MODESTUM EURASIA Journal of Mathematics, Science and Technology Education, 2025, 21(9), em2698
ISSN:1305-8223 (online)
OPEN ACCESS Research Paper https://doi.org/10.29333/ejmste/16829

# Primary school prospective teachers' perceptions and beliefs on gender stereotypes in science: A case study

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Received 11 February 2025 ▪ Accepted 26 June 2025

**Abstract**

This study aims to investigate prospective primary school teachers' attitudes towards scientific disciplines and perceptions of gender stereotypes. In particular, the objective is to understand how the perception of prospective teachers changes before and after attending a course on physics education at the degree course in primary education sciences at the University of Palermo, which is focused on innovative pedagogical methodologies. The participants, 119 prospective teachers, answered the same questionnaire before and after they took part in the course. They answered open-ended and closed-ended questions about gender stereotypes in scientific disciplines. We then conducted an interview with four prospective teachers to delve deeper into some of the topics covered in the two questionnaires. The analysis of the responses given to the questionnaire before the course showed that pre-service teachers' perceptions largely conformed to typical gender stereotypes. On the other hand, the answers given to the questionnaire at the end of the course highlighted a change in pre-service teachers' perception and awareness of gender's impact.

**Keywords:** prospective primary school teacher, gender differences, gender-balanced teaching

## INTRODUCTION

Despite the many strides women have made in recent decades, they remain underrepresented in some STEM fields (Corbett & Hill, 2015; Gruber et al., 2021; Hill et al., 2010). In the last few decades, the number of women graduates in STEM fields is increased (Hamrick, 2021; National Center for Science and Engineering Statistics [NCSES], 2023). However, in 2020 in the United State, women were underrepresented among graduates at all levels in physical and earth sciences, mathematics and computer science, and engineering. In contrast, they earned 66% of bachelor's degrees, 67% of master's degrees, and 60% of doctorates in social and behavioral sciences. Among the fields in which women are most underrepresented are physics and computer science, with 24% and 21% of women graduates, respectively in 2020 (NCSES, 2023).

At the European level, the she figures 2021 report shows that women continue to be overrepresented in education (67%) but choose less frequently to enroll in STEM courses (Corbett & Hill, 2015). Data from 2018 show that women continue to be underrepresented even among PhD students in the STEM fields of physical sciences (38.4%), mathematics and statistics (32.5%), ICT (20.8%), and engineering (27%) (European Commission, 2021). Between 2015 and 2018, there was little progress towards female representation among doctoral students in these narrow fields of STEM.

Therefore, while progress has been made toward gender equality in the life and social sciences, several fields of STEM subjects continue to be characterized by persistent gender disparities in representation, feelings of inclusion, and pay equity (Schmader, 2022).

The reasons for the lack of girls in science are certainly not due to a lack of academic skills, but to socio-cultural factors (Hill et al., 2010): women's relatively minor interest in male-dominated STEM careers is likely limited by gender stereotypes (Schmader, 2022).


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**Contribution to the literature**

- This study focuses attention on gender differences in primary school and describing the role that teachers play in counteracting the spread of stereotypes.
- The study helps analyze prospective teachers' perceptions and beliefs about gender stereotypes in science in primary education through an open-ended questionnaire.
- The study highlights the importance of university training for future teachers, which should place greater emphasis on gender issues.

The persistence of gender stereotypes in culture can create a form of systemic bias that often goes unrecognized, affecting women's ability to feel a sense of belonging and fit in STEM fields (Schmader, 2022). Research has also shown that stereotypes can implicitly shape discriminatory behaviors and attitudes toward women in STEM disciplines (Rice & Barth, 2016).

Research shows that children begin to learn these gender stereotypes as early as preschool (Gonzalez et al., 2021; Keller, 2001; Mustapha, 2014; Tiedemann, 2002) within the family and social context of reference: just think of parents' expectations and the predominant role of social media. Subsequently, they can find reinforcement within the education system through books, curricular activities and teachers' behavior (Mustapha, 2014).

The beliefs students hold about their abilities, values, and actions are profoundly shaped by the influential individuals they encounter throughout their lives, with teachers being key among them. Teachers have the ability to either reinforce or challenge societal and gender-based expectations of behavior, playing a pivotal role in fostering an open and adaptable mindset in children on a daily basis (Navarro et al., 2022; Trautner et al., 2005).

How a teacher interacts with a student is based on his or her personal beliefs about how a boy or girl should grow up (Erden & Wolfgang, 2004).

Teachers' attitudes toward science and mathematics, combined with their teaching practices, have a strong influence on student achievement, students' attitudes toward these subjects, scientific literacy, and on student interest in pursuing STEM careers (Kazempour, 2014; Wendt & Rockinson-Szapkiw, 2018; Wilkins, 2010).

Studies have shown that pre-service primary teachers frequently have low self-efficacy in teaching mathematics and science, feel better prepared to teach life and earth sciences than to teach chemistry, physics, and engineering, and tend to avoid teaching the latter (Banilower et al., 2013; Brígido, 2013; Mateos-Núñez et al., 2020).

Korur et al. (2016) found that primary teachers who displayed negative attitudes toward teaching science, dedicated less time to scientific topics and their classes were more lecture-like. These teachers then generate these same feelings in their students, especially with female pupils (Legañoa et al., 2017).

