Is STEM Education Gender Neutral? An Analysis of Teachers' Perceptions of Gender Differences in Five Countries

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ABSTRACT

Thesis. The authors investigate the extent to which STEM (Science, Technology, Engineering, Mathematics) education is perceived as gender-neutral by educators across Europe, with a focus on how these perceptions influence student engagement and the perpetuation of gender gaps.

Methods. A mixed-methods approach was employed, combining quantitative survey data from 167 teachers in Germany, Poland, Romania, Türkiye, and Portugal with qualitative insights from focus group interviews. The study aimed to assess educators' awareness of gender imbalances in STEM fields, their attitudes toward inclusivity, and the pedagogical practices they adopt in response to perceived disparities.

Results. Findings indicate that while a majority of teachers acknowledge the existence of gender disparities in STEM education, their interpretations and proposed responses differ significantly. Some educators minimise the issue, while others emphasise its systemic nature.

Conclusion. The results point to a lack of unified understanding and underscore the urgent need for professional development focused on gender-sensitive teaching strategies. The conclusion emphasises the pivotal role teachers play in either challenging or reinforcing stereotypes and highlights the necessity of integrating gender awareness into teacher training programs.

Originality. This research offers a cross-national perspective on teachers' perceptions of gender in STEM, contributing valuable insights into the social dynamics shaping educational equity.

Keywords: STEM, gender equality, gender stereotypes, inclusive education, educational policy.

Introduction

STEM is an acronym referring to four core disciplinary areas: Science, Technology, Engineering, and Mathematics. It represents an integrated approach to education and skills development, in which learning is grounded in interdisciplinarity and the application of knowledge to real-world technical, social, and environmental challenges. STEM education constitutes the foundation of knowledge-based innovation economies, and its significance is growing in the context of global challenges and digital transformation (McDonald, 2016). The aim of STEM education is not only the transmission of subject-specific knowledge but also the development of analytical thinking, creativity, problem-solving competencies, and interdisciplinary collaboration. Furthermore, it is designed to foster students' conceptual understanding of the interrelations among scientific and mathematical domains, enabling them to comprehend

engineering and technology — fields that play a critical role in preparing students for meaningful participation in an increasingly digitalised world (English, 2015).

Teaching subjects that comprise STEM plays a crucial role in shaping the future of the global economy and developing innovative solutions to contemporary social, environmental, and technological challenges. In the face of increasing demand for specialists in these fields, ensuring equal access to STEM education for all students, regardless of gender, becomes paramount (Harrison et al., 2020; McLean, 2024). Unfortunately, despite progress in promoting gender equality, women and girls remain significantly underrepresented in STEM education and related careers (Ertl et al., 2017; Avolio et al., 2020). In many countries worldwide, including Europe, significant disparities persist in the engagement of girls and boys in these areas (Wang & Degol, 2017; Patall et al., 2018; Stewart-Williams & Halsey, 2021).

Although girls' STEM skills are similar to those of boys at an early age, they tend to exhibit lower confidence in their STEM abilities and interest as they grow older (Stoet & Geary, 2018). According to data published by UNESCO in 2024, girls account for only about 35% of graduates in STEM fields at the higher education level worldwide (Global Education Monitoring Report Team, 2024). Conversely, findings from the 2018 PISA study (OECD, 2019) indicate that boys and girls achieve similar results in science and mathematics. In fact, while girls outperform boys in digital competencies, women become less engaged in STEM as they age. The report ''She Figures 2021'' (European Commission, 2021) highlighted that in Europe, women constitute only one-quarter of self-employed professionals in STEM, 32% of doctoral graduates in science and mathematics, and 41% of the overall workforce. According to the same study, women represent only 20% of ICT graduates, with only 17% working in the technology sector. Women also comprise merely 24% of self-employed professionals in technical occupations such as science, engineering, or ICT. There are numerous socio-cultural reasons for this phenomenon, and research shows that girls often encounter various barriers that limit their interest and engagement in the sciences, including gender stereotypes, unconscious biases in classrooms, and a lack of appropriate role models (King, 2016; Tabassum & Nayak, 2021).

The issue of gender in STEM education is not merely a social concern (Casad et al., 2021); it also has significant economic implications. According to a 2020 report by the World Economic Forum (2020), increasing the participation of women in STEM could contribute to substantial growth in innovation and economic development. Women bring diverse perspectives and experiences, which are crucial in problem-solving processes and the creation of new technologies (Dahn & DeLiema, 2020; Chen et al., 2021).

