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# Overcoming stereotypes in teacher training: Responses from a systematic review to address the gender gap in STEM

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**ABSTRACT**
The unequal presence of women in scientific and technological fields compared to men may have its origins partly in the compulsory educational stages and performance of teachers involved therein. This study aims to systematically review the existing literature on science and technology teacher training to address the gender gap in STEM studies, identifying aspects with didactic implications. Following the PRISMA systematic methodology, 37 references published between 2008 and 2022 were selected. The studies were carried out in 14 countries following different qualitative and quantitative research methodologies, together with the design and implementation of training proposals. The result of the content analysis of the studies is expressed in five emerging categories: attitudes towards science and technology and their teaching, perceptions and beliefs regarding the student profile, educational methodologies in pre-service teacher training, and the emotions and invisibility of female role models. In view of the results, up to now not enough attention has been paid to teacher training in aspects to address the teaching of scientific-technological disciplines from a gender perspective. It is proposed to train teachers through reflection to detect the persistence of gender inequality, break down stereotypes and incorporate female role models into scientific-technological education, as well as consider the effect of emotions in the learning of these disciplines. The ultimate aim is to incorporate a gender perspective into the teaching identity of future science and technology educators and, so that it is reflected in their teaching and contributes to reducing the gender gap in STEM professions.

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## Introduction

At present, and despite the high demand for jobs in Science, Technology, Engineering and Mathematics (STEM) related fields, this situation being of special concern in the case of girls (Cadaret et al., 2017; Gómez et al., 2022; Holmegaard et al., 2012). According to UN data (2023), female representation accounts for just over 35% in these studies and less than a third in the workplace, being even lower in cutting-edge sectors such as artificial intelligence, where only one in five professionals is a woman. According to various studies, this circumstance begins to manifest itself in the stages of compulsory education, mainly in the adolescent period where girls' lack of interest in scientific-

technological studies becomes apparent (Kerkhoven et al., 2016; Patall et al., 2018; Pey-Tee & Subramaniam, 2023; Vázquez & Manassero, 2008).

## Barriers to Women's Participation in STEM

The underrepresentation of women in STEM disciplines is deeply rooted in a complex interplay of historical, social, cultural, economic, racial, ethnic and institutional factors (Avolio et al., 2024; Owuondo, 2023; Page, 2024; Shah et al., 2024). Historically, gender norms and stereotypes have positioned women in subordinate roles within families, societies and organisations, perpetuating their exclusion from fields traditionally dominated by men (Amirtham & Kumar, 2023; Cheryan & Plaut, 2010). Cultural and patriarchal traditions have further reinforced these disparities, particularly in regions where women face systemic barriers to access education and career advancement in STEM (Avolio et al., 2024; Studdard, 2002). Institutional practices and labour-economic dynamics exacerbate these challenges, as women often encounter a lack of role models, insufficient support mechanisms, and discrimination in leadership roles (Avolio et al., 2024; Hoyer, 2024). Moreover, the masculine culture prevalent in fields such as engineering, computer science and physics undermines women's sense of belonging and self-efficacy, contrasting with the comparatively better gender balance in disciplines such as biology and chemistry (Cheryan et al., 2017). These barriers, compounded by factors such as race, ethnicity and socioeconomic status, create a multilayered problem that hinders progress towards achieving gender equity in STEM worldwide (Amirtham & Kumar, 2023; Hoyer, 2024).

Among the key causes, studies such those by Archer et al. (2010) and Rossi and Barajas (2015) point to the lack of female role models in these knowledge fields, which could explain why girls do not opt for these disciplines. Kerkhoven et al. (2016) and Sáinz (2017) argue that another issue that could be having an influence on this is the presence of gender biases and clichés associated with people working in STEM fields (e.g. lack of empathy and antisocial characteristics) promoted by different spheres of society, including the education system. This gives rise to identity-related problems in girls who internalise an image of STEM disciplines loaded with stereotypes and disconnected from their own interests (Archer et al., 2010; Ceci et al., 2009; Martín-Gámez et al., 2022; Wang & Degol, 2017). Added to this is the traditional way of teaching and the androcentric image students have of scientific and technological disciplines, generally associated with gender stereotypes attributed to professionals in these fields (Del Olmo-Muñoz et al., 2022). In this regard, and although it is hoped that teachers do not explicitly support them, even unconsciously or unintentionally, it seems these gender stereotypes may persist and have been integrated into their own experiences since childhood, affecting their interaction with students (Bertrand et al., 2005; Gheith & Aljaberi, 2019).

## Gender-Responsive Teacher Training and Educational Interventions in Scientific-Technological Disciplines

Studies such as that by Merayo and Ayuso (2022) reveal that very few teachers from scientific-technological fields receive gender-responsive training, and state that reducing the gender gap in science and technology education would have a positive impact on employment, helping to reduce bottlenecks in the job market and increase the productivity of women. There is a notable gap in existing research regarding practical training programmes for pre-service teachers training that effectively promote gender-perspective teaching practices (Hasenhütl et al., 2024; Miralles-Cardona et al., 2023; Rarieya et al., 2024). Although some studies have addressed gender-perspective STEM instruction (Hasenhütl et al., 2024; Miralles-Cardona et al., 2023), they largely focus on evaluating teaching ideas rather than developing comprehensive training programmes that equip educators with the skills and knowledge necessary to perform STEM teaching with a gender perspective. Miralles-Cardona et al. (2023) highlight that cultural and contextual challenges, such as those observed in Greece and Spain, often leave pre-service STEM teachers graduating without sufficient confidence in gender knowledge and skills, emphasising the need for culturally relevant training programmes. In this regard, Rarieya et

