

Gender stereotypes in STEM: a systemic review of studies conducted at primary and secondary school

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Abstract

Currently, there is ambiguity regarding the volume of empirical research that delves into gender stereotypes linked to STEM in primary and secondary education. To shed light on the prevailing literature and pertinent challenges, we undertook a systematic review, adhering to the PRISMA guidelines. This examination encompassed empirical studies sourced from Scopus and Web of Science, culminating in the inclusion of twenty-four studies. The findings underscore the imperative to augment prior research that provides empirical insights into social and scientific narratives surrounding gender stereotypes. This review illuminates gender disparities within the educational system and the reduced female engagement in STEM. Concurrently, it advocates for formulating public policies and early-stage interventions to highlight how STEM disciplines can bridge these gender imbalances at the primary and secondary school stages. From our vantage point, this systematic review will catalyse forthcoming empirical inquiries. Whether stemming from real-world practices or geared towards enriching a specific theoretical framework, such research, especially involving students from Latin American nations, is of the essence. Notably, our search did not uncover any studies addressing the themes broached in this investigation about these regions. It is thus pressing to accelerate efforts in these territories to acknowledge the cultural and societal hurdles impinging upon STEM education.

Keywords

Primary school – Secondary school – Gender stereotypes – STEM – Empirical education research.

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Estereótipos de gênero em STEM: uma revisão sistemática de estudos realizados no ensino fundamental e médio

Resumo

Atualmente, há ambiguidade quanto ao volume de pesquisas empíricas que exploram estereótipos de gênero vinculados às áreas de STEM na educação básica e secundária. Para esclarecer a literatura prevalente e os desafios pertinentes, realizamos uma revisão sistemática, aderindo às diretrizes PRISMA. Este exame abrangeu estudos empíricos oriundos da Scopus e Web of Science, culminando na inclusão de vinte e quatro estudos. Os achados destacam a imperativa necessidade de aumentar as pesquisas anteriores que fornecem insights empíricos sobre as narrativas sociais e científicas em torno dos estereótipos de gênero. Esta revisão ilumina as disparidades de gênero dentro do sistema educacional e a reduzida participação feminina nas áreas de STEM. Concomitantemente, defende a formulação de políticas públicas e intervenções precoces para destacar como as disciplinas de STEM podem reduzir esses desequilíbrios de gênero nos estágios de educação básica e secundária. Do nosso ponto de vista, esta revisão sistemática catalisará futuras investigações empíricas. Seja proveniente de práticas do mundo real ou voltada para o enriquecimento de um quadro teórico específico, tais pesquisas, especialmente envolvendo estudantes de países latino-americanos, são essenciais. Notavelmente, nossa busca não encontrou estudos abordando os temas tratados nesta investigação sobre essas regiões. Portanto, é urgente acelerar os esforços nesses territórios para reconhecer os obstáculos culturais e sociais que afetam a educação em STEM.

Palavras-chave

Ensino fundamental – Ensino médio – Estereótipos de gênero – STEM – Pesquisa empírica em educação.

Introduction

Knowledge in science, technology, engineering, and maths (commonly known as STEM) is perceived as essential to address numerous global challenges, including economic growth, employability, sustainability, and social welfare (OECD, 2020). In this light, current employment opportunities need to meet the demands of the job market in various countries, primarily due to an insufficient number of young people pursuing careers in STEM fields (Barth *et al.*, 2018; Will *et al.*, 2020). This imbalance becomes more pronounced when noting that in many Western countries, women have fewer opportunities than men to engage in STEM education and careers, despite demonstrating equivalent competencies in maths and science (OECD, 2015, 2019).



Research addressing the underrepresentation of women in STEM suggests that the gender gap is not due to innate abilities. Instead, significant differences are observed in the attitudes and future aspirations of men and women towards learning (Breda *et al.*, 2020; Reinking; Martin, 2018). This perspective highlights the role of social influencers, such as parents and teachers, who may still view STEM as a predominantly male domain. Consequently, these perceptions lead students to internalise societal norms, values, and roles, shaping their career choices (Eccles, 2009; Sáinz; Eccles, 2012).

In this context, it is evident that men are associated with a higher level of competence and interest in maths, technology, and physics, whereas women are often linked to interests, abilities, and professions traditionally considered feminine, such as the humanities or biology (Sáinz; Eccles, 2012; Sáinz; Meneses, 2018). However, young women tend to perform as well as young men in maths and science at school (Bieri *et al.*, 2014; Brown; Stone, 2016), and as adults (Reinking; Martin, 2018), they often perform as well or better than their male counterparts in STEM-related tests or projects. It can be observed then that patterns related to roles and gender stereotypes, rather than actual performance levels in these subjects (Bieri *et al.*, 2014; Brown; Stone, 2016), might explain why women are less inclined towards studies or professions in these fields (Sáinz; Meneses, 2018). This situation is particularly true if one considers the current limited connection between female students and female role models in STEM fields (Sáinz, 2020). Indeed, research indicates that the absence of such role models leads young women to believe that success in STEM is unattainable for them (Eccles, 2009; Isaacson *et al.*, 2020; Makarova; Aeschlimann; Herzog, 2019). Conversely, some studies highlight interventions that have successfully challenged these stereotypical beliefs among young women regarding STEM (Sáinz; Meneses, 2018; Tolbert, 2020).