Pursuing gender equality in STEM also serves the objectives of the United Nations Sustainable Development Goals, aimed at providing inclusive and equitable quality education and achieving gender equality (Campbell et al., 2022; Leal Filho et al., 2023). Encouraging girls to pursue education and careers in STEM is not only vital for addressing the graduate shortage in the STEM workforce (González-Pérez et al., 2020),

but also essential for diversifying and enriching the perspectives of researchers and entrepreneurs in STEM, enabling them to tackle complex problems and view the world from various angles.

The literature emphasises the significance of teachers' roles in promoting gender equality in STEM education (Casad et al., 2021). As key influencers in shaping students' attitudes, teachers have the potential to challenge stereotypes and implement practices that can enhance girls' participation in STEM (Dhiman, 2023). An appropriate teaching approach that considers diverse gender perspectives can yield positive outcomes in motivating girls to study STEM subjects (Dierickx et al., 2022).

In the context of these issues, the aim of this article is to analyse teachers' perceptions regarding gender differences in STEM education and assess the extent to which curricula are inclusive and gender-neutral. A comparative analysis of survey results was conducted across five countries: Germany, Poland, Portugal, Romania, and Türkiye. The article also puts forth specific recommendations to increase the representation of girls in STEM and suggest educational policy changes that may help overcome existing barriers.

Research Methodology

As part of the 'STEM for Inclusive Schools' project co-financed by the European Commission (project number: KA220-NW-23-30-151162), a comprehensive empirical study was conducted (in April and May 2024) based on a two-phase mixed-methods approach, aimed at capturing both quantitative and qualitative dimensions of inclusive STEM education, with particular emphasis on gender-related issues. Project partners were responsible for conducting the research in their respective countries: in Poland, the Łukasiewicz Research Network – Institute for Sustainable Technologies, Paderborn University in Germany, "Dunarea de Jos" University of Galati and School No. 7 Galati in Romania, Inovatif ve Girisimci Toplum Dernegi in Türkiye and Sucessos Criativos, Lda in Portugal.

The selection of five countries – Germany, Poland, Portugal, Romania, and Türkiye – was a deliberate decision derived from the structure of the project consortium, which was purposefully designed to reflect geographical, cultural, educational, and socio-economic diversity across Europe. This heterogeneity enables a comprehensive and multidimensional perspective on STEM education and offers an array of national approaches to the integration of digital technologies and gender equality in school systems. The inclusion of countries with varying educational systems and social norms makes it possible to compare local conditions and identify both universal barriers and context-specific best practices in promoting inclusivity in STEM.

This composition ensures the transnational character of the research, which is essential for generating generalisable conclusions and for formulating evidence-based, Europe-wide educational policy recommendations grounded in empirical data.

The study had two primary objectives: (1) to understand the needs, challenges, and opportunities associated with the integration of digital technologies in teaching and learning in the STEM field, and (2) to identify best practices that enhance participation and inclusivity in these areas, with particular attention to addressing the identified gender disparity in STEM representation. This article focuses on the second objective and aims to analyse how teachers from different countries perceive gender differences and what actions they take to support equal access to STEM education for students of both genders.

The key research question is: Is STEM education in these countries conducted in a gender-neutral manner, or do teachers recognise and respond to gender differences in their teaching?

The data collected during the study allows for a better understanding of the challenges faced by teachers and enables the formulation of recommendations for educational policy in this area.

The development of the research methodology was the responsibility of the Polish organisation, Łukasiewicz — Institute for Sustainable Technologies. The study involved teachers representing various subjects within STEM and different educational levels — both primary and secondary schools. It was divided into two phases: the first phase involved conducting a survey to collect quantitative data, while the second phase, which provided qualitative data, consisted of in-depth interviews based on the previously conducted surveys. In phase 1, 107 teachers participated, and in phase 2, 60 teachers were involved.

Phase 1: The developed questionnaire focused on several areas, namely investigating various aspects of STEM education and related issues, such as:

- Frequency of technology use in STEM teaching. Example question: "How often do you use technology in STEM lessons?". Response options: ranging from "daily" to "never."
- Importance of STEM education for future career opportunities. Teachers evaluated the significance of STEM education for students.
- Challenges in STEM teaching. Inquiries regarding the difficulties encountered in their professional practice.
- Perception of gender differences in STEM. Example question: "Do you perceive gender differences in STEM fields?" Response options: a) It exists and needs to be addressed; b) It exists but is not a significant issue; c) It does not exist.