al. (2024) note that while ongoing professional development in a pedagogy with a gender perspective is crucial, the lack of structured programmes offering continuous learning opportunities, including mentoring, coaching, and reflective practices, hinders teachers' ability to effectively understand and apply these strategies. It is thus vital to set into motion interventions that respond to this gender gap and assure equal opportunities for learners, with the essential collaboration of the entire educational community (Holmlund et al., 2018; Sáinz, 2020). This, in addition, means following the guidelines of those who promulgate Nature of Science (NOS) teaching, asserting that attention also be paid to the socio-cultural, political, economic, etc., circumstances and contexts that influence its development in a decisive way, and which the Science, Technology and Society (STS) approach has integrated from the outset (Acevedo-Díaz & García-Carmona, 2016).

In this regard, teacher training should provide ideas and tools for promoting the creation and utilisation of didactic resources and materials that adopt a gender perspective, seeking to dismantle gender stereotypes and roles (Lleixa et al., 2020). Such training should raise awareness of gender inequalities, affording coeducation its true meaning and importance. The objective is a conscious and explicit intervention in the breaking down of gender biases and prejudices, revealing situations of discrimination and inequality, and favouring comprehensive training in all its diversity and richness. Furthermore, as Esteves (2018) and Martín-Gámez et al. (2021) set out, it is necessary to undertake an in-depth review of teaching resources such as textbooks, to include inclusive vocabulary, avoiding stereotyped and sexist content, and replacing images of roles traditionally assigned to women or men with the presence of both genders in the performance of various functions.

In short, the scarce participation of women in science and technology translates into a loss of talent, of new innovating scientific perspectives, socioeconomic development, competitiveness and social justice (Vázquez-Cupeiro, 2015). In order to make efforts to combat such a situation and promote diversity through equal participation and excellence of men and women it is necessary to reflect on what can be done from science-technology education. Teachers in this sense may be key, it being necessary to act from their initial training to make them aware of the problem and provide capabilities that permit them to tackle the teaching and learning of scientific-technological disciplines from a gender perspective.

## Aims of the Research and Research Question

The aim of this work is to conduct a systematic review of what has been achieved so far in science and technology teacher training to help combat the gender gap in STEM studies, identifying aspects that may have didactic implications. The purpose is to summarise the available scientific information on this topic, increase the validity of the conclusions drawn from individual studies and identify aspects that may have didactic implications that can be extrapolated to future research (Petticrew & Roberts, 2006). Specifically, with the present study, the following research question is established: What strategies and methodologies have been researched in the context of science and technology teacher training to effectively incorporate a gender perspective and reduce the gender gap in STEM education?

The aims of the systematic review are to synthesise existing literature on gender perspectives in science and technology teacher training and to identify gaps in the current research, and to highlight key considerations to incorporate a gender perspective into teaching identity of future science and technology educators.

## Significance of the Study

The findings of this study will have significant implications for science and technology teacher training. By synthesising the existing literature on gender perspectives, this review will highlight the critical need to address the gender gap in STEM education. Additionally, the results will serve as a valuable resource for policymakers in designing initiatives and frameworks that will foster gender

equity in education. Ultimately, this study will lay a solid foundation for future research aimed at integrating a gender perspective into pre-service science and technology teacher training.

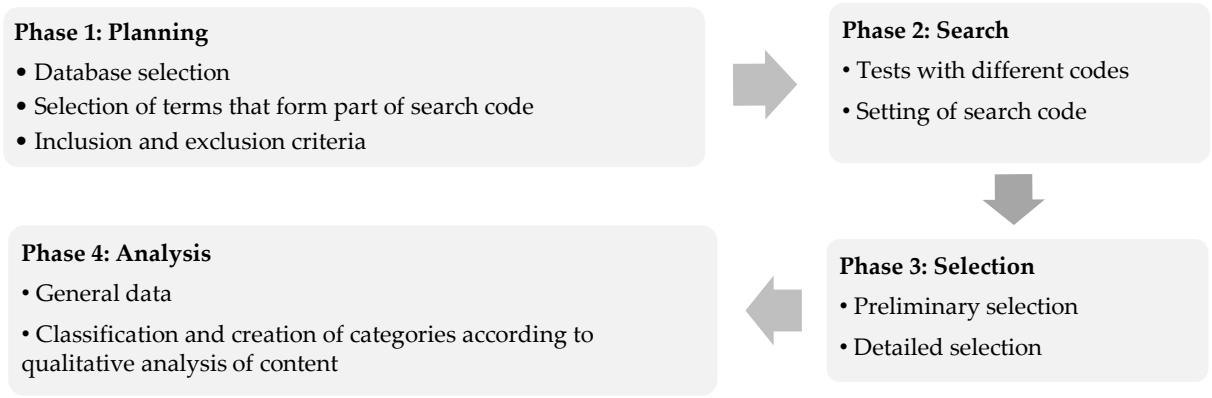
## Method

### Bibliographical Search Planning and Strategy

The bibliographical search was exhaustive and performed by selecting publications based on a series of criteria, in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement, permitting valid and reliable evidence to be obtained. This statement is designed to make systematic reviews transparent, complete and accurate, facilitating evidence-based decision-making (Moher et al., 2009; Page et al., 2021). The review was carried out in four phases: planning, search, selection, and analysis (Figure 1).