Teachers tend to exhibit gender biases that might discourage girls from choosing STEM subjects (Hand et al., 2017). In particular, some international studies have indicated that teachers overestimate girls' language skills (Hinnant et al., 2009; Ready & Wright, 2011), while boys are considered to be better at math (Trautner et al., 2005; Wilkins, 2010), although they achieve the same levels of success. The analysis conducted by Hand et al. (2017) revealed significant gender role biases: on average, teachers reported that boys are better at STEM subjects and that girls are better at humanities.

Teachers tend to treat males and females differently, showing different attitudes and expectations based on gender (Tiedemann, 2002). The scientific literature confirms that these consequences for students: teachers' expectations influence preferences about school subjects and pupils' future aspirations (Van den Broeck et al., 2020). Therefore, children may end up expressing professional interests in line with previously learned gender stereotypes, drastically orienting their future career choices (Ramaci et al., 2017; Zysberg & Berry, 2005). Teachers who relate differently to boys and girls in the classroom based on gender differences often express benevolent sexism (Leaper & Brown, 2014).

Despite the importance of teachers' role in this process, teachers' effect on a primary school level is mostly ignored in interest and career research (Kim et al., 2015).

It's equally important to acknowledge that teachers' beliefs have a profound impact not only on the school and workplace atmosphere, but more importantly, on students' learning and their perception of self-efficacy starting from primary school (Cabras et al., 2022; Webb-Williams, 2018).

Summarizing the state of research, the vast majority of studies have shown significant lower self-efficacy in science and gender-related beliefs about science among teachers. Still, there is a lack of studies that analyze how university education can modify gender stereotypes.

Therefore, we aim to enrich the scientific discourse by answering the following three questions:

1. How do prospective primary school teachers perceive science teaching?

2. What beliefs do prospective teachers have about science and about female and male students' competencies in science?
3. How can prospective teachers' gender stereotypes change before and after a university course that addresses scientific content through active learning methodologies?

The data collected are not intended to be generalized, as they are strongly linked to the specific context in which the study was conducted. However, our findings can give us an indication for research on the relationship between gender-based differences in teachers' beliefs, their instruction, and the decisions they make in the classroom. Furthermore, the results of our study will reinforce the need to improve university training on gender-related issues.

## METHODS

The present research aims to investigate gender perceptions among a sample of prospective primary school teachers from Southern Italy. In this part of the country, unfortunately, the gender gap is more pronounced compared to the North (Venture & STEAMiamocci, 2020).

Our objective is twofold. On the one hand, we aim to understand how gender stereotypes can influence future teachers' perceptions of scientific disciplines. On the other hand, we seek to analyze how attending the university course "physics for primary school and kindergarten", part of the degree program in primary education sciences at the University of Palermo, can modify these gender stereotypes. The course, which is based on active learning methodologies, aims to foster reflection on this topic and on the crucial role teachers play in shaping students' self-efficacy perceptions.

This study can be considered a pilot study, as the data analyzed will be used in the future for several purposes. Firstly, to improve the core aspects of the course "physics education in primary school". Secondly, the insights provided by the participating teachers will serve as the basis for further research to be carried out in primary schools, with the goal of implementing innovative teaching methods to help reduce the gender gap in scientific disciplines.

To analyze the gender perceptions of future teachers, we submitted a questionnaire with open-ended and closed-ended questions to them at the beginning and end of the course "physics for primary school and kindergarten". Following this, a small sample of four students was interviewed to further explore perceptions and opinions on gender differences in scientific disciplines. We randomly selected three female students and one male student for the group.

### Data Analysis

The data were subjected to quantitative and qualitative analysis. According to numerous studies (Lune & Berg, 2017; Onwuegbuzie et al., 2012) a thorough examination of the language employed by students during interviews or questionnaire responses can offer insights into their beliefs and thoughts about a particular issue or problem.

The responses and interviews were analyzed by searching for "indicator words or utterances" and looking at specific aspects of the students' answers. This analysis of the semantic properties of their language was grounded in the distinction made by French psychologist Pauhlan between the sense and meaning of a word, emphasizing "the preponderance of the sense of a word over its meaning" (Vygotsky, 1986). Pauhlan describes sense as "the sum of all the psychological events triggered in our consciousness by the word. It is a dynamic, fluid, complex whole, with several zones of varying stability. Meaning is just one of these zones, the most stable and precise one. A word acquires its meaning from the context in which it is used; in different contexts, its sense changes" (Vygotsky, 1986, pp. 244-245).

### The Course "Physics for Primary School and Kindergarten"

The course "physics for primary school and kindergarten" is held during the fourth year of the degree course in primary education sciences.

It is divided into two parts: the first, lasting 43 hours, is characterized by lectures held in the classroom, during which some physics contents are addressed. Through lectures and exercises, students will learn about the concepts and measurement of length, surface, volume, the concept of mass and density, interaction between bodies and the concept of force, the laws of dynamics, the concept of energy and work, mechanical and thermal energy. Some basic concepts of electricity and magnetism, sound and light are also briefly introduced at the end of the course.