The questionnaire was initially created in English, and then translated into Polish, Romanian, German, Turkish, and Portuguese. It consisted of 35 questions with single or multiple-choice options, along with the possibility for respondents to provide additional answers for certain questions.

According to the established methodology, the survey could be conducted using both printed forms and an online form (in this case, Google Forms was used). For respondents filling out the paper version, the coordinating individual in each country collected

the forms and entered the data into a dedicated online form, creating a repository of all provided responses.

Phase 2: The second phase of the study involved teachers participating in a focus group interview, which provided an in-depth analysis of the previously conducted surveys. These interviews could be conducted both in person and through available digital platforms (e.g.: Zoom, Microsoft Teams, Google Meet). The information gathered in this manner enriched the study by providing qualitative data in the analysed sector.

The format and approach used in the interviews adhered to the guidelines detailed in the methodology. The interviews were conducted according to design principles, in a setting characterised by utmost respect and trust, and participants were encouraged to openly share their experiences and opinions. During the interviews, open-ended questions were posed, allowing for free expression. Interviewers were required to take ongoing notes of the responses and subsequently prepare a national report to be submitted to the study coordinator, the Polish organisation.

Based on the data provided from both the first and second phases of the study, Łukasiewicz-ITEE prepared a final report along with a comparative analysis. The results regarding gender issues in STEM are presented below.

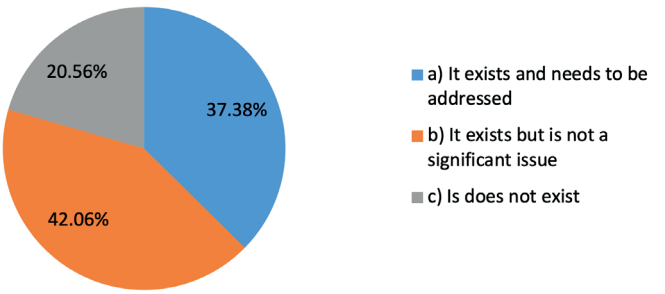
Research Results

Clear differences in the perception of the gender gap in STEM across different countries emerged from the question: ’Do you perceive the gender gap in STEM fields?” (Table 1). Although the majority of teachers agree that a gender gap exists, their approaches to the significance of this issue vary. In countries such as Türkiye and Germany, where the problem is perceived as serious, one might expect greater pressure for political reforms and actions. In contrast, in Poland and Portugal, where the gender gap is viewed as less significant, additional initiatives may be necessary to raise awareness on the issue and promote gender equality in the sciences.

Table 1.
Teachers’ answers to the question ‘Do you perceive the gender gap in STEM fields?’

1.11. Do you perceive the gender gap in STEM fields?			
	a) It exists and needs to be addressed	b) It exists but is not a significant issue	c) It does not exist
Germany	50% (5)	30% (3)	20% (2)
Poland	28,6% (4)	57,1% (8)	14,3% (2)
Portugal	41,7% (10)	50% (12)	8,3% (2)
Romania 1	17,6% (3)	47,1% (8)	35,3% (6)
Romania 2	34,6% (9)	42,3% (11)	23,1% (6)

1.11. Do you perceive the gender gap in STEM fields?			
Türkiye	56,3% (9)	18,8% (3)	25% (4)
TOTAL	37,38% (40)	42,06% (45)	20,56% (22)



Almost 80% of the surveyed teachers noticed the gender gap in STEM fields, of which 42,06% believe that it is not a significant issue, and 37,38% admitted that it needed to be addressed. The remaining 20,56% of respondents believe that the gender gap in STEM fields does not exist.

Source: Own Research.

The largest percentage of teachers believes that the gender gap exists but it is not a significant problem (42.06%). This category was the most frequently chosen in Poland (57.1%), Portugal (50%), and both regions of Romania (47.1% in Romania 1 and 42.3% in Romania 2). This indicates that in many countries, the issue of the gender gap is acknowledged but not perceived as critical or urgent.

A significant percentage of teachers (37.38%) believes that the gender gap exists and needs to be addressed. This category was most commonly selected by teachers from Türkiye (56.3%) and Germany (50%). This suggests a greater awareness and urgency regarding the issue in these countries, indicating that the matter of gender equality requires immediate action within their educational systems.