**Figure 1**

*Phases of bibliographical review method used*




### Phases 1 and 2: Planning and Search

The study followed the PRISMA guidelines to ensure transparency and rigor in the systematic review process. To ensure the methodological rigor of the included studies, the following custom quality assessment criteria were applied: relevance to the topic, clarity and transparency of objectives and research questions, rigor in methodology, consistency between study findings and conclusions drawn, and quality of publications. The process began with the selection of the two most categorise and comprehensive social science databases, Web of Science (WOS) and Scopus (Ramírez-Segado et al., 2021). In turn, the search code terms were selected, amongst those that had previously been observed in articles related to pre-service teacher education and the lack of interest in STEM studies on the part of girls.

There was then a planning of the specific search criteria in terms of inclusion and exclusion of references found, considering the following eligibility criteria:

- Studies specific to the pre-service teachers training and directly related to the subject addressed.
- References published in Spanish and/or English.

Considering this framework, the three authors of this work applied the inclusion and exclusion criteria, as well as reference selection. Subsequently, the results obtained were compared, and in cases where there were discrepancies, a discussion ensued until an agreement was reached among the three researchers. This validated process contributed to minimise the limitations of the study, i.e. the risk of bias.

The process of conducting this systematic review was designed to minimise the risk of bias at every stage, following a rigorous and validated methodology. The selection of databases (Web of Science and Scopus), recognised for their comprehensive coverage and categorisation of social science research, was the first step to mitigate selection bias. These databases ensured access to a broad and diverse range of high-quality references. The search terms used were carefully chosen based on prior observations in articles related to pre-service teacher education and the lack of interest in STEM studies among girls. This strategic selection aimed to reduce potential biases related to search strategy design, ensuring the inclusion of studies most relevant to the research objectives. Additionally, eligibility criteria were clearly defined before the search began, focusing on studies directly related to pre-service teacher training and published in Spanish and/or English. This predefined framework helped mitigate biases by applying consistent standards across all references. Regarding reporting biases, we acknowledge that the reliance on published literature can introduce certain limitations, such as publication bias, where studies with negative or non-significant findings may be underrepresented. To address this, we included references from grey literature sources where available and documented any potential evidence of selective reporting within the studies analysed. We also considered the possibility of language bias by incorporating studies published in both Spanish and English, expanding the scope of this review to minimise this form of bias. Finally, while our methodological rigor helped mitigate these biases, we acknowledge that some level of undetected bias may remain, particularly regarding the comprehensiveness of the available literature and the inclusion of unpublished studies. This limitation is inherent to systematic reviews. However, by combining independent evaluations, predefined criteria, and thorough discussions, the risk of bias has substantially been reduced, enhancing the reliability of this review findings.

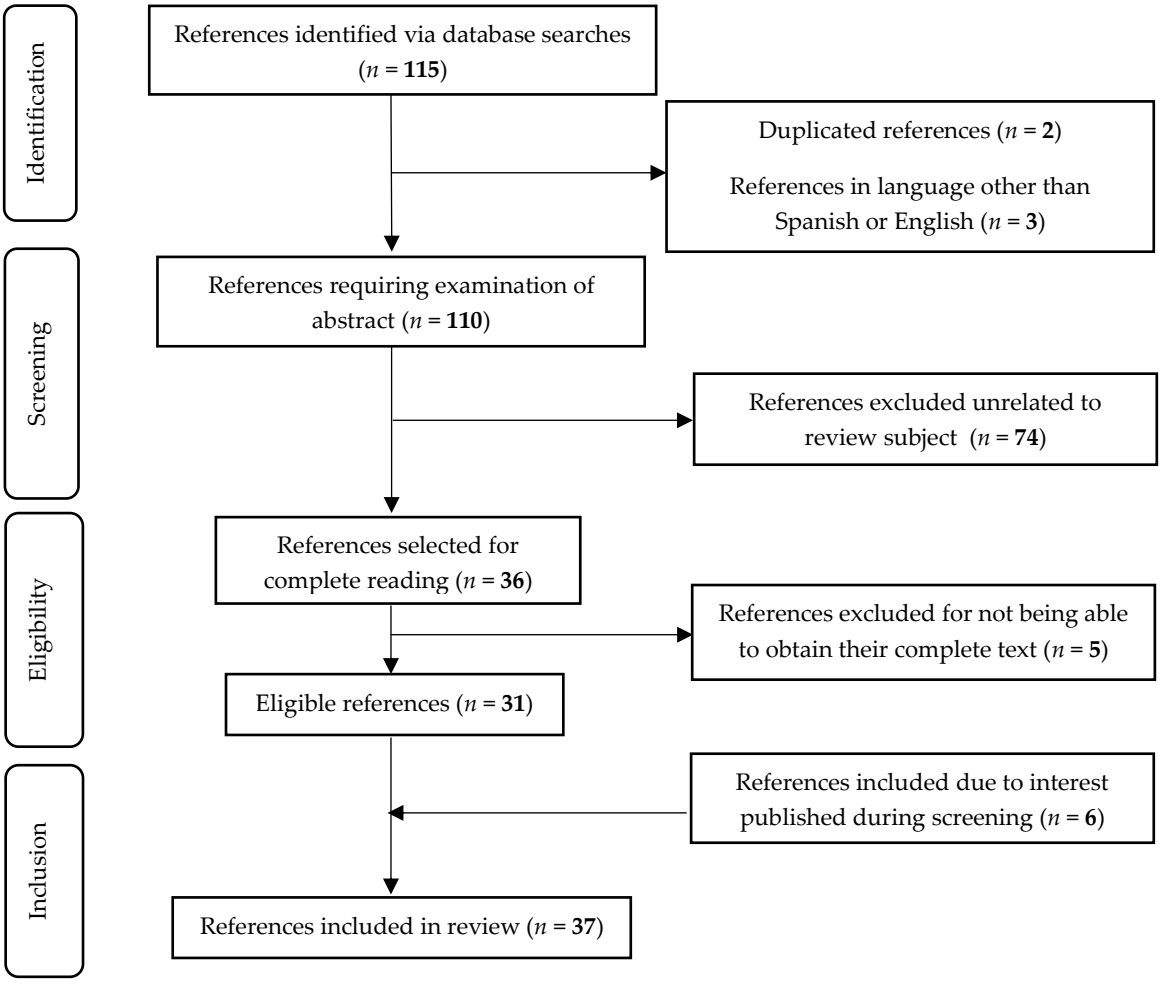
Next, tests were carried out with 24 different codes, in order to obtain results in the two databases that included all of the desired search terms, not only in the title, but also in the abstract and keywords of each publication. As a result of a long process of reflection, the chosen code was: (STEM study* OR STEM education* OR "science* education*" OR "attitude* toward*" science*) AND (teacher* training OR "pre service*" teacher*) AND (gender* role* OR gender* difference* OR gender* stereotype* OR gender* gap* OR gender* issue* OR gender* identity* OR gender* discrimination* OR gender* perspective*). The use of asterisks (*) allows finding declinations, and inverted commas (" ") restricts certain words to appear together.