In this context, two recent systematic reviews investigating the efficacy of interventions addressing the ‘pipeline leakage’ phenomenon affecting the female population worldwide closely align with the systematic review proposed in this paper (Prieto-Rodriguez; Sincock; Blackmore, 2020; Van de Hurk; Meelissen; Van Langen, 2019).

Specifically, the first review, conducted by Prieto-Rodriguez, Sincock & Blackmore (2020), identified the characteristics of STEM interventions targeting young women at secondary education levels and analysed these interventions. The second review, conducted by Van den Hurk, Meelissen & Van Langen (2019), aimed to identify successful interventions, supported by empirical evidence, at the student, school, or environmental level to bolster interest in STEM or prevent dropouts in STEM fields among students at primary, secondary, and tertiary levels.

In light of the findings from both reviews, it becomes apparent that despite the keen academic interest in the under-representation of females in these fields of study, there is a lack of robust research evaluating the effects of interventions on female students on the cusp of choosing their future careers. Recognising these shortcomings, Prieto-Rodriguez, Sincock & Blackmore (2020) contend that the limited efficacy of the methods employed is primarily due to their being one-off or short-term interventions, which generally fail to significantly influence young women’s decisions to pursue university degrees or advanced-level courses in STEM. Echoing this sentiment, Van den Hurk, Meelissen & Van



Langen (2019) shift the discussion towards how the empirical evidence from numerous interventions designed to boost interest and sustain engagement in STEM education remains inadequate to craft strategic and experimental models that deter both talented young men and young women from exiting STEM education prematurely.

However, there is limited knowledge about empirical studies addressing gender stereotypes associated with STEM at primary and secondary school levels. To identify relevant studies from recent years, a systematic review of scientific articles published in the past five years was undertaken. The evidence from the selected articles consistently highlights the issue of the under-representation of women in STEM, even though each study varies in terms of its descriptive characteristics, methodologies, and objectives.

Recognising that the considerable diversity among these studies complicates direct comparisons of the results is crucial. Despite these constraints, the examination and assessment of the selected studies aimed to outline the most pertinent findings, underscore the principal practical and theoretical implications, and share some effective strategies to challenge gender stereotypes in STEM areas at both primary and secondary school levels.

Method

This paper presents a systematic review. A systematic review of previous research has become a crucial and pertinent step before embarking on specific disciplinary research challenges (Borrego; Foster; Froyd, 2014). Initiating new primary studies without being adequately informed can lead to unnecessary, inappropriate, irrelevant, or unethical research (Gough; Thomas; Oliver, 2012). In this vein, a systematic review can serve various objectives and fulfil multiple purposes (Borrego; Foster; Froyd, 2014; Gough; Thomas; Oliver, 2012).

This paper aims to undertake a systematic review of the scientific literature with the following objectives:

1. To identify empirical studies conducted in the past five years with primary and secondary students, where facets related to gender stereotypes in STEM areas are analysed.
2. To explore the descriptive and methodological characteristics of the selected studies: countries in which they were undertaken, educational stages, sample size and nature, research methodologies, duration, data collection methods, and types of analyses used.
3. To analyse the objectives, results, and theories on which the selected studies are based.
4. To describe the main implications that highlight the perspective to study in future research and its possible impact on some aspects related to gender stereotypes in STEM areas with primary and secondary level students.

Eligibility criteria

Specifically, for inclusion criteria, empirical research articles published in the past five years were identified, which addressed aspects related to gender stereotypes in STEM disciplines, and where the participants or target sample were students from primary and secondary education levels.



As exclusion criteria, literature reviews and meta-analyses, references addressing gender stereotypes in disciplines outside of STEM, and articles examining stereotypes within STEM—aside from gender in this context—were disregarded. Moreover, studies focusing on STEM subjects but not involving primary or secondary education samples were omitted. Specifically, research involving infants and preschool children, university students, professionals within STEM disciplines, the general adult population, and studies that might encompass primary and secondary students but include the excluded samples were set aside.

