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Future primary teachers and pedagogical interactions with boys and girls

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Abstract

This study analyzes the interactions based on student gender that are promoted by future primary school teachers, with three distinct profiles in the subjects of natural sciences and math. The three teacher profiles combine socioemotional variables related to the teaching of these two subjects and variables related to gender bias. 17 class videos of both mathematics and natural sciences in the context of pre-service teacher preparation were analyzed regarding the interactions that took place. A prevalence of interactions directed towards boys was found. Regarding the type of profile, it was found that pre-service teachers with masculine traits promoted more interactions with gender equity. The implications for primary teacher preparation and for the creation of school environments in which girls are encouraged to engage in mathematics and natural sciences are discussed.

Keywords: pedagogical interactions, pre-service teachers, primary school education, gender biases, socioemotional variables

INTRODUCTION

For a long time, the belief that women possess lower cognitive abilities than men in science and mathematics has been perpetuated (Wang & Degol, 2013). Nevertheless, there is ample evidence that shows that this belief is a consequence of gender stereotypes that are present and reproduced in our culture, especially in the school system (Sakellariou & Fang, 2021), progressively alienating girls from these disciplines (United Nations Educational Scientific and Cultural Organization [UNESCO], 2019).

In fact, schools are not free from stereotypes; these are implicitly transmitted to students through the interactions that take place within them (Denessen et al., 2022), such practices could explain the gender gaps in the subjects of mathematics (Espinoza & Taut, 2016) and natural sciences (Danielsson et al., 2023). Primary school teachers have a crucial role as they are the first representatives of the scientific community with whom children will interact (Michaluk et al., 2018).

With the purpose of improving primary education, the focus has long been placed on teachers' disciplinary mastery (Riegle-Crumb et al., 2015; Varas et al., 2018). As relevant as content knowledge is, it is also necessary to consider the socioemotional dimension of being a teacher. In effect, future teachers are influenced by a set of beliefs, attitudes, and emotions regarding the teaching and learning of different school subjects, which are linked to their own school experience (Korur et al., 2016; Verdugo et al., 2017).

Furthermore, a teacher's negative socioemotional inclinations toward mathematics and science are transmitted to their students (Legañoa et al., 2017; Lewis, 2015; Oppermann et al., 2019; Van der Sandt & O'Brien, 2017; Yu et al., 2023), and to a greater extent to female students (Espinoza & Taut, 2016; Fournier et al., 2020; Ortega et al., 2020). These inclinations are mediated by the teacher's own gender biases, which are also transmitted to their students (Ortega et al., 2020; UNESCO, 2019), reproducing the belief that boys are better than girls in mathematics and science (Finlayson, 2014; Gurin et al., 2017; Lewis, 2015; Yu et al., 2023).

Hence, accounting for socioemotional variables, existing gender biases, and the impact of pedagogical interactions is fundamental for improving primary teachers and primary teacher education and for equity in the learning of mathematics and science (Mizala et al., 2015). Thus, the purpose of this study is to analyze the interactions promoted by pre-service primary school teachers in the subjects of mathematics and science, considering socioemotional variables associated with the

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Contribution to the literature

- The article shows that many pedagogical interactions in science and mathematics classes occur between the female pre-service teacher and male students, either because the pre-service teacher addresses them directly or because boys initiate interactions with the teacher.
- The article shows that the most prevalent pedagogical interactions in science and mathematics classes do not promote complex cognitive skills in neither boys nor girls. It shows that female pre-service teachers with high masculinity and low submission promote pedagogical interactions with more equitable gender participation in science and mathematics classes.
- The article shows that female pre-service teachers characterized by traits of indecision, passivity, and insecurity in teaching science or mathematics promote pedagogical interactions that occur more frequently with boys.

teaching of these subjects, the teachers' gender biases, and the gender of the students.

Pedagogical Interactions and Gender Gaps in Science & Mathematics

International evidence concerning the pedagogical interactions between teachers and students shows that these differ based on student gender: the interaction rate between teachers and male students has been found to be higher than the rate between teachers and female students (Ortega et al., 2020). Minasyan (2017) argues that male students demand more attention and instructions from their teachers than female students due to their disruptive behavior and are reprimanded by their teachers more than their female peers. Furthermore, the author suggests that boys tend to be more active, answering more questions than girls, regardless of whether they raise their hands or not. On another note, Mamnoun and Nfissi (2023) point out that teachers ask male students more cognitively demanding questions than their female counterparts.

Several studies have been conducted in Chile regarding this issue. Espinoza and Taut (2016) examined the interactions taking place during math, working with 20 7th grade teachers (primary education in Chile is divided into grade 1-grade 8 for children between six-14 years of age). They found that teachers interacted less with female students and that these interactions were less challenging in terms of the cognitive abilities they required, whereas teachers' interactions with their male students included approximately twice the number of questions and required more cognitively complex tasks, such as arguing, elaborating, inferring, and transferring. Moreover, it was observed that female students participated three times less than male students (both spontaneously and directed) and received less feedback from their teachers. Another study carried out in Chile (Ortega et al., 2020) analyzed 79 audiovisual observations of mathematics classes and found that girls interacted with their mathematics teachers with less frequency, both in interactions initiated by the teacher and by the students themselves.