## Phase 3: Selection

The search strategy employed provided a total of 115 references (109 from WOS and 6 from Scopus), 2 of which were excluded as duplicates and another 3 were rejected for being written neither in Spanish nor English. Following the reading of their abstracts, of the 110 references, those that did not address the review subject were screened, leaving a remaining total of 36 publications. 5 of these were excluded as it was not possible to obtain their complete texts. 6 more examples were added to the 31 eligible studies that were considered to be of interest and published during the screening and eligibility process. Finally, a total of 37 bibliographical references (published from 2008 onwards) were considered as valid for the review, shown with an asterisk (*) in the bibliographical references section, of which 31 are articles published in scientific journals and 6 are proceeding papers included in conference record books. The complete process carried out for the selection of studies is outlined in Figure 2 flowchart.

**Figure 2**

*Reference selection PRISMA diagram*




## Phase 4: Analysis

The analysis phase was divided into two parts. The first involved an initial analysis from which general data were extracted, including the country the research pertained to, the year it was carried out and the educational level of the participating teachers. In the second part an analysis was performed focusing on the content of the studies. Following the complete reading of the 37 selected works, they were classified, firstly considering what the study carried out consisted of and, secondly, what content it addressed. There was then an inductive categorisation process to identify common patterns. Following the generation of some initial categories, more specific categories were created as the analysis progressed, leading to a system of interrelated categories.

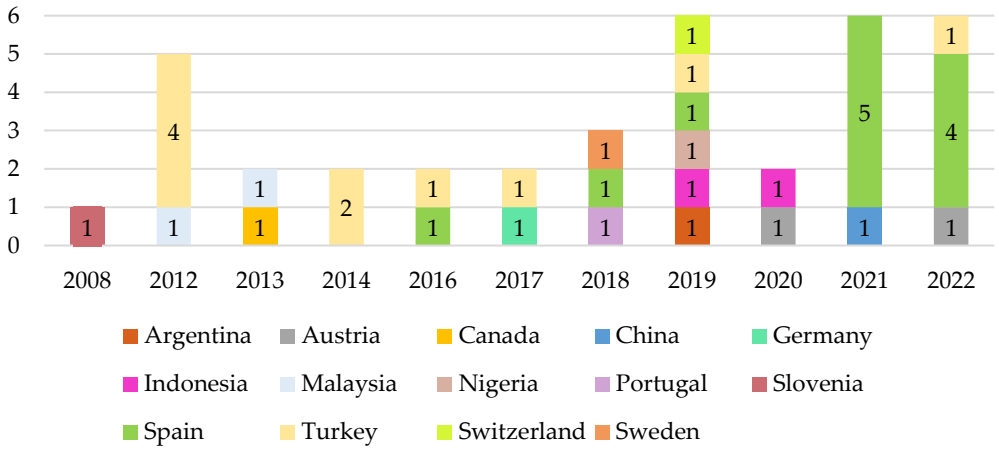
# Findings

## General Data

The 37 selected studies conducted their research in fourteen countries (Argentina, Austria, Canada, China, Germany, Indonesia, Malaysia, Nigeria, Portugal, Slovenia, Spain, Turkey, Switzerland, and Sweden) and were published between 2008 and 2022. The highest number of works came from Spain and Turkey, 12 and 10, respectively, and 2019, 2021 and 2022 were the years that saw the most studies published, 6 in each (Figure 3).