Information sources and search strategy

A systematic review protocol was developed to identify articles indexed within the two primary global bibliographic reference databases: Web of Science (WOS) and Scopus. As such, records from other sources were not considered. To validate the review protocol, the terms (“STEM AND ‘GENDER STEREOTYPES’”) were used as search strings, integrating keywords and Boolean operators across both databases. For more efficient use of the search engine, it was necessary to pre-set boundaries following the inclusion and exclusion criteria. For the WOS database, the search was tailored by topics; articles from the past five years were selected; there was a preference for articles written in English, with no country-based exclusions; press articles and publications with citations from emerging sources were disregarded (WOS, 2021). For Scopus, document searches were focused on the article title, abstract, and keywords; with a restriction to publications from the last five years; there was a preference for articles in English, again with no exclusions based on country; and press articles were excluded (Scopus, 2021).

Identification and selection of studies

The search within the WOS and Scopus databases was conducted up to 30th July 2021. The initial search yielded one hundred fifty-four records, seventy-nine indexed in WOS and seventy-five in Scopus. This set encompassed articles in their final form, published in English between 2017 and 2021. The PRISMA 2020 statement (Page *et al.*, 2021) was utilised to guide the information flow and ensure that certain key elements were included in the systematic review. Additionally, using the Zotero software and the storage tools provided by WOS and Scopus, duplicate references were removed. This process left ninety-eight articles to screen based on the pre-established inclusion and exclusion criteria.

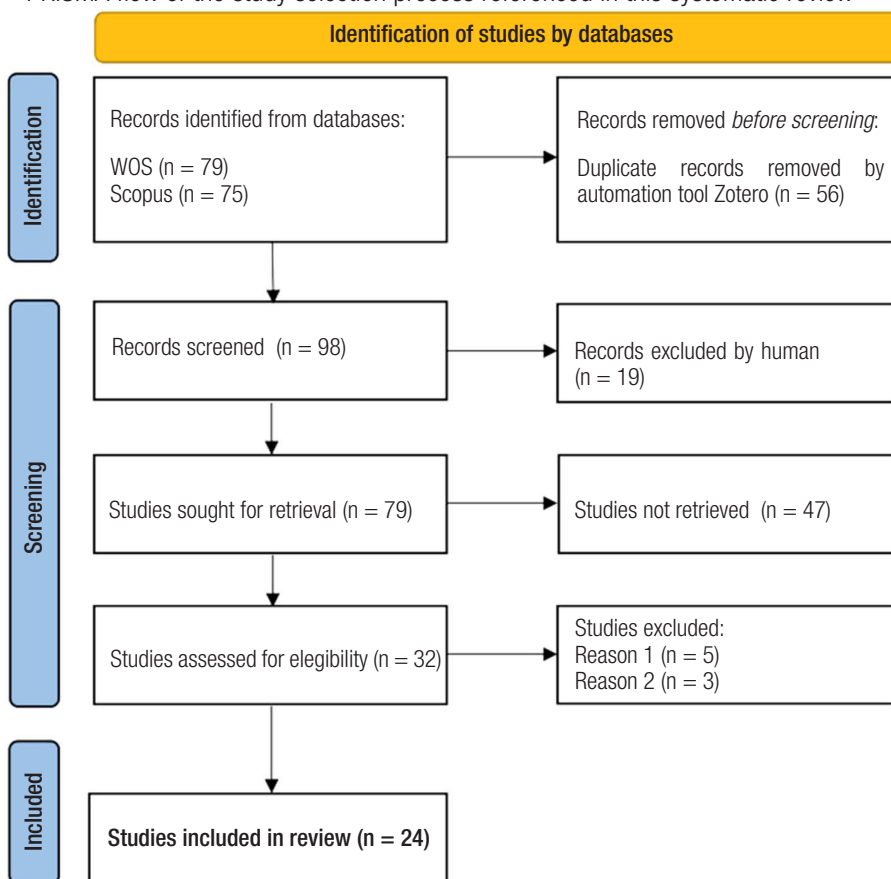
Study selection process

From the aggregate number of articles (excluding duplicates), those irrelevant to the study were manually removed. This process involved excluding manuscripts (one article), meta-analyses (one article), references discussing gender stereotypes in disciplines outside of STEM (fourteen articles), and those investigating other stereotypes within STEM (one



article on racial stereotypes and two articles on ‘nerd-genius’ stereotypes). This selection left a total of seventy-nine articles, the titles and abstracts of which were reviewed for relevance to gender stereotypes in STEM disciplines. Following these eliminations, thirty-two articles remained that were deemed eligible for review. At this stage, complete readings of these articles were undertaken. Only empirical research pieces closely related to this paper’s objective and fitting the specified selection criteria were retained. Concurrently, studies that included, in addition to primary or secondary students, younger children or preschool attendees were excluded (five articles). Similarly, secondary and university students’ research was omitted (three articles). The search and selection process concluded with twenty-four articles. Figure 1 illustrates the PRISMA workflow, indicating the number of articles selected at each stage.

Figure 1 – PRISMA flow of the study selection process referenced in this systematic review



Source: Adaptation by the authors, from “The PRISMA 2020 Statement: An Updated Guideline for Reporting Systematic Reviews” (Page *et al.*, 2021).