The least number of respondents (20.56%) believes that the gender gap does not exist. Surprisingly, a high percentage of such responses came from Romania 1 (35.3%), which may indicate local factors that make the gender gap issue less visible or perceived as resolved. In Germany, 20% of teachers also believe that the problem does not exist, suggesting a degree of polarization in the perception of this issue.

The analysis of responses provided by teachers during the in-depth interviews highlights key findings regarding how teachers perceive gender inequalities and what actions they suggest to address these disparities, with particular emphasis on increasing girls' participation in the sciences as the interviews revealed a significant underrepresentation of women in technical and scientific fields, a concern particularly emphasized by teachers from Romania, who attributed this disparity to entrenched stereotypes and societal expectations regarding gender roles. Teachers from other countries, such as Germany, Poland, and Turkey, pointed out the absence of female role models

in STEM curricula and the persistence of gender biases that restrict girls' participation. They stressed the necessity for systemic changes, including the incorporation of female role models into educational materials, the establishment of mentoring programs, and the adoption of practical teaching methods that illustrate real-world applications of STEM to more effectively engage female students.

Germany

In Germany, teachers agree that STEM education is neither fully gender-neutral nor sufficiently inclusive. Despite some progress towards incorporating women's perspectives, curricula do not fully incorporate varied perspectives. While topics related to the role of women in STEM are addressed, teachers emphasise that women continue to be one of the most underrepresented groups in the sciences. They point to the need for a deeper integration of diverse perspectives and the introduction of role models in the form of female scientists and engineers in educational materials and textbooks.

'Girls' Day', organised in Germany to encourage girls to explore technical professions, is perceived by teachers as not yielding lasting results. They believe that one-time events do not change students' attitudes or lead to changes in their educational decisions. For this reason, they suggest more sustainable actions, such as mentoring, where women in high positions in STEM can serve as role models for younger girls. Teachers also propose the introduction of practical teaching methods that demonstrate the real-world applications of STEM, which could more effectively engage female students.

Poland

Polish teachers acknowledge that the STEM curriculum is becoming more inclusive; however, significant gaps still exist. Women continue to be underrepresented, particularly in fields such as engineering and computer science. They emphasise that curricula often overlook the historical achievements of women in STEM, which limits role models for girls. There is also a lack of appropriate educational resources and teachers qualified in the latest technologies, especially in schools located in less socio-economically privileged regions.

To improve the situation, teachers recommend the introduction of more diverse educational content that highlights the achievements of women and various social groups. It is also important to increase the availability of technologies and educational tools that are tailored to different learning styles, which could attract more girls to STEM. Teachers emphasise that systematic support, such as the establishment of student support groups, could help develop STEM skills in a more conducive environment.

Portugal

Teachers in Portugal indicate that STEM education at the national level is neither fully inclusive nor gender-neutral. While there is an awareness of the need to incorporate diverse perspectives, there is a lack of a strategic approach and practical actions toward equality in STEM. Teachers note that equality in the STEM curriculum is not treated as a primary goal, and the existing fragmentation in the educational programme leads to a lack of coordination across different educational levels.

Furthermore, STEM curricula in Portugal are often outdated, making it difficult to incorporate contemporary, diverse perspectives, including those of women. Teachers suggest that comprehensive planning, collaboration, and the introduction of projects based on teamwork could help make STEM education more inclusive. They highlight the need to strengthen cooperation among teachers, students, and the community to promote diversity and equality.

Romania

In Romania, teachers highlight significant gender inequalities in STEM education. Women remain underrepresented in technical and scientific positions, a situation stemming from entrenched stereotypes and societal expectations regarding gender roles. To address these disparities, teachers suggest promoting women in the sciences and technical fields through mentoring and incorporating more female role models into the curriculum. They also emphasise the need for active measures to combat gender bias in schools and to support girls in pursuing careers in STEM.

In the context of minority groups, such as the Roma community, teachers note that these groups have limited access to high-quality STEM education. They propose the implementation of special support programmes that would help increase the representation of ethnic minorities in STEM and the introduction of more culturally responsive educational content.

Türkiye

In Türkiye, teachers acknowledge that the STEM curriculum is not sufficiently inclusive or gender-neutral. Only a small number of teachers believe that the current programme meets the needs of girls and underrepresented groups. It is widely thought that the curriculum is too standardised and fails to consider the diverse needs of students, particularly those of girls and immigrant students.