**Figure 3**

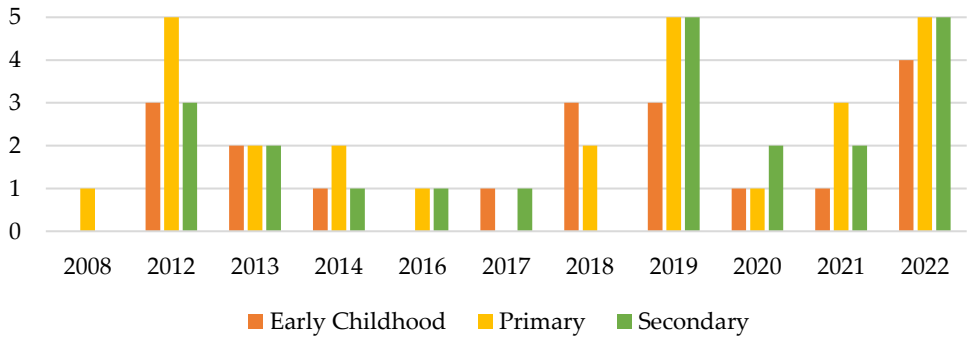
*Countries research carried out and year of publication of the 37 studies included in the review*




Moreover, attention should be drawn to the fact that in regard to the studies carried out on pre-service teachers (PST), 19 studies were from Early Childhood Education (ECE) (stage between 0-5 years of age), 27 studies from Primary Education (PE) (stage between 6-12 years of age) and 22 studies from Secondary Education (SE) (stage between 13-16 years of age). We analysed studies that focused their research on one, two, or all three educational stages. It can also be appreciated that, in recent years, research has focused more on PE and SE future teachers, which may be due to the lack of interest on the part of students, and above all girls, in science-technology studies at baccalaureate and university level (Figure 4).

**Figure 4**

*Educational stages of the trainee teachers participating in the research and year of publication of the 37 studies included in review*




In line with the aim of synthesising the existing literature on gender perspectives in science and technology PST training education and identifying gaps in current research, our results show that the

concentration of studies in certain regions and years could introduce a risk of bias, particularly in terms of geographical and temporal biases. This could limit the generalisability of the findings and may suggest an overrepresentation of studies from specific contexts, such as Spain and Turkey. The underrepresentation of other regions may lead to an incomplete view of the global landscape of gender-sensitive science and technology PST training education. On the other hand, the possible exclusion of publications not in English or Spanish could have limited the diversity of the included studies. There could also be publication bias, as studies showing positive results on the inclusion of a gender perspective in science and technology PST training education are more likely to be published, while those with neutral or negative results may remain unpublished.

## Category Classification and Creation

The results of the content analysis show that the studies included in the review revolve around two axes:

1) Results of qualitative and quantitative research on PST attitudes, emotions, perceptions or beliefs influenced by stereotypes in relation to scientific-technological disciplines (31 studies).
2) Design and implementation of proposals for PST education aimed at analysing PST emotions, skills and self-efficacy when faced with different innovating methodologies in scientific-technological disciplines (6 studies).

These findings align with the aim of highlighting key considerations for incorporating a gender perspective into the teacher identity of PST in science and technology fields. Furthermore, they are relevant to the research question: "What strategies and methodologies have been investigated in the context of science and technology teacher training to effectively incorporate a gender perspective and reduce the gender gap in STEM education?" The research shows that there is a clear focus on how gender-related stereotypes impact PST' perceptions and emotions. The studies in the first axis (31 studies) explore how stereotypes shape PST' attitudes and beliefs, with many focusing on how gender biases in STEM impact PST' confidence, interest, and pedagogical approaches. These insights are crucial for identifying effective strategies for incorporating a gender perspective into teacher training programmes. However, the second axis (6 studies), which focuses on the design and implementation of proposals aimed at analysing the emotions and self-efficacy of higher education teachers, highlights the need for more specific and innovative methodologies that actively address gender inequalities in scientific and technological disciplines. Our study highlights existing gaps in the research, particularly regarding innovative methodologies and comprehensive strategies that directly address the gender gap in STEM education. The risks of bias, as mentioned in previous sections -specifically reporting and geographical biases, as well as the potential impact of publication and language biases- should be carefully considered when interpreting these results and acknowledging the limitations of our study. Future research should focus on addressing these gaps by exploring novel strategies and methodologies.

The categorisation process involved constructing a system of emerging categories, which allowed the organization and classification of qualitative data (content of analysed references) based on various thematic criteria (Miles et al., 2014). The process began with a thorough reading of the 37 selected studies, during which initial codes were assigned to key themes and findings that emerged from the data. These codes were then grouped into broader categories. As the analysis progressed, these initial categories were refined and expanded to reflect the recurring patterns and relationships identified across the studies. The emerging categories demonstrated the highest relevance and alignment with the data. As they emerged, their overall generality and significance were consistently refined and validated for relevance. Following the categorisation performed on the content of the studies, the analysis produced five emerging categories. The first includes PST attitudes towards science and technology and the teaching thereof. The second considers perceptions and beliefs on the appropriate student profile for choosing scientific-technological fields. The third category contemplates how different methodologies employed in pre-service science and technology teacher education

influence the attitudes, perceptions and professional competencies of future teachers. The fourth category reflects PST emotions experienced when dealing with the teaching of science and technology disciplines. Lastly, the fifth category shows the lack of female references and PST awareness or ignorance thereof. Each of these categories, which emerge from the content analysis of the studies included in the review, is presented below.