In the second part of the course, during a pedagogical workshop, lasting 16 hours during 4 meetings, the prospective teachers reflect on the didactics of physical concepts they previously studied, on pedagogical theories and on the variables to be analyzed within the classroom context. Through the planning of a teaching/learning unit aimed at primary school students, and the development of simple experiments and the use of computer simulations as part of the in-class activities, they can reflect and discuss their ideas in a collaborative and dynamic context.

A fundamental aspect of the second part of the course is the introduction to a specific teaching methodology that is widely used in the teaching of scientific disciplines: inquiry based science education (IBSE). A

fairly common definition of IBSE in the literature is the one given by Linn et al. (2004): "Inquiry is an intentional process of diagnosing problems, critically analyzing situations, distinguishing between various possible alternatives, planning study and exploration activities, constructing conjectures, searching for information, building models, comparing oneself in a peer context, and elaborating coherent arguments." Inquiry is therefore a process of active exploration. Through it, critical, logical, and creative skills are put in place to ask questions about situations of specific interest and commit to giving answers to these questions.

Therefore, the prospective teachers first study the basics of didactics of physics, and in the second part of the course they apply theory to practice. During the workshop, they must create a teaching/learning unit aimed at primary school under the supervision of experienced teachers as tutors. Prospective teachers are divided into groups: in cooperative learning mode, they carry out the didactic intervention by appropriately choosing some physics content and carrying out simple experiments to be proposed in their future classrooms. In the last part of the workshop, each group briefly presents their teaching/learning unit to the classmates.

At the end of the course, the pre-service teachers are submitted to a written test and an oral interview on physical concepts and discuss the teaching/learning unit they prepared during the workshop.

### The Research Sample

The research sample is composed of 119 prospective teachers, enrolled in the degree course in "primary education sciences" at the University of Palermo. They attend the fourth year of the course and have previously attended lectures on pedagogy and psychology, and on teaching other scientific disciplines (mathematics, biology, chemistry). Their ages range from 21 and 30 years old, and most of them come from small towns in the Sicilian hinterland.

Women account for almost all of the participants in the survey (110), while men account for only 9. The over-representation of the female gender in humanities courses is well known and reaches its peak here.

### The Questionnaire

The questionnaire consists of 8 questions: 6 of them are open-ended questions and 2 of them are closed questions. It was specifically created for this research, but some questions from two previously used questionnaires were also included. In particular, references are made to the studies of Guerrini (2015) and Huang and Fraser (2009). Both studies provide questionnaires on teachers' perceptions and the second specifically investigates the presence of stereotypes in scientific disciplines. The questions have been adapted to our context and have been changed from a Likert scale to open-ended questions.

The first group of questions analyzes subjective perception and personal relationships with scientific disciplines. It aims to understand how future teachers assess their competencies, whether they feel ready to teach these school subjects and what are their possible concerns or fears related to teaching science in the classroom.

The second group of questions is aimed at understanding the perception of gender differences in scientific disciplines. One of the objectives of the research is to find out how much this issue is felt in the training of the teaching staff and the teaching activity in the classroom. Future teachers were asked to answer questions about pupils' favorite subjects, interest in science disciplines, attitudes towards activities at school and gender stereotypes; underlining the differences between male and female students. The difference between interest and competencies is specifically emphasized to understand to what extent future teachers consider these aspects to be connected in the teaching-learning process.

The last group of questions examine pre-service teachers' perspectives on how in-service teacher training or classroom teaching should address gender issues. They ask if it might be useful to address gender-related techniques in teacher training and refresher courses and to organize information sessions on equal opportunities and gender differences.

The questionnaire underwent content validation with experts in Physics Education and face validation with fifth-year students from the same degree course.

## RESULTS

The questions in the questionnaire made it possible to deeply investigate different aspects of gender difference in the school environment. In particular, an exhaustive picture emerged of the ideas, self-evaluations, judgments of future primary school teachers and the relationship they have with scientific subjects. It was possible to make a comparison between the beginning and the end of the course "physics for primary school and kindergarten", observing the changes in perceptions and evaluations that occurred in the students.

The prospective teachers attending the course have almost reached the end of their training and have completed three years of internship. For this reason, the answers reflect the actual experiences lived and observed in the classroom, as well as the studies conducted.

The results are presented here in three sections, following the threefold breakdown of the questionnaire.