Results

Descriptive and methodological characteristics of the studies

The principal characteristics discerned from the twenty-four chosen studies illustrate the countries of execution, school levels, sample sizes, and the specific number of female samples. A summary is outlined in Table 1.

Regarding the initial aspect of description, the studies were conducted in the following countries: United States (four), Germany (four), Spain (three), Italy (two), Sweden (two), United Kingdom (one), Croatia (one), Finland (one), Malaysia (one), China (one), Israel (one), a combined study in Tanzania and Zimbabwe (one), and Turkey (one). Additionally, one study spans sixty-six distinct geographic zones. Moreover, five studies were solely implemented at primary school levels, seventeen at secondary school levels, and two studies spanned both primary and secondary levels.

Regarding sample size, five papers include more than one thousand participants, seventeen studies have over one hundred participants, and two studies feature fewer than one hundred participants. Seventeen articles delineate male and female participants, five exclusively showcase female participants, and two studies do not specify the gender distribution of their samples (as seen in Table 1). Furthermore, one of the papers also engaged parents, while another involved counsellors and science and maths teachers.

Table 1 – Descriptive characteristics of the included studies

Research	Country/nation	School level	Sample	Female sample
Alam <i>et al.</i> (2021)	Malaysia	Secondary	211	211
Berra & Cavaletto (2020)	Italy	Secondary	572	304
Breda <i>et al.</i> (2020)	66 nations	Secondary	300.000	No specified
Colantonio <i>et al.</i> (2021)	Italy	Primary-Secondary	893	470
Ergun & Balcin (2019)	Turkey	Secondary	119	57
Fernández-Cézar <i>et al.</i> (2020)	Spain	Secondary	404	188
Fernández-García <i>et al.</i> (2019)	Spain	Secondary	2.364	1.197
González-Pérez <i>et al.</i> (2020)	Spain	Primary-Secondary	304	304
Hopp <i>et al.</i> (2020)	Germany	Secondary	124	124
Ikonen <i>et al.</i> (2019)	Finland	Primary	246	150
Isaacson <i>et al.</i> (2020)	Israel	Secondary	20	20
Ito & McPherson (2018)	United States	Secondary	127/256	53/121
Liu (2020)	China	Secondary	18.032	No specified
Makarova <i>et al.</i> (2019)	Sweden	Secondary	1.364	738
Master <i>et al.</i> (2017)	United States	Primary	96	48
McGuire <i>et al.</i> (2020)	United Kingdom	Primary	213	110
Muenks <i>et al.</i> (2020)	United States	Secondary	117	62
Selimbegović <i>et al.</i> (2019)	Croatia	Primary	880	438
Sinclair <i>et al.</i> (2019)	Sweden	Secondary	456	190
Starr & Simpkin (2021)	United States	Secondary	22.190	11.095
Steegh <i>et al.</i> (2020)	Germany	Secondary	445	227
Steegh <i>et al.</i> (2021)	Germany	Secondary	445	227
Tolbert (2020)	Tanzania-Zimbabwe	Secondary	170	170
Wille <i>et al.</i> (2018)	Germany	Primary	335	163

Source: Prepared by the authors.



Regarding participants' ages in primary school levels, the valid information from studies encompasses an age range spanning from 6 to 16 years. Similarly, for secondary school levels, the valid information from studies covers an age range between 13 and 18 years. The primary methodological characteristics of the selected studies highlight the research approaches, their duration, the data collection methods, and the types of analysis used. A summary is presented in Table 2.

Regarding the type of research, twenty studies generally adopted a quantitative approach, while four studies reported using both quantitative and qualitative methods simultaneously. Of these, only two investigations described themselves as longitudinal. Regarding data collection, fourteen studies utilised a single method, referring to questionnaires, surveys, content analysis, and tests. Furthermore, some studies employed two methods concurrently. Specifically, three studies adopted surveys and observation, three combined surveys and tests, two used questionnaires and content analysis, one utilised questionnaires and tests, and one employed surveys and interviews. Concerning the procedures for analysing the data, five studies solely undertook a descriptive analysis, two studies carried out both descriptive and inferential analyses, and one executed a descriptive and inductive analysis. Additionally, ten studies reported a descriptive and correlational analysis, and six solely used a correlational analysis.