### *Attitudes Towards Science and Technology and their Teaching*

Positive or negative attitudes on the part of teachers towards science and technology and their teaching have a strong bearing on how their students will react to the disciplines (Awofala et al., 2019; Wahyudiati et al., 2019). Having positive attitudes towards scientific-technological subjects and the teaching thereof contributes to the development of related skills and a deeper appreciation of the importance of these in day-to-day life (Vázquez & Manassero, 2004, 2009; Bellová et al., 2021).

Works such as those by Juriševič et al. (2008) and Doğru and Çelik (2019) reveal that female trainee teachers participating in their studies held more negative attitudes than their male counterparts as regards the social image of science and its teaching. However, and in relation to specific curricular content, a number of studies reflect an entirely inverse situation, showing that female teachers in training in fact have more positive attitudes towards concern for the environment and renewable energies (Özerkeskin et al., 2012; Ozsoy, 2012; Madhawa et al., 2013; Doğru & Çelik, 2019; Rivadulla et al., 2021).

Regarding those aspects that could encourage positive attitudes in future teachers, the study by Mazas and Bravo (2018) recognises that the greater the scientific-technological knowledge held by PST, the more awareness they are of its importance in the development of society, and their curiosity and critical attitude towards such knowledge increases.

On the other hand, Steele et al. (2013) and Arabit et al. (2021) underline that future female teachers face barriers to developing the teaching of scientific-technological materials including a lack of resources, specific spaces and in-depth training in the use of new technologies. In this regard, Repenning et al. (2019) conclude that teachers at all educational levels should show considerably positive attitudes towards disciplines such as computers and technology in order to foster interest in their students, especially girls.

The studies taken together highlight a dual narrative: while teachers' attitudes are recognised as influential by various authors (Avolio et al., 2024; Owuondo, 2023; Page, 2024; Shah et al., 2013), gender-based differences and external barriers introduce variability in how these attitudes develop. Discrepancies across studies suggest that broader systemic issues, such as stereotypes and resource constraints, interact with teachers' personal factors such as depth of knowledge and subject-specific preferences. By identifying these trends and differences, it becomes clear that targeted interventions must address both intrinsic and extrinsic factors to promote positive attitudes towards science and technology education.

### *Perceptions and Beliefs Regarding the Student Profile*

As Fernandes and Carim (2018) suggest, there is a persistence of stereotyped beliefs as they are passed down the generations, and incorporated into individuals through the process of socialisation, conditioning their way of thinking and, as a result, their behaviour in the context of the classroom as teachers. In this sense, perceptions and beliefs on the part of teachers in regard to the profile of students who should opt for scientific-technological fields may have an influence on aspects such as their teaching approach, interactions with their students and their interpretations of the academic progress and personal development of these and, in general, their commitment to teaching (Tan & Maeda, 2021).

There are studies that indicate PST tend to connect engineering or technology to physical and thus more male-orientated work (Kuvac & Koc, 2022; Wahyudiati et al., 2019; García-Morís & Alfonso-Cendón, 2022). Other results point to how PST conceive that students who choose scientific-

technological fields should have aptitudes and skills in these disciplines, show interest in science or technology, be logical, curious, hard-working, organised and methodical, assigning these traits mostly to girls (Merayo & Ayuso, 2022).

A number of studies show that women in pre-service technology and physics teacher education consider that male teachers and students perform better in teaching and learning these subjects than they and their female students do (Berber & Oral, 2012; Xu et al., 2021; Kuvac & Koc, 2022). The study by Fernandez and Cardim (2018) also indicates how female teachers in initial early childhood and primary teacher training consider that differences exist as regards aptitudes between men and women, and that these influence professional choices regarding scientific-technological degrees. The study by Ayuso et al. (2022) draws attention to the beliefs of secondary education PST, who perceive that girls possess more skills necessary for continuing with studies in the scientific-technological sphere than boys, finding however that the former do not choose them due to low self-esteem.

The studies reviewed reveal how stereotypes and perceptions influence teachers' beliefs about the profile of students in STEM disciplines. While the association of STEM disciplines with masculine physicality reinforces traditional gender roles, there is growing recognition of girls' intellectual and organizational strengths in these disciplines. However, discrepancies in how these beliefs translate into expectations and outcomes (ranging from self-esteem issues to differential perceptions of performance) highlight the complexity of addressing gender disparities in STEM education. Addressing these biases requires targeted interventions to challenge stereotypes and foster environments where all students, regardless of gender, feel empowered to pursue careers in science and technology.

### *Educational Methodologies in Pre-Service Teacher Training*

The different methodologies employed in pre-service teacher training may have a significant bearing on the perceptions and attitudes of future educators towards science and technology (Sánchez-Martín et al., 2018). Moreover, these methodologies influence the professional skills that teachers may develop in order to teach scientific-technological subjects with a gender perspective. In this regard it is very important for future teachers to be aware of how the methodologies they choose can integrate approaches that promote gender equality.