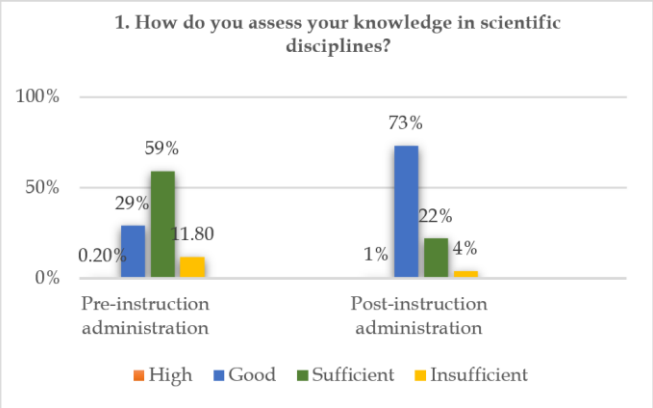


**Figure 1.** Comparison pre-/post-question n.1 (Source: Authors' own elaboration)

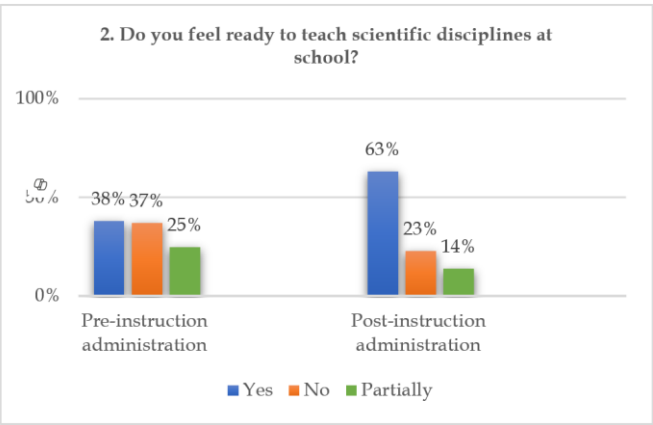


**Figure 2.** Comparison pre-/post-question n.2 (Source: Authors' own elaboration)

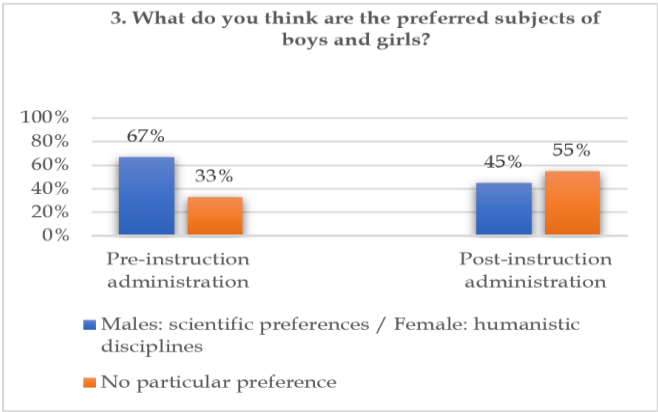


**Figure 3.** Comparison pre-/post-question n.3 (Source: Authors' own elaboration)

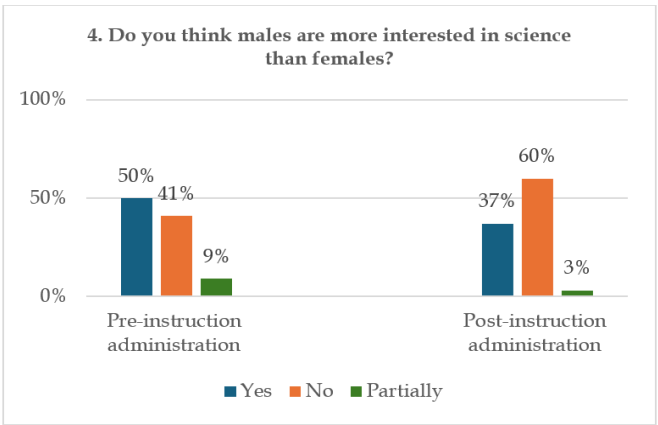


**Figure 4.** Comparison pre-/post-question n.4 (Source: Authors' own elaboration)

## Part I

The analysis of the pre-instruction administration shows that 59% of the prospective teachers think that they have basic or barely sufficient knowledge in scientific disciplines (**Figure 1**). 11.8% of them believe they have insufficient knowledge to teach scientific disciplines. At the same time, 62% of them do not feel completely ready to teach science subjects in primary school, due to fears mainly of a psychological nature (**Figure 2**). Conversely, only 37% of them feel fully prepared to teach in the classroom, thanks to previous courses taken in their course of study. 25% of them say they feel only partially prepared to teach scientific disciplines in school, indicating only some topics or only the first grades of primary school.

From the analysis of the post-instruction administration, the preferences expressed in one's preferred disciplines remain almost unchanged. However, there is a variation in the self-assessment of their skills and the majority of respondents (75%) rate theirs better, describing them as good or adequate (**Figure 1**). In addition, the percentages of those who believe they have insufficient knowledge to deal with the school teaching of scientific disciplines have decreased, from 11.8% in the 1st administration to 4% in the 2nd (**Figure 1**). The percentages of those who do not feel absolutely ready to teach scientific disciplines have decreased from 37% to 23% (**Figure 2**).

## Part II

The second group of questions aims to understand what the actual perception of gender differences in scientific disciplines of future teachers is.

During the pre-instruction administration, 67% of respondents stated that "Girls prefer humanistic subjects while boys prefer scientific subjects" and 33% of respondents said that "I don't think there are disciplines that girls prefer and others that boys prefer" (**Figure 3**). The difference between those who support traditional and non-traditional preferences is therefore marked.

In question n.4, the research sample is almost equally divided in believing whether boys are more interested in scientific disciplines than girls, with 50% of responses favorable (**Figure 4**).