Table 2 – Methodological characteristics of the included studies

<i>Research</i>	<i>Perspective</i>	<i>Techniques</i>	<i>Analysis</i>
Alam <i>et al.</i> (2021)	Quantitative	Survey	Correlational
Berra & Cavaletto (2020)	Quantitative/Qualitative	Survey/Observation	Descriptive
Breda <i>et al.</i> (2020)	Quantitative	Test	Correlational
Colantonio <i>et al.</i> (2021)	Quantitative	Survey	Descriptive/Correlational
Ergun & Balcin (2019)	Quantitative	Survey	Descriptive
Fernández-César <i>et al.</i> (2020)	Quantitative	Questionnaire	Descriptive/Inferential
Fernández-García <i>et al.</i> (2019)	Quantitative	Questionnaire	Descriptive/Correlational
González-Pérez <i>et al.</i> (2020)	Quantitative	Questionnaire	Correlational
Hopp <i>et al.</i> (2020)	Quantitative	Questionnaires/Content	Descriptive
Ikonen <i>et al.</i> (2019)	Quantitative/Qualitative	Survey/Interview	Descriptive/Inductive
Isaacson <i>et al.</i> (2020)	Quantitative/Qualitative	Survey/Observation	Descriptive
Ito & McPherson (2018)	Quantitative	Survey	Correlational
Liu (2020)	Quantitative	Survey	Descriptive/Correlational
Makarova <i>et al.</i> (2019)	Quantitative	Survey	Descriptive/Inferential
Master <i>et al.</i> (2017)	Quantitative	Content	Descriptive/Correlational
McGuire <i>et al.</i> (2020)	Quantitative	Survey	Correlational
Muenks <i>et al.</i> (2020)	Quantitative	Survey/Test	Descriptive/Correlational
Selimbegović <i>et al.</i> (2019)	Quantitative	Questionnaire	Descriptive/Correlational
Sinclair <i>et al.</i> (2019)	Quantitative	Questionnaires/Content	Correlational
Starr & Simpkin (2021)	Quantitative	Surveys	Descriptive/Correlational
Steeh <i>et al.</i> (2020)	Quantitative	Test/Survey	Descriptive/Correlational
Steeh <i>et al.</i> (2021)	Quantitative	Test/Survey	Descriptive/Correlational
Tolbert (2020)	Quantitative/Qualitative	Survey/Observation	Descriptive
Wille <i>et al.</i> (2018)	Quantitative	Questionnaire/Test	Descriptive/Correlational

Source: Prepared by the authors.



Objectives, results, and theories of the studies

Regarding the primary objectives of the selected studies, it is evident that all address the issue of the underrepresentation of women in the selection and specialisation of STEM fields. However, the approaches to addressing this phenomenon vary. Concerning the studies exclusively focused on primary education, two pieces of research aim to examine the role of gender stereotypes and gender identification in predicting pupils' expectations of success in STEM fields. Among the noteworthy results, it was emphasised that stereotyped beliefs and gender identification predicted the success expectations in STEM, impacting the career preferences of young women more significantly (Ikonen *et al.*, 2019; Selimbegović *et al.*, 2019).

Also, two articles can be distinguished, which propose to examine the effects of stereotype endorsement, motivational dispositions, and attitudes among young women and young men (Master *et al.*, 2017; Will *et al.*, 2018). The results in both revealed studies show that young men are more likely to endorse stereotypes suggesting that young men are better than young women in the assessed STEM domains. However, in the study by Will *et al.* (2018), the motivation and attitudes measured in young women were not affected by stereotypes. In contrast, in Master *et al.* (2017), the motivational attitudes and dispositions of the young women improved after the intervention, despite the persistence of gender stereotypes. Lastly, one study explored deviations from gender norms within groups of classmates in terms of their choices in STEM or non-STEM disciplines. Specifically, the results reveal that, compared to young men, young women do not negatively evaluate classmates who challenge the boundaries of gender-stereotyped activities (McGuire; Jefferys; Rutland, 2020).

Regarding the research conducted in secondary education, four articles aimed to investigate the factors influencing students' perceptions and decisions related to specialising in STEM areas. The factors examined include gender stereotypes, motivation, attitude, self-concept, and teacher stereotypes (Alam *et al.*, 2021; Ergun; Balcin, 2019; Ito; McPherson, 2018; Sinclair; Nilsson; Cederskär, 2019). In general, the findings indicate that attitude, motivation, and self-concept serve as strong and positive predictors of the intention to pursue STEM education. Conversely, gender and teacher stereotypes are identified as negative predictors.

On the other hand, four articles aim to investigate the impact and prevalence of stereotypes on secondary school students, particularly concerning gender, STEM subjects, and scientists, and whether these beliefs are connected to students' aspirations in entering highly masculinised fields (Breda *et al.*, 2020; Fernández-Cézar *et al.*, 2020; Makarova; Aeschlimann; Herzog, 2019; Steegh *et al.*, 2020). The findings highlight that these stereotypical beliefs had a more substantial negative impact on female participants' inclination to pursue majors in STEM fields compared to their male counterparts. Consequently, stereotypes associating STEM fields with males are significantly linked to the underrepresentation of females in these knowledge domains. It is worth noting that in Fernández-Cézar *et al.* (2020), the students participating in the study generally held an egalitarian view of gender in STEM stereotypes, considering scientists equally and displaying a low acceptance rate of gender stereotypes.