To improve inclusivity, teachers recommend enriching the curriculum with diverse cultural, social, and gender perspectives, as well as introducing role models that demonstrate to girls that they can succeed in STEM. They also propose organising special events and programmes that promote diversity in STEM and increasing the number of practical activities that would be more engaging for girls.

Comparative Analysis of National Results

In all the analysed countries, teachers agree that STEM education is neither fully gender-neutral nor inclusive, although there are differences in the approach to these issues. A common problem is the underrepresentation of women in STEM education, particularly in fields such as engineering, computer science, and technical sciences. Teachers from various countries indicate that curricula do not sufficiently showcase women's achievements, which limits their access to role models. There is also a need for better representation of diverse perspectives — not only gender-related, but also social and cultural — which could help girls from various social groups better identify with the sciences.

However, there are differences in the approach to reforming STEM curricula among countries. In countries like Germany and Poland, teachers emphasise the need to modernise educational content to reflect the real problems of the contemporary world, such as climate change, digitisation, and technological innovations. In both of these countries, there is also a stress on the necessity of introducing role models and mentoring, which would help girls acknowledge their position in STEM. In Germany, teachers highlight the importance of sustained, long-term actions, such as systematic mentoring programmes, which would be more effective than one-off initiatives like 'Girls' Day'.

Conversely, in Portugal and Romania, teachers focus on the need for a more strategic approach to incorporating inclusivity in STEM education. They point out that curricula are often outdated and they underline lack of coordination, which makes it difficult to integrate diverse perspectives. In both countries, actions such as better organisation and collaboration among teachers, students, and local communities, as well as the introduction of team projects that promote cooperation and the integration of various groups, including girls and minorities, are suggested. In Romania, particular attention is also drawn to the challenges related to the underrepresentation of ethnic minorities, such as the Roma community, in STEM education, which requires additional support and educational initiatives.

Türkiye, like other countries, struggles with the issue of insufficient inclusivity in STEM education. However, teachers in Türkiye particularly emphasise the need to adapt curricula to the diverse needs of students, such as girls and immigrant students. They also highlight the role of local communities and families in increasing girls' participation in STEM, which distinguishes Türkiye from other countries where the focus is mainly on changes in curricula and school practices. In Türkiye, there is a call for diversifying educational materials, updating course content, and organising events that promote diversity in STEM.

A common thread across all countries is the recognition that insufficient inclusion stems from existing stereotypes and gender biases that limit girls' participation in STEM. Teachers stress that curricula must be more responsive to social, cultural, and gender diversity, and that equality initiatives must be systemic and sustainable to yield long-term effects. In every country, there is a need for greater support in the form of mentoring, collaboration with local communities, and better integration of technology

and teaching methods that are adapted to the diverse needs of students, particularly girls and underrepresented groups.

To sum up, while all countries face similar issues related to gender inequalities and lack of inclusivity in STEM education, they differ in their approaches to addressing these problems. Germany and Poland focus on modernising curricula and establishing lasting role models, while Portugal and Romania highlight the need for strategic planning and better coordination of educational programmes. Türkiye, in turn, emphasises the role of families and local communities in promoting girls' participation in STEM, which sets its approach apart from that of other countries.

Discussion

To make STEM education more gender-neutral and increase girls' participation in STEM, a change in the existing educational policy and the introduction of integrated actions at multiple levels are necessary. Analysing the data obtained in both phases of the study, the following recommendations can be proposed to make STEM education more inclusive for girls.

First and foremost, it is crucial to introduce role models in STEM education that represent successful women in the fields of science, technology, engineering, and mathematics. Teachers from the analysed countries emphasise that the visibility of women in these roles is essential for girls to identify with them. Therefore, curricula should be enriched with educational materials that showcase women's achievements, as well as regular meetings with women working in STEM who could share their experiences. This approach aims to show girls that they can succeed in these fields, which in the long term will help eliminate existing stereotypes about gender roles.

The next step is the flexibility of curricula, which will allow educational content to be adapted to the actual needs of students. Many suggestions from teachers focus on the need to implement project-based learning and integrate practical applications of STEM. Students should have the opportunity to work on real social problems, such as climate change or digitisation. Such an approach will not only increase girls' engagement but also help them understand how STEM affects their lives and the world around them. Introducing projects that require teamwork can also promote integration among students of both genders.