Conversely, in the post-instruction administration, the percentages are significantly different: 55% of prospective teachers say that there are no differences between the subjects that the children prefer (**Figure 3**). The percentage of those who advocate differentiation in

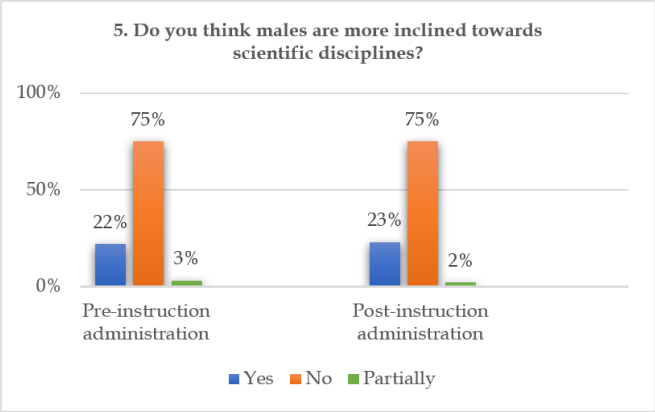


**Figure 5.** Comparison pre-/post-question n.5 (Source: Authors' own elaboration)

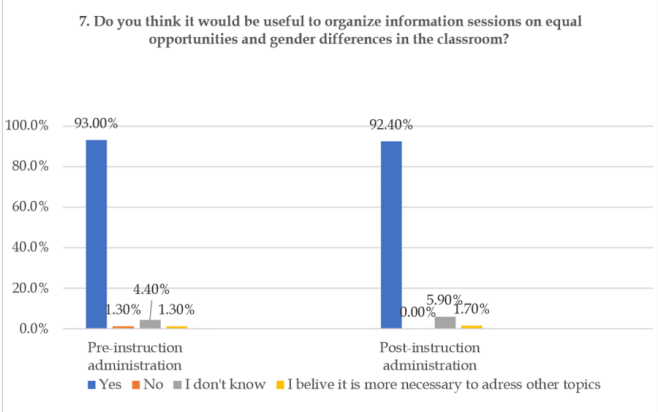


**Figure 7.** Comparison pre-/post-question n.7 (Source: Authors' own elaboration)

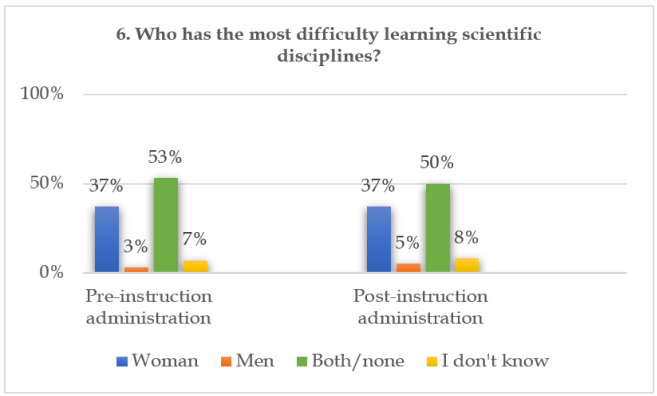


**Figure 6.** Comparison pre-/post-question n.6 (Source: Authors' own elaboration)

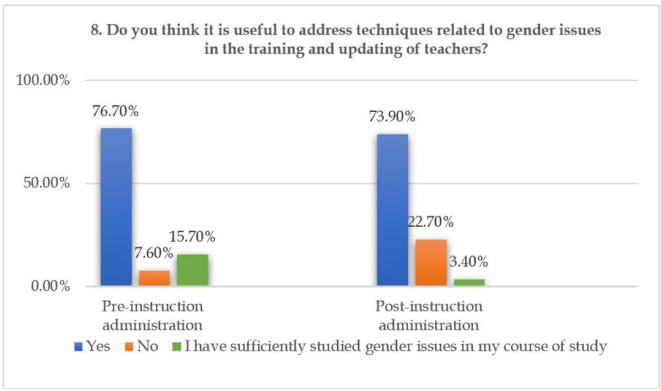


**Figure 8.** Comparison pre-/post-question n.8 (Source: Authors' own elaboration)

interest based on gender decreases from 50% to 37% (**Figure 4**). In both administrations of the questionnaire, about 75% claim that males are not more gifted and competent than females, as "Preferring is not synonymous with being talented".

The prospective teachers state that males show more interest in scientific disciplines (**Figure 5**), but this interest does not seem to be correlated with better abilities or better outcomes ("greater interest does not imply better abilities"). The percentages between the pre and post instruction administration have not substantially changed (**Figure 5**).

Answers to question n.6 allow us to do a deeper examination of the ideas already highlighted in answers to the previous question. It is asked who encounters more difficulties in scientific subjects among males and females. It is well known that one of the most deeply rooted prejudices in the conception of common sense is that the male, in addition to being more interested, is also by nature more inclined to mathematical-scientific disciplines (Master, 2021). In contrast, women should have more difficulties because of their high emotionality which prevents the study of such "hard" disciplines.

In both the pre-administration and post-administration (**Figure 6**), just over half of the prospective teachers say that "The difficulties encountered in learning are not gender-related." On the other hand, 37% think that women encounter more difficulties, due to low interest, low self-esteem, fewer stimuli and greater emotionality.

It is significant that only 3% of respondents said that men have more difficulties; in fact, common sense shows that it is unusual to think that a man may encounter greater difficulties than a woman in scientific disciplines.

## Part III

In question n.7, the prospective teachers could choose from among three different closed-end answers. In both the pre- and post-instruction phases, over 93% of participants responded that they believe it is useful to organize classroom meetings and activities to discuss gender differences with students (**Figure 7**).

Similarly, in question n. 8 more than 70% of prospective teachers believe it is useful to address techniques related to gender issues in the training and professional development of teachers and over 90% believe it is useful to organize information sessions on equal opportunities and gender differences in classes (**Figure 8**).