Additionally, four studies have been identified that examine the effectiveness of intervention proposals aimed at promoting the participation of young women and women in STEM disciplines, enhancing their perceptions of job opportunities, or incorporating female role models in these fields (Berra *et al.*, 2020; Hopp; Stoeger; Ziegler, 2020; Isaacson *et al.*, 2020; Tolbert, 2020). Among the most notable results, it is apparent that these interventions are well received, even in cases where significant gender gaps in perceptions of capabilities and intentions for success in STEM are observed.

Furthermore, four articles delve into the beliefs of parents and teachers regarding students' capabilities, the prevalence of gender stereotypes within those beliefs, and the actual intentions of students concerning their career choices and expectations within STEM fields (Fernández-García *et al.*, 2019; Muenks *et al.*, 2020; Starr; Simpkins, 2021; Steegh *et al.*, 2021). Additionally, one study examines students' performance and family privilege's influence on STEM academic aspirations (Liu, 2020).

Regarding the research concerning parents, teachers, and students' stereotypical beliefs, they demonstrate a more substantial influence of gender roles rather than students' abilities. This vision can impact the likelihood of encouraging young women and young women to pursue specialisations or careers in STEM fields, particularly when these young women possess fewer family privileges or have limited access to educational resources (Liu, 2020).

Lastly, two studies simultaneously incorporate both primary and secondary education levels. The first investigation explored how students perceive astronomy using an identity framework with four dimensions: interest, utility value, confidence, and conceptual knowledge. The study revealed that students' interest in astronomy and their confidence in their performance tend to decrease as they age (Colantonio *et al.*, 2021). The second research focused on the influence of female role models on young women's preferences for STEM studies. The results indicate that the stronger the counter-stereotypical traits of the white female role model presented in the session, the stronger the connection between expectations of success in mathematics and the inclination to pursue STEM studies (González-Pérez; Mateos de Cabo; Sáinz, 2020).

Concerning the identified theoretical frameworks, it is indicated that out of the twenty-four articles, nine aim to test theoretical models. Among these, five of the nine studies exclusively build their research upon the expectancy-value motivational framework (Eccles (Parsons *et al.*, 1983; Wigfield; Eccles, 2000). Notably, the studies conducted by Muenks *et al.* (2020), Steegh *et al.* (2020), and Steegh *et al.* (2021) intervene at the secondary education level. Selimbegović *et al.* (2019) focus on primary education intervention, while González-Pérez, Mateos de Cabo & Sáinz (2020) simultaneously intervene in primary and secondary education settings.

Among the nine studies identified, three of them not only utilised the expectancy-value model but also incorporated a second theoretical framework. Specifically, Starr & Simpkins (2021) supplemented the expectancy-value model with the balanced identity theory (Greenwald *et al.*, 2002) in their research involving secondary school students. This addition aimed to contribute to the scientific exploration of skills, identities, and gender stereotypes among adolescents. Then, in the context of primary education, Will



et al. (2018) introduced the stereotype threat theory (Steele; Aronson, 1995) to their study. This additional theoretical lens enabled them to examine the effects of stereotype threat on motivation among primary school students. On another note, Colantonio *et al.* (2021) enhance the expectancy-value motivational framework with the identity-based motivation theory (Oyserman, 2013). Their study incorporates this theory to better understand the factors influencing students' motivation and identities in astronomy. Lastly, in the study conducted by Alam *et al.* (2021), the planned behaviour theory (Ajzen, 1991) and the social cognitive career theory (Lent; Brown; Hacktt, 1994) are combined to provide a comprehensive explanation for planned behaviour, cognitive career choice, and STEM-related self-efficacy. This integration of theoretical frameworks enhances their understanding of the factors influencing students' decisions and self-beliefs in the context of STEM careers.

Implications and discussion

Based on the results presented in the selected studies, this review affirms that young women and young men currently encounter many cultural, social, and motivational obstacles when considering enrolment in STEM careers at the college level (Will *et al.*, 2020). Research conducted among elementary and high school students consistently demonstrates that many female students endorse gender-stereotypical beliefs, particularly in STEM-related subjects and mathematics (Breda *et al.*, 2020; Makarova; Aeschlimann; Herzog, 2019). This evidence leads to a tendency for young women to exhibit lower interest in pursuing and majoring in STEM-related disciplines. Moreover, it can be observed that young women are more inclined to perceive STEM areas as domains primarily associated with males (Selimbegović *et al.*, 2019; Steegh *et al.*, 2020). These perceptions could be influenced by societal factors, such as parents, teachers, and peers, who persist in viewing STEM fields as male-oriented career options (Fernández-García *et al.*, 2019; Muenks *et al.*, 2020; Starr; Simpkins, 2021; Steegh *et al.*, 2021).

