
Siani and Dacin (2018)	SCCT (Social cognitive career theory).	Quantitative. Questionnaire on attitudes toward STEM disciplines in high school students. Cohort of students of 11 y 12 years old.	Extension skills play a crucial role in promoting participation in STEM. The educational level of parents influences students' intention to pursue STEM studies.
Makarova et al. (2019)	SCCT (Social cognitive career theory).	Quantitative. Perception questionnaire on masculinity using semantic differentials. Transversal. Study of 1,364 students from high school.	Men in mathematics have the attribution of masculinity. Gender stereotypes can influence the aspirations of men and women.
Stearns et al. (2020)	SCCT y EVT (Social Cognitive Career theory and Expectancy-Value theory).	Mixed. Roots of STEM success database. Interviews. 16.710 *STEM* graduated students. 173 university students on their last year.	Gender differences in first-year university grades do not explain the gender gap in the selection of a STEM major.
Lundberg (2020)	Social identity theory of intergroup behavior.	Quantitative. Sub-sample of Wave Add Health survey.	Concerns about gender identity can influence and undermine the educational prospects of women and men through masculinity norms that discourage academic performance.
Çiftçi et al. (2020)	SCCT (Social cognitive career theory).	Quantitative. STEM attitude scale and career interest survey. 774 high school students.	There is a stronger correlation between attitudes and interest in STEM among men than among women.
Cotner et al. (2020)	SCCT (Social cognitive career theory).	Quantitative. Test anxiety scale and confidence with classroom performance. Academic Performance Data. 400 university students.	Women expressed more test anxiety than men, and the anxiety they experienced negatively predicted their classroom performance.

(Continued)

TABLE 2 (Continued)

Authors	Theory	Methodology	Results
Salmela-Aro (2020)	EVT (Expectancy-Value theory).	Quantitative. Mind the gap database. FinEdu longitudinal study database. Longitudinal study. High school students from 9° to 11° grade.	Interest in STEM subjects decreases during secondary education.
Demir et al. (2021)	SCCT (Social cognitive career theory).	Quantitative. STEM-oriented attitude scale. 408 high school students of 6°,7° y 8° grade.	Student attitudes toward STEM vary depending on whether they are female or male.
Mitsopoulou and Pavlatou (2021)	SCCT (Social cognitive career theory).	Quantitative. Questionnaire on students' attitudes toward higher education. 301 high school students, between 14 to 16 years old.	Six factors of interest in STEM: gender, learning experiences, expectations, social support, family background, and self-efficacy. Expectations plus self-efficacy generate STEM interest.
Ayuso et al. (2021)	Stereotype threat theory.	Quantitative. Questionnaire on factors influencing students' experience with mathematics. 2.137 Elementary students and 143 elementary teachers.	Gender differences in self-efficacy become more pronounced as students grow older, and test anxiety increases. Women perceive themselves as worse than men in mathematics.
Alam et al. (2021)	SCCT (Social cognitive career theory).	Quantitative. Scales on self-concept, self-efficacy, attitudes, gender stereotypes, teacher stereotypes, intentions, and expectations. 211 high school students.	Attitudes, gender, and expectations of career outcomes are positive and significant predictors of STEM attitudes, while gender stereotypes and teaching roles are negative predictors.
Master et al. (2017)	STEMO (Stereotypes, Motivation and Outcomes).	Quantitative. Laboratory test, experimental group, and control group. 6-year-old children within a total of 96.	Men held gender stereotypes that they were better than women in robotics and programming. Women who received programming experience reported higher technological interest and self-efficacy compared to women without experience.
Ashlock et al. (2021)	EVT and STEMO (Expectancy-Value theory and Stereotypes, Motivation and Outcomes).	Mixed. Self-reported academic performance in mathematics and science. Survey on academic efficacy, computer skills, sociodemographic variables, self-conceptualizations. Focus groups. 3,902 high school students.	Sociopsychological processes can disadvantage women because they are not consistent with them.
Moè et al. (2021)	SCCT (Social cognitive career theory).	Quantitative. Self-report questionnaires. Mental Rotation and Verbal Fluency tests. 138 women and 120 men, current university students.	Women in STEM reported higher incremental beliefs than non-STEM women. Men outperformed women, and STEM students outperformed non-STEM students in mental rotation, while women outperformed men in verbal fluency.
Anaya et al. (2022)	SCCT (Social cognitive career theory).	Quantitative. Data from the child development supplement (CDS) and transition to adulthood (TA) projects in the panel study of income dynamics (PSID). Longitudinal study. From 0 to 18 years old.	There are significant gender differences in math test scores and self-perceived skills during childhood. Having a parent who works in a science-related field influences these differences.
Chan (2022)	SCCT (Social cognitive career theory).	Quantitative. Self-efficacy, interest, and academic and professional aspirations scale in STEM. 3.020 High school students.	Gender differences in self-efficacy, interest, and educational aspirations in STEM are more evident in students who endorse gender stereotypes.
Cuevas et al. (2022)	SCCT (Social cognitive career theory).	Quantitative. Questionnaire on factors influencing the decision to pursue a STEM career. 338 High school students.	Factors that influence men and women not to study STEM: self-efficacy, gender stereotypes, family background, and environment. Women perceive themselves as incapable of pursuing an engineering career compared to men.