Thus, diverse studies show how attitudes and perceptions of secondary education trainee teachers are favourable when active innovative methodologies and gamified learning strategies are implemented (Kahraman, 2014; Lay & Khoo, 2012; Akçöltekin, 2016; Çam & Geban, 2017; Bejarajo & García, 2016; Krause et al., 2017; Díaz-Noguera, 2019; Reiman, 2019; Repenning, 2019; Wahyudiati et al., 2020). Furthermore, if their teacher training also includes a collaborative and inclusive peer-to-peer methodology, they become aware of the importance of adopting more inclusive teaching approaches in order to attract female talent and combat gender stereotypes within science and technology (Díaz-Noguera, 2019; Ayuso et al., 2022).

For instance, Kollmayer et al. (2020), via their REFLECT training programme, propose the use of reflexive coeducation to encourage PST to undertake deep critical analysis of gender-related matters in order to overcome the stereotypes and inequalities that may be present in the curriculum, educational materials and classroom interactions. In this programme future teachers reflected on their own gender stereotypes, examined whether or not their idea of teaching was influenced by these and developed teaching competencies in this regard. The REFLECT programme led to an increase in knowledge on gender differences in education and concluded that only those teachers who know how to counteract existing gender stereotypes in their teaching, and who furthermore believe themselves to be capable of resolving inequalities, will promote change.

Similar conclusions are drawn from the studies presented by Díez-Bedmar (2022) and by Acisli et al., (2012), who indicate that asking questions and knowing how to analyse the responses with a gender perspective is key in the training of teachers so they are able to apply it in their professional sphere. In addition, these authors draw attention to the importance of adopting approaches from PST training that enhance knowledge on equality and critical analysis of gender stereotypes. Similar

approaches are proposed by Gullberg et al. (2018) and Kuvac and Koc (2014), who indicate the importance of developing critical thinking on the part of PST from self-reflection on their stereotyped gender patterns, as they will be able to change their future classroom behaviours by being aware of their own actions and thoughts.

Evidence points to the importance of integrating diverse methodologies into initial teacher education (Akhtar et al., 2024; Reinoso et al., 2024) to address gender stereotypes and promote inclusion in science and technology education. Active learning strategies such as gamification and collaboration are widely recognized for their ability to enhance engagement and foster inclusive practices. At the same time, reflective methodologies that focus on self-awareness and critical analysis provide a deeper foundation for addressing stereotypes and promoting long-term change. By combining these approaches, teacher education programmes can equip PST with the tools, awareness, and agency to foster their professional practices with a gender perspective.

### *Emotions*

A holistic perspective of education recognises the interconnection between the emotional, social and cognitive aspect of learning (Garritz, 2010; Kind, 2009; Park & Oliver, 2008; Tobin & Fraser, 1990). The integration of attention to emotions into teaching practice can contribute to the holistic development of students by promoting a more enriching and rewarding learning process. Nevertheless, no studies have been found aimed at raising awareness among future teachers of scientific-technological subjects as regards the considerable impact of the emotions experienced by their students.

Studies that address emotions and initial training of science and technology teachers normally focus on analysing emotions experienced by these future educators as they must deal with the teaching of scientific-technological materials. Along these lines, the study by Bravo-Lucas et al. (2022) shows how their participating teachers expressed negative emotions towards the teaching of physics and, in this case, the women did so more than the men.

Bravo-Lucas et al. (2022) state that emotions have an influence on science teaching and learning, and that teachers' memories of the emotions experienced in the learning of the different science subjects in their time at school are maintained in the subsequent teaching thereof. Thus, half of the PST participating in the study by Steel et al. (2013) admitted to feeling stressed about having to teach primary education science, and stated that their experiences with the subject were largely negative or neutral during their school years.

In this regard, Hernández-Barco et al. (2021) recommend using active methodologies during PST education such as project-based learning in a gamified context, given that they will have positive affective consequences and translate into an improvement in trainee attitudes towards science and a reduction in anxiety. These authors also recognise that these types of methodologies will foster their own curiosity and afford greater confidence in their future teaching practice. López-Banet et al. (2021) likewise recommend that teachers maintain a favourable emotional connection to the sciences that centres not just on knowledge of the content but also procedural and epistemic understanding, along with scientific comprehension of the phenomena with their appropriate interpretation, thus seeking to promote in their students a favourable emotional connection towards science and technology.

All research indicates the fundamental role of emotions in the training of science and technology PST, but they differ in their emphasis on specific aspects. While some focus on the negative emotions experienced by science and technology teachers and their origins in previous schooling, others explore interventions, such as active methodologies, to promote positive emotional outcomes. However, a significant gap persists in the preparation of PST to address emotional dimensions during their pupils' learning. Bridging this gap would require integrating training strategies that stress both teacher and student emotions, thus fostering a more holistic and effective approach to science and technology education.

### *Invisibility of Female Role Models*

The lack of female role models may have consequences with regard to the perception and aspirations of learners related to scientific-technological spheres (Benavent et al., 2020). This may be one of the impediments to overcoming the gender gap in these areas and, with it, contributing to a more equal educational and social environment.