In this context, the influence of gender stereotypes on adolescents' career aspirations is deeply embedded within a belief system encompassing conventional cultural norms of gender roles and self-perceptions associated with gender. These perceptions are shaped by personal identity, collective identity, and the behavioural decisions that validate these identities (Eccles, 2009; Eccles; Wigfield, 2020). In alignment with this perspective, analyses consistently highlight that the endorsement of stereotypical beliefs aligning school subjects with socially accepted gender roles (McGuire; Jefferys; Rutland, 2020; Sinclair; Nilsson; Cederskär, 2019) underscores the significant disparity in occupational and educational choices between men and women.

In the situations outlined above, each of the examined empirical studies contributes to advancing our comprehension of the potential origins and outcomes primarily within the everyday contexts where young women and young men interact (Eccles, 2009; Sáinz; Eccles, 2012). Recommendations derived from this analysis stress the importance of addressing aspects that can enhance students' perceptions and appreciation of STEM fields, irrespective of their gender. These findings underscore the need for timely and effective interventions to foster positive attitudes towards STEM disciplines.



From the parents' perspective, Muenks *et al.* (2020) and Fernández-García *et al.* (2019) recommend guiding parents' perceptions regarding their daughters' abilities in STEM tasks. Practical guidance can assist parents in supporting female students' learning, motivation, and academic achievements within these subject areas. Additionally, the study by Starr & Simpkins (2021) suggests that parents and teachers should be cautious about not reinforcing gender stereotypes within the school environment. By recognising their roles as influential social agents, they can contribute to preventing the internalisation of these stereotypical beliefs as adolescents grow and mature.

Steeh *et al.* (2021) indicate that young men with weaker scientific stereotypes and more substantial parental support are likelier to develop optimistic attitudes. Conversely, young women, particularly those who receive less parental support, are more likely to belong to a group characterised by pessimistic attitudes and concerns about their potential for success. In contrast, Liu (2020) study proposes the creation of educational and social programs with a focus on eradicating these stereotypes and promoting the development of non-sexist STEM fields. In line with this, McGuire, Jefferys & Rutland (2020) further highlight the impact of classmates on students' perceptions. They reveal that the STEM domain and the participants' gender influence the connections between individual and group evaluations based on students' beliefs.

Moving on to the subjects of perceptions, aspirations, and students' choices, Ikonen *et al.* (2019) and Fernández-Cézar *et al.* (2020) establish that school orientation can serve as a valuable platform for supporting young men in exploring their career paths free from societal pressures and gender-related expectations.

Concerning gender stereotypes in STEM and their impact on students' aspirations and choices, Ergun & Balcin (2019), Ito & McPherson (2018), and Selimbegović *et al.* (2019) propose that educational institutions and policies should implement awareness campaigns aimed at introducing various career possibilities from an early age. These campaigns should target children of all genders and focus on disseminating information while actively working to eliminate materials that perpetuate stereotypes. By creating an environment that encourages open-mindedness and inclusivity, educational systems can play a crucial role in dispelling gender biases and providing equal opportunities for all students to explore and choose their career paths without being constrained by traditional gender norms.

Related to interventions and initiatives aimed at enhancing the representation of young women in STEM fields, González-Pérez, Mateos de Cabo & Sáinz (2020) emphasise the effectiveness of showcasing female role models in STEM to lead workshops or interventions. They suggest that such actions positively impact participants' sense of belonging within the STEM field and strengthen their academic expectations. By providing relatable and successful role models, these interventions can inspire and empower young women to consider and pursue STEM pathways with increased confidence and motivation.

Simultaneously, the research conducted by Colantonio *et al.* (2021) and Isaacson *et al.* (2020) puts forward spatial science as a unique and multidisciplinary platform for active science learning. Their studies underscore that spatial science programs provide sustainable evidence of increasing young women's confidence and comfort with STEM



subjects. Moreover, insights from studies by Berra & Cavaletto (2020), Hopp, Stoeger & Ziegler (2020), Master *et al.* (2017), Tolber (2020), and Will *et al.* (2018) collectively suggest that participation in socialisation experiences through projects yields positive outcomes, particularly for female groups. The results indicate that after completing these activities, young women express a heightened sense of capability and an increased inclination to pursue further study in these disciplines, even at the professional level. This evidence illustrates that such initiatives have the potential to inspire and empower young women to consider and pursue STEM pathways with more enthusiasm and determination.

In summary, the review underscores the emerging advancement of empirical research focused on examining the impact of gender stereotypes on the issue of female underrepresentation in STEM-related fields, particularly at the secondary level and even more so at the primary level. This body of research highlights the need for ongoing efforts to combat gender stereotypes and create inclusive environments encouraging young women to engage in STEM subjects and pursue careers in these areas.