**Table 1** presents a summary outline of the questionnaire, divided into three sections (**Appendix A**).

**Table 1.** Summary table of the questionnaire

| Thematic | Questions |
|---|---|
| Part 1. Teacher's self-efficacy in science | 1 & 2 |
| Part 2. Teacher's gender stereotypes | 3, 4, 5, & 6 |
| Part 3. Teacher gender training | 7 & 8 |

In summary, the first part of the questionnaire revealed that prospective teachers, who were almost exclusively women, demonstrated low self-efficacy in scientific subjects. The results showed some improvement in the post-administration. The second part of the questionnaire highlights that, even among prospective teachers, many gender stereotypes related to women and science subjects are widespread. For example, many of them stated that boys are more interested in science than girls and that girls have more difficulty with scientific subjects. These beliefs showed a change in the post-administration.

Finally, in the last part of the questionnaire, both in the pre and post-administration, prospective teachers expressed the need to include gender-related topics more prominently in both their initial training and ongoing professional development.

## The Interviews

After analyzing the responses from both questionnaire administration, some particularly significant answers were selected. Some of them highlighted advanced knowledge and reflections on the topic, while others were stereotypical. On the basis of these responses, a small sample of four students (three women and one man) was randomly chosen to conduct a brief interview, with the aim of exploring these opposing views in more depth. Three women were drawn from the women's sample and one man from the men's sample to gain representation of both genders. The interviews were carried out individually with each one of the four prospective teachers and lasted 15 minutes.

Each interviewed prospective teacher was asked to explain more about the answers provided in written form in the questionnaire, in order to analyze further details useful for understanding in depth their point of view on gender differences in scientific disciplines. In addition, the following questions not included in the questionnaire were asked to facilitate and broaden the discussion.

1. Can you tell me about some episodes that you observed during the internship in the classroom and that particularly struck you about the gender difference?
2. Do you notice a difference in the interests of boys and girls in their school subjects? If yes, which ones?
3. Why do males seem to be more interested in science than females?
4. Do, in your opinion, girls think they are worse at scientific disciplines?
5. What could help pupils to have fewer difficulties in studying scientific subjects?

Two of the interviewed prospective teachers said that they re-evaluated the importance of the gender variable only after attending the course and taking the questionnaires. Previously, they had not given particular importance to this issue, as they believed that gender equality in the school environment had been achieved.

The first and the second respondents present a stereotypical view and unconscious biases. They only partially recognize the influence that gender stereotypes have on students.

The first one has not developed an awareness that socio-cultural constraints represent the most powerful explanatory factor for performance differences between sexes (Spelke, 2005). He claims that boys generally prefer scientific subjects because science is more practical but adds that both genders are equally capable.

The future teacher has not fully understood the effects that gender biases can have on female students' perception of self-efficacy (Webb-Williams, 2018). He believes that girls perceive themselves as confident and with higher science self-efficacy, overlooking the potential influence of societal expectations and stereotypes.

However, he emphasizes the role of stereotypes that begin to settle during primary school and then manifest themselves strongly over the following years. The school must work in synergy with the family, the main place for the spread of prejudices and stereotypes.

The second respondent argues that males and females show a different interest in scientific disciplines, and this is caused both by the biological factor, that determines general characteristics that differ between boys and girls, and by the influence of gender stereotypes. However, recent research suggests that the lack of women in STEAM courses is not due to genetic reasons or a lack of ability, but rather to socio-cultural factors (Corbett & Hill, 2015; Hill et al., 2010; Schmader, 2022). These beliefs are also held by teachers and suggest that men may have a natural disposition for mathematics (Reuben et al., 2014) and the sciences (Hinnant et al., 2009) while women may have innate abilities for language (Johnson et al., 2017).

During the interview, the student argues that the lower interest generally shown by female students is not related to lesser abilities or skills in scientific disciplines and emphasizes the role of the family in transmitting gender stereotypes. She highlights the central role of the school, which must help the student build a self-image that is not the result of acquired preconditioning.

The third and the fourth interviewees acknowledge that gender stereotypes can influence students'

expectations and how they approach the subject. They observe differences between males and females in science learning. In particular, they observe that boys often have more positive attitudes towards science and are more interested. In line with studies in the literature (Corbett & Hill, 2015; Gonzalez et al., 2021; Schmader, 2022) they assert that this is caused by the strong impact that stereotypes have on students starting as early as primary school (Webb-Williams, 2018).

During the interview, both interviewees emphasize the central role of teachers and the school, which must create an inclusive environment where both boys and girls feel equally encouraged to pursue scientific studies without being influenced by societal expectations or biases.

Additionally, the last interviewee focuses on students' perception of self-efficacy in science. She argues that girls often see themselves as less capable and less skilled compared to their male peers. This finding aligns with research in this area that demonstrates lower self-efficacy among female students at various levels of education (Firat, 2020; Gilchrist, 2024; Nissen et al., 2016; Marshman et al., 2018a, 2018b).

In summary, it emerged that two of the interviewees attribute standardized attitudes and behaviors to the two sexes, where males are described as those who need more concrete feedback, have greater manual skills, are less talkative, more logical, and at the same time restless. Conversely, girls are described as more studious, calm, and reflective. The other two interviewees are more aware of how gender stereotypes affect students.