To counteract gender stereotypes and biases, teachers should attend training on identifying and eliminating unconscious biases in their classrooms. It is important for teachers to confront stereotypical perceptions of gender in the sciences and to practice inclusive teaching methods. Systematic training could help teachers develop the skills necessary to actively and consciously engage girls in STEM.

Additionally, to increase the accessibility of STEM education for girls, technological and infrastructural support is essential. Teachers from Poland and Romania note

that the lack of modern educational resources, especially in less privileged regions, can limit students' opportunities. Therefore, educational policies should consider increasing investments in educational infrastructure to ensure equality in access to technology that can be appealing to girls. Educational programmes should be enriched with modern teaching tools, such as e-learning platforms, laboratories, and diverse educational resources.

At the national level, a curriculum reform is necessary that would consider diverse gender perspectives and the needs of female students. Current curricula in Germany, Portugal, and Romania are often outdated and inadequately adapted to contemporary challenges, making it difficult to promote gender equality. It is crucial to introduce new curriculum standards that place greater emphasis on gender equality and the integration of diverse viewpoints. Educational programmes should be updated to reflect women's contributions to STEM and adapt to the changing needs of students.

The reform of educational policy should also include support for scholarships and mentoring programmes. Establishing funds for scholarships for girls who want to pursue STEM fields, as well as mentoring programmes, can serve as an incentive for studying in these areas. Such actions can help eliminate financial barriers and promote active participation of girls in STEM.

Within the school context, it is important to promote collaboration and create STEM clubs that encourage students to work together. Organising regular workshops, competitions, and projects that promote integration between students of both genders can contribute to building an atmosphere of support and cooperation. Female students should have the opportunity to participate in projects that not only develop their technical skills but also support their confidence in the STEM field.

Conclusions

To conclude, the analysis of teachers' perceptions regarding gender differences in STEM education across five countries has shown that the issue of gender neutrality in these fields is complex and requires a multifaceted approach. The research findings confirm that a considerable number of teachers acknowledges the existence of a gender gap in science, technology, engineering, and mathematics; however, opinions differ on whether this issue constitutes a significant barrier that requires urgent action. Moreover, this research not only fills a gap in the existing literature but also provides actionable insights for policymakers, curriculum designers, and educators seeking to construct STEM education as a truly equitable and inclusive domain of learning.

In response to the research question, 'Is STEM education gender-neutral?', it can be stated that this education, at least in the context of teachers' perceptions, is not entirely neutral. There is a clear need to adjust educational practices and school policies to more effectively support girls in their educational paths in STEM fields. While some teachers

believe that the gender gap is not a key issue, the results unequivocally indicate the necessity for targeted changes.

The actions suggested in the article, such as systemic reforms, the introduction of training programmes for teachers, and greater involvement in promoting gender equality in classrooms, represent crucial steps toward creating a more inclusive educational environment. Therefore, the response to the question of gender neutrality in STEM education indicates that current practices do not ensure full equality, and future initiatives should focus on breaking stereotypes and levelling the playing field for all students, regardless of gender.

The relevance of this study extends beyond a mere diagnosis of the state of STEM education in the selected countries. This article makes a substantive contribution to academic discourse on gender equality in education, emphasising that teachers play a pivotal role as cultural mediators—either perpetuating or dismantling gender stereotypes in science, technology, engineering, and mathematics instruction. The findings reveal that, although most educators acknowledge the existence of a gender gap in STEM, their interpretations of the issue and the strategies they propose to address it vary significantly depending on the national context.

This work is particularly important as it provides empirical evidence of the absence of a coherent, cross-cultural framework for addressing gender disparities in STEM education. In practice, this leads to unequal educational and professional opportunities for girls and young women. The study further demonstrates that without proper preparation and support for teachers to work in gender- and culturally diverse classrooms, even the most progressive curricula may fail to achieve intended goals related to inclusion and equity.

From the perspective of educational policy and practice, the findings point to the urgent need for systemic action aimed at enhancing teacher training in gender-sensitive pedagogy and at fostering intercultural and anti-discriminatory competencies. The recommendations derived from this study may serve as a foundation for the development of international standards on gender equality in STEM education, in alignment with Sustainable Development Goals 4 (quality education) and 5 (gender equality), as well as with the strategic priorities of the European Union's educational agenda.

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