Teacher Variables Associated with Gender Gaps in Science & Mathematics Attitudes Towards Teaching Science & Mathematics

Attitudes represent an organization of beliefs about an object that predisposes individuals in their actions towards that object (Moscovici, 1985). Therefore, attitudes towards teaching science and mathematics can be understood as a teacher's or future teacher's predisposition to act favorably or unfavorably towards the teaching of these disciplines. Teachers with favorable attitudes towards teaching science and mathematics foster a positive predisposition towards these subjects and an interest in pursuing scientific careers (Kazempour, 2014; Wendt & Rockinson-Szapkiw, 2018), while unfavorable attitudes are related to lack of knowledge, insecurity in teaching, and disliking science and mathematics (Korur et al., 2016). These predispositions are transmitted to their students, especially to girls (Legañoa et al., 2017; Van der Sandt & O'Brien, 2017; Yu et al., 2023). This higher susceptibility in girls can be explained by gender identification with their female teachers; this effect could be heightened given the high proportion of female primary school teachers globally. In Chile, 78% of primary teachers are female (Ministerio de Educación [Ministry of Education] [Mineduc], 2017).

Self-Efficacy in Teaching Science & Mathematics

According to Bandura (1997), self-efficacy consists of two dimensions:

(1) outcome expectancy, which corresponds to a person's belief that their behavior will produce the expected results and

(2) personal efficacy, which is a person's confidence in executing actions that lead to achieving a goal.

In this sense, self-efficacy in teaching science and mathematics can be understood as a teacher's or future teacher's belief in procuring student learning in these disciplines and confidence that their pedagogical actions will enable them to do so. Teachers with higher self-efficacy display a willingness to change their teaching methods, persistence while facing challenging situations

Table 1. Types of profiles of future female teachers according to Navarro et al. (2022)

Type of profile	Level	Description
1	High masculinity & low submission	Teachers in training characterized by being competitive, decisive, self-confident, & with good leadership skills.
2	Low masculinity, high submission, low attitude towards teaching science & mathematics, & low self-efficacy in teaching science & mathematics	Teachers in training characterized as insecure, indecisive, passive, & conformist. They feel nervous when it comes to teaching science or mathematics & believe that science & mathematics are difficult.
3	High femininity, high attitude towards teaching science & mathematics, & high self-efficacy in teaching science & mathematics	Teachers in training characterized by being generous, understanding, & cooperative. They think that science & mathematics should be taught as soon as possible; they feel happy teaching these subjects; think they can successfully solve mathematics problems; & declare that they will look for better strategies to answer doubts of their students.

(Chan & Lay, 2021; Menon & Sadler, 2016; Verdugo et al., 2017), and confidence in their positive impact on scientific (Menon, 2020) and mathematical (Peker et al., 2018) learning. Conversely, lower self-efficacy translates into teachers who favor theoretical classes (Mateos-Núñez et al., 2020), and avoid scientific inquiry (Menon & Sadler, 2016). An association has been observed between teachers who declare having had negative experiences with science and mathematics in their own school trajectory and lower self-efficacy in teaching these disciplines (Menon & Sadler, 2016; Nelson, 2015).

Gender Stereotypes of Pre-Service Teachers in Science & Mathematics

Gender stereotypes correspond to deeply rooted cultural patterns established from an early age (Banjong, 2014), defining different expectations for men and women, and creating incompatibilities towards certain disciplines or careers (Del Río et al., 2013; Dunkake & Schuchart, 2015; Mizala et al., 2015; Shepherd, 2016; Thomas, 2017; UNESCO, 2019). Teachers are not exempt from these beliefs and may presuppose that men have innate abilities in science (Reuben et al., 2014) and mathematics (Espinoza et al., 2014). Hence, success in girls is attributed to their effort, while in boys, it is attributed to their natural abilities (Espinoza et al., 2014). At the level of pedagogical interactions, teachers transmit biased and implicit messages that can affect girls' self-concept and self-efficacy, ultimately limiting their participation in science and mathematics (de Kraker-Pauw et al., 2016; Del Río et al., 2013; Espinoza & Taut, 2016).

PRESENT STUDY

The background presented makes it evident that there is a need to delve deeper into initial teacher education regarding pedagogical interactions and the variables that may be associated with the disadvantageous difference in treatment of girls in science and mathematics classes.

Therefore, the aim of this study is to analyze the interactions promoted by pre-service primary education teachers in the subjects of science and math, based on student gender and considering socio-affective variables associated with the teaching of these subjects and gender biases. This aim can be broken down into the following research questions:

1. What pedagogical interactions are promoted, with frequency, by pre-service primary teachers in the subjects of science and math, according to student gender?
2. What are the characteristics of the pedagogical interactions based on student gender, considering socio-affective variables and gender biases, of pre-service primary education teachers?

METHOD

Participants

Using a convenience sample, 15 female pre-service primary school teachers finishing their senior year were selected from a private university in the Metropolitan Region of Chile. 17 class videos were analyzed, which corresponded to an audiovisual record that the pre-service teachers had to carry out as part of their practical training in science and mathematics in different schools.

Table 1 shows the classification of the pre-service teachers into three profiles according to a hierarchical cluster analysis carried out in a previous study (Navarro et al