In line with previous studies (Firat, 2020) all interviewees acknowledged the severity of this issue at the primary school level and they propose cooperative methodologies that foster peer relationships to promote inclusive learning.

Each of them assigns a different value to the impact that gender biases can have on students. Their different ideas represent different levels of awareness of how stereotypes can influence students' educational and subsequently professional choices, ranging from those who advocate the importance of genetic/biological factors that somehow orient the two genders towards different fields to those who are clear about the role of the conditioning we are subjected to daily. The interviews correspond in a representative manner to the positions emerged from the analysis of the responses provided in the questionnaire.

## DISCUSSION

Regarding the first research question (i.e., *How do prospective primary school teachers perceive science teaching?*) the following can be concluded. Most prospective primary school teachers perceive science teaching as difficult and show low self-efficacy, describing themselves as poorly prepared and lacking competence.

In particular, in the pre-test they considered themselves inadequately prepared for scientific disciplines due to a lack of knowledge and experience, they doubted their teaching potential and considered the topics too demanding and difficult. Some of their claims were "*I definitely think that scientific subjects are more difficult to make understandable*", "*not being able to express myself well*", and "*the greatest difficulty I could encounter is not being able to adequately convey scientific content, as they are difficult for a primary school child to understand*". The choice to use the verb "convey" is not accidental: it highlights the conscious and/or unconscious tendency to perceive teaching as something the teacher must convey to their students, according to a traditional perspective.

These results are consistent with the studies present in the literature; it is well known that teachers often perceive themselves to have insufficient STEM knowledge, have heard about the concept of STEM but could not explain it (Nadelson et al., 2013; Ren et al., 2016). Unfavorable experiences in these subjects lead to teachers with these dispositions (negative predispositions or attitudes, anxiety, low self-efficacy, etc.), who risk passing the same feelings on to their students (Legañoa et al., 2017). In particular, given that most primary teachers are women, their negative attitudes toward science are more likely to have an influence on girls than on boys (Anedda & Collet, 2019; Beilock et al., 2010; Finlayson, 2014; Gurin et al., 2017;).

In the post-instruction administration, it is possible to observe an improvement in the level of self-efficacy: about 20% (**Figure 1**) of the sample reported feeling more competent and consequently more prepared for classroom teaching. However, most prospective teachers continued to state that they don't feel fully ready to teach scientific disciplines, and they expressed fear of not being able to engage students or boring them.

The results from this study suggest that it is possible to actively modify self-efficacy and confidence toward scientific subjects through active and engaged participation in a university course. In fact, prospective teachers who received integrated training with physics content and pedagogy gained greater self-esteem, which can have a significant impact on their professional development (Cabras et al., 2022; Navarro et al., 2022).

The second and third research questions are closely related. They aimed to understand whether prospective teachers hold gender biases in science teaching and how these biases changed after attending the course "physics education for primary and early childhood education".

The results of the pre-test show a strongly stereotypical view of prospective teachers. In the pre-instruction administration they stated in various responses that girls prefer verbal language and oral

explanation, while boys prefer scientific disciplines that utilize mathematics. Most of the analyzed sample supports the stereotype of science/math = male, humanistic subjects = female, attributing pupils' preferences and interests to gender. A small percentage of respondents cited studies on the biological differences between male and female brains that they had read during their degree program, which supposedly lead pupils to develop certain skills more easily than others.

These results would be consistent within the literature. Research has shown that teachers tend to exhibit gender biases which may be discouraging to girls that would otherwise be interested in STEM fields (Cabras et al., 2022; Hand et al., 2017; Wendt & Rockinson-Szapkiw, 2018). Teachers suggest that men may have a natural disposition for sciences (Erden & Wolfgang, 2004), while women may have innate abilities for language (Hinnant et al., 2009).

In our study, by the end of the course, some differences in the beliefs of aspiring teachers were observed. The percentage of those who supported stereotypical preferences between males and females decreased from 65% to 45% (**Figure 3**), as did the percentage of respondents who believe that males are more interested in scientific disciplines, which decreased from 50% to 37% (**Figure 4**). In addition, in the answers of post-instruction administration they no longer make constant references to observed differences in males and females but rather attribute the causes: "to psychological reasons and cultural conditioning that lead boys to choose scientific fields more and girls to choose humanities fields" or "a social issue that leads some to claim that boys are more interested in scientific disciplines than girls".

The course has certainly led to a greater awareness of the impact that the social and cultural context can have on pupils' preferences and choices.

In line with other studies (Merma-Molina, 2003; Lindner et al., 2022), the results suggest that targeted training can help teachers recognize and overcome their own biases.

Despite the effectiveness of the course, 23% of respondents (**Figure 5**) still believe that boys are more inclined towards scientific disciplines, and almost 40% of the sample (**Figure 6**) believes that girls may encounter greater difficulties in studying scientific disciplines. They cite various reasons: lack of interest ("*Women have more difficulties, perhaps because they are less interested and less motivated*"), low self-esteem ("*Women, but only due to the mistaken belief that they are not suited*"), lack of stimuli, being more emotional.

As indicated by several studies (Farnworth et al., 2023; Mhlanga & Goronga, 2024) an integrated approach that generates gender-equitable behaviors is needed to eliminate gender stereotyping in society.