In this context, among the twenty-four studies examined, only five studies focus on elementary school students. Moreover, only one of these studies evaluates young men and women's stereotypes regarding STEM fields while testing an intervention to enhance young women's motivation in STEM despite these stereotypes. This low quantity highlights the limited exposure of elementary students to STEM experiences, which in turn poses challenges in positively influencing young women to develop their STEM-related knowledge and consider opportunities in these fields (Master *et al.*, 2017; Will *et al.*, 2018). The scarcity of early STEM exposure further illustrates the importance of initiating interventions and programs that promote gender-inclusive STEM learning early to foster equal opportunities and aspirations among young women and young men.

Furthermore, it is worth noting that most studies reviewed are characterised as one-time or short-term interventions, with two exceptions: the longitudinal studies conducted by Starr & Simpkins (2021) and Hopp, Stoeger & Ziegler (2020). From these studies, it follows the importance of considering longitudinal designs in future research or interventions to enhance interest and permanence in STEM education. Establishing causal relationships through experimental and longitudinal approaches is crucial to achieving a substantial and sustainable impact over time on young women's decisions to pursue STEM studies at the university or high school level (Prieto-Rodríguez; Sincock; Blackmore, 2020; Van den Hurk; Meelissen; Van Langen, 2019). These designs enable researchers to understand the long-term effects of interventions better and develop strategies to create lasting and meaningful change in encouraging gender diversity and representation in STEM fields.

Conclusion

This review aimed to identify empirical studies conducted within the past five years involving primary and secondary school students, focusing on analysing gender stereotypes within STEM domains. As discussed, recent research underlines the necessity of adopting empirical and long-term intervention perspectives. This approach is crucial



for shaping educational policies and addressing gender gaps and stereotypes that create unequal and unjust learning environments.

This urgency is magnified when considering effective strategies involving families and schools. The stereotypes explored in this study tend to be transmitted primarily through the environments in which students develop and can persist into adulthood (Liu, 2020; Selimbegović *et al.*, 2019; Starr; Simpkins, 2021). Addressing and challenging these stereotypes early on through comprehensive and sustained interventions can foster a more inclusive and equitable educational landscape, encouraging the engagement and success of all students, regardless of gender, in STEM fields.

From our viewpoint, it is imperative for future empirical research to venture into a new realm of understanding, either through practical implementations or by contributing to specific theoretical frameworks. A noteworthy avenue for such research would involve students from Latin American countries. Studies addressing this review's issues have yet to be identified within this geographical context. It is urgent to fill this gap and advance progress in these regions to address the cultural and social challenges that impact the educational landscape.

For instance, in countries like Chile, the scarcity of STEM-focused school practices and the absence of pedagogical strategies tailored to gender inclusivity constitute a compelling case. This scenario likely contributes to the significant gender disparity observed in the likelihood of Chilean young women pursuing studies or careers in STEM fields as compared to their male counterparts (OECD, 2017). Investigating and intervening in such contexts can provide insights into Latin American students' specific challenges, helping develop strategies to foster more significant gender equity in STEM education and beyond.

Significantly, this systematic review reveals a positive trend where empirical research addressing gender stereotypes within STEM fields has shown notable growth over the last three years. Between 2017 and 2018, a mere three studies had been published. However, from 2019 until 30th July 2021, twenty-one studies have been published.

Despite this progress, an evident gap in primary education remains. Among the recent studies, sixteen have solely focused on secondary school students, two have considered participants from both primary and secondary levels, and only three studies have centred on primary education. This discrepancy is noteworthy since gender stereotypes have been found to exert a considerable influence even in the earliest stages of education, particularly within STEM-related domains (Master *et al.*, 2017). This evidence reinforces the significance of addressing these stereotypes and promoting gender equality from the foundational levels of education to create a more balanced and inclusive learning environment.

Regarding the motivational dimension, particularly within school, future research must embrace holistic and integrative perspectives, as the qualitative approach exemplifies. By adopting this approach, the obtained results can be thoroughly analysed through the lens of interpretative richness, contextualisation, and a deep understanding of the situated information provided by the students (Eccles; Wigfield, 2020).



In conclusion, we acknowledge the complexity of gender stereotypes within the school system, encompassing various dimensions and factors. However, our confidence is anchored in the evidence presented within this systematic review. It strongly suggests that fostering knowledge, skills, motivation, and belonging can significantly enhance young women's interest and perseverance in STEM education (Makarova; Aeschlimann; Herzog, 2019; González-Pérez; Mateos de Cabo; Sáinz, 2020). Achieving this requires school systems to adopt models that comprehensively identify the influencing factors within primary and secondary education (Selimbegović *et al.*, 2019; Starr; Simpkins, 2021). Furthermore, intervention strategies that connect STEM education with the everyday lives of female students are crucial in promoting sustained engagement (Sáinz, 2020; Sáinz; Eccles, 2012). By aligning these efforts, we can create an educational environment encouraging young women to explore and excel in STEM fields, ensuring equitable opportunities and a diverse future for these critical domains.

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