Learning experiences in overcoming the gender gap in STEM education

Based on the reviewed research, the relevance of learning experiences that foster interest in STEM among women can be concluded. These experiences include extracurricular activities focused on scientific enrichment (Master et al., 2017; Siani and Dacin, 2018; Rundgren et al., 2019; Demïr et al., 2021). Within this framework, the absence of connections with scientific activities in teaching and learning practices in educational institutions is detrimental to overcoming the gap, as it not only hinders engagement in STEM careers but also hampers innovation, creativity, critical thinking, and student autonomy. Studies indicate that learning experiences are essential for entering and persisting in these fields (Maltese and Tai, 2011; Wang, 2013). Overall participation in several types of scientific education experiences, including informal, every day, and school-directed experiences (DeWitt and Archer, 2017), is significant for developing scientific capital among female students.

The growth mindset (Perez-Felkner et al., 2017; Moè et al., 2021) emerges from successful learning experiences, triggering positive activating emotions such as motivation and interest (Ayuso et al., 2021). In this way, it would facilitate overcoming the gender gap in these fields, which are essential for sustainable development. Implicit and explicit stereotypical beliefs about gender roles must be eradicated to progress in social, economic, and cultural advancement. This is not only beneficial for states but also for non-governmental entities in terms of providing a skilled workforce (Legewie and DiPrete, 2014), thus promoting the reduction of social inequalities.

Conclusion

This systematic review endeavors to uncover the prevailing trends in research conducted between 2012 and 2022, focusing on the factors that contribute to gender disparities in STEM fields. The insights derived from this initial exploration serve as the foundation for a comprehensive examination of our research findings and their implications for fostering gender equity in STEM education and career.

Returning to the research questions, we can indicate that:

- Q1: The most investigated topics are factors influencing the gender gap in STEM as well as educational interventions to promote interest and motivation.
- Q2: The most used theories are the social cognitive career theory, as it provides insights into the determinants that influence career choices.
- Q3: The addressed topics focus on women and are studied by considering variables that should be considered in gender gaps in STEM. Possible solutions are also emerging in the discussions.
- Q4: The most used method is quantitative, and the predominant instruments and techniques for gathering information are databases and surveys.

Ultimately, the space for research growth is evident both at the theoretical and methodological levels, due to the predominance of quantitative studies, with a minority presence of qualitative and mixed methods studies. While quantitative studies are of high quality, as they are longitudinal, experimental, and observational, it is important to explore the reality through other approaches that allow for a deeper understanding of the issue.

On the other hand, the tools used as self-report instruments and databases are insufficient for understanding the phenomenon. Subsequent studies should investigate other factors that influence the gender gap in STEM education and link them with critical perspectives on the underlying causes, rather than just focusing on the consequences or self-perceptions of those stereotypical beliefs. The combined effects and experiences across educational levels must be observed to understand academic and career choices.

The findings of this systematic review offer a comprehensive summary of the empirical research conducted within this field of study. This study aims to promote scientific knowledge from a global perspective. It is of utmost importance for researchers and policymakers to be knowledgeable about the systematization of STEM studies and the gender gap. This knowledge is crucial for understanding the methods developed to advance knowledge, raise awareness about the issue, and propose innovative solutions to address this phenomenon.

Limitations

The present systematic review concentrated exclusively on the gender gap within the binary framework of women and men. Nevertheless, it is crucial to incorporate the perspective of intersectionality in future systematic reviews, as it encompasses various categories of analysis that would significantly contribute to the investigation of disparities in STEM fields.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

FB-V: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. NS-G: Funding acquisition, Resources, Visualization, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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