The data collected in the pre and post-tests for question 7 and question 8 confirm the lack of attention to these issues both in initial training and in-service training, as already indicated in Guerrini's (2015) research. The topic of gender is not an integral part of teacher training in Italy, unlike in Belgium, the United Kingdom, France, Austria, and the Netherlands (Scantlebury, 2014).

From the analysis of the responses, we can affirm that the course has led to extensive and profound reflections on the topic of gender, but the issue remains open. For aspiring teachers, it is essential to fully understand the strong connection between interest and the development of competencies, as well as the impact that stereotypes can have in influencing the educational and career choices of future citizens.

## CONCLUSIONS

Scientific research is increasingly addressing the complex issue of gender disparities and actively seeking to reduce the gap between men and women in STEM fields (OECD, 2022). Increasing teachers' awareness of gender stereotypes through professional development is an urgent need to promote gender equity in STEM fields and improve social justice in K-12 education (Kuchynka et al., 2022).

To achieve this, it is essential to start with the training of prospective teachers, as they play a crucial role in educating the next generations and can either reinforce or reduce the impact that stereotypes may have on students (Zhou et al., 2023).

The present study analyzes the beliefs and ideas of prospective teachers on gender issues and, in line with recent literature (Lindner et al., 2022; Martínez-Galaz et al., 2024), highlights how academic education–when implemented through an active, hands-on course–can influence prospective teachers' perceptions of gender stereotypes and, consequently, their teaching practices.

The findings show that most future primary school teachers have low self-efficacy in science and consider teaching this subject to be difficult. This contributes to reinforcing gender stereotypes (Kazempour, 2014; Firat, 2020). From the responses analyzed, it emerged that common gender stereotypes–such as the belief that women are less inclined toward science–are still widespread among prospective primary school teachers. These results are consistent with several studies in the literature (Kazempour, 2014; Mateos-Núñez et al., 2020; Navarro et al., 2022).

The course physics for primary school and early childhood education addressed multiple aspects: physics content, practical labs, and guided discussions were all included. These components contributed to improving prospective teachers' self-efficacy and promoting constructive reflection on gender differences in science. Prospective teachers have partially modified

their ideas and beliefs about pupils' interests and preferences, moving away from a stereotypical view and understanding the importance and impact of stereotypes on students' lives and self-perception, reflecting extensively on the teacher's role in this process.

Although the teachers' views on science and students' abilities are clearly gender-related, discussing assumptions about the influence of gender is rarely seen as an important facet of a teacher's pedagogical knowledge (Hussénius et al., 2013; Scantlebury, 2014).

On the other hand, this study supports the hypothesis that content knowledge is necessary but insufficient in preparing highly-qualified teachers (Navarro et al., 2022). Promoting courses and activities aimed at studying gender differences during the initial teacher training is effective in addressing gender disparities in STEM education. Attention to gender differences, already during the initial teacher training, has promoted new reflections, fostering a new awareness among students. Therefore, introducing the study of this topic during university education will allow teachers to personalize and improve their teaching practice, making it even more effective.

The results of this study confirm the need to act on initial teacher education in order to simultaneously improve their competencies, their sense of scientific self-efficacy and promote inclusive teaching practices aimed at addressing gender disparities (Lindner et al., 2022; Navarro et al., 2022; Thaba-Nkadimene, 2024).

In summary, to promote greater gender equality in the teaching and learning of science, as well as in the future career choices of girls, it is crucial to enhance primary teacher education, shifting beyond a purely subject-based approach.

**Author contributions: GG & CF:** resources, visualization, writing – review & editing; **GG & ORB:** conceptualization, data curation, formal analysis, funding acquisition, investigation, methodology, software, validation, writing – original draft; **CF & GT:** conceptualization, data curation, supervision, validation; **GG:** writing – original draft; **CF & ORB:** conceptualization, data curation, funding acquisition, methodology, project administration, software, supervision, validation; **GG & GT:** conceptualization, formal analysis, methodology, software, supervision, writing – original draft. All authors agreed with the results and conclusions.

**Funding:** No funding source is reported for this study.

**Ethical statement:** The authors stated that the study does not require any ethical approval. The data were collected anonymously. No interaction or intervention with human subjects was involved. It is a retrospective analysis of archival data. The dataset used is fully de-identified, with no direct or indirect identifiers that could be used to re-identify individuals. The authors further stated that the data do not include private, sensitive, or confidential information. The study adhered to the ethical principles of the American Psychological Association ethical standards.

**Declaration of interest:** No conflict of interest is declared by the authors.

**Data sharing statement:** Data supporting the findings and conclusions are available upon request from the corresponding author.

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## APPENDIX A: THE QUESTIONNAIRE

Sex: _____

Age: _____

### I° Part

1. How do you assess your knowledge in scientific disciplines?
2. Do you feel ready to teach scientific disciplines at school?

#### II° Part

3. What do you think are the preferred subjects of boys and girls?
4. Do you think males are more interested in science than females?
5. Do you think males are more inclined towards scientific disciplines?
6. Who has the most difficulty learning scientific disciplines?

#### III° Part

7. Do you think it is useful to address techniques related to gender issues in the training and updating of teachers?
8. Do you think it would be useful to organize information sessions on equal opportunities and gender differences in the classroom?