Nevertheless, few studies address this topic and its relationship to the training of future teachers. One such example, by Merayo and Ayuso (2022), shows that pre-service secondary education teachers think that amongst the reasons for pupils not taking subjects in the scientific and technological sphere, as well as preconceived ideas, is the lack of female role models, examples of the contributions of women to the building of scientific-technological knowledge and the history of science and technology. In the same vein, Goreth and Vollmer (2022) reveal that technology PST consider research in this area conducted by women to be strongly under-represented. For these teachers, girls do not have female role models to follow and reach the conclusion that it is not a field for them. For their part, the PST participating in the study by Fernandes and Cardim (2018) consider this situation to be reinforced by textbooks used in the classroom, which seldom allude to the participation of women in science or technology and, when they do, it is still represented in a stereotypical manner, evidencing an androcentric and traditional image of science.

The invisibility of female role models is a widespread problem that perpetuates gender disparities in these fields, as previously reported in their studies by Archer et al. (2010), Avolio et al. (2024), Hoyer (2024) and Rossi and Barajas (2015). The studies reviewed highlight the detrimental effects of this invisibility on girls' aspirations and perceptions of science and technology teachers. However, while there is consensus on causes such as biased educational materials and the absence of female contributions in curricula, there is limited exploration of specific strategies to address these issues in teacher education programmes. Future research should focus on practical approaches to integrate women's achievements in science and technology into teacher education, empowering science and technology teachers to create gender-responsive learning environments.

## Conclusion and Didactic Implications

This article presents a systematic review that shows what has been researched so far in science and technology teacher training to help combat the gender gap in STEM studies, identifying aspects that may have didactic implications. Giles et al. (2023) emphasise the importance of teacher identity development for meaningful engagement with teaching and preparing future STEM teachers in their transitions from student to professional, contributing to recruiting students for scientific and technological fields. That is why, with those didactic implications, we try to highlight what to be aware of in order to incorporate a gender perspective to the science and technology teacher identity.

In general terms, it can be seen that this issue has been little addressed since 2008, although in recent years the number of studies found has increased. This seems to indicate that up to now not enough attention has been paid to training teachers in aspects that could help them to address the teaching of scientific-technological disciplines from a gender perspective. Therefore, research in this area should be encouraged to generate more evidence on the need to incorporate a gender perspective into the training of science and technology teachers, as well as, by developing specific training modules focused on teaching strategies with a gender perspective. Furthermore, educational policymakers at the institutional level can draw on this research to design initiatives, the explicit integration of gender perspectives into curricula, and resources aimed at reducing the gender gap in science and technology areas. Future research could explore areas such as longitudinal studies to assess the long-term impact of teaching practices with a gender perspective, thereby helping to evaluate the effectiveness and sustainability of these approaches in narrowing the gender gap in science and technology education.

An analysis of the aims of the studies included in the review makes it possible to state that over half of them are focused on detecting attitudes, perceptions and beliefs, and there are still very few that concentrate on applying training programmes that promote the acquisition of professional

competencies to achieve a gender-responsive identity in the teaching of scientific-technological disciplines. Those that do show that using active methodologies in teacher training such as learning based on gamification, inquiry or problems and challenges helps in this aim, promoting the establishment of favourable affective connections in regard to attitudes and emotions (Hernández-Barco et al., 2021; Sánchez-Martín et al., 2018). We fully agree with them, especially with Kollmayer et al. (2020) in their recommendation to apply methodologies in teacher training that encourage critical reflection on gender issues such as stereotypes, roles, inequalities, etc., which may be present in the curriculum, educational materials and classroom interactions.

Furthermore, it is also important to draw attention to the fact that very few works have been found that endeavour to analyse whether teachers are aware of the lack of female role models in scientific-technological education, and the consequences of this for students, above all girls. We subscribe to the indications of studies that do address this issue, such as that by Fernandes and Cardim (2018), which stresses the need to counteract the shortcomings of textbooks in this regard. To this end, there is a need to boost training of critical-minded teachers able to develop strategies to include familiar and current female role models in order to demystify gender stereotypes associated with scientific-technological professions. Moreover, adopting these approaches would help to change teachers' beliefs on the profile required of students who opt to study STEM subjects. In this regard, we highlight the proposals of Merayo and Ayuso (2022), who warn of the negative influence of teachers with unequal perceptions regarding the engineering performance of men and women, beliefs that must be eradicated to avoid affecting the self-esteem of female students and encourage them to focus their studies on these areas.

Lastly, while we coincide with the approaches of Juriševič et al. (2008), Bisquerra and Pérez (2007), Hernández-Barco et al. (2021) and Bravo et al. (2022), who propose that during pre-service education it is important to provide teachers with both cognitive and emotional knowledge and competencies that enable them to maintain a favourable emotional connection towards the teaching of science and technology, it is interesting to emphasise that no studies have been found that focus on training teachers to take into consideration the emotions they will generate in their future students when teaching scientific-technological subjects. Emotions influence cognition, motivation, interest and learning of science and technology, thus teachers need to be aware of their potential and how they influence the development of work in the classroom. It is therefore necessary for teachers to also be capable of identifying emotions in their students and have at their disposal methodological strategies to promote those that activate their learning.

As recommendations for implementing strategies in PST training to promote a gender perspective in science and technology teacher identity, we propose practical interventions and initiatives based on gender-responsive analysis of educational resources and materials (e.g. textbooks, learning activities, educational games), followed by guided design of teaching proposals. Key aspects to take into account in the analysis and design may be: the image of science shown (collaborative activity beyond academics, with importance for society and current professional perspectives), emotions promoted (e.g., avoid boredom, seek surprise), and the visibility of female references (not only historical models, but also contemporary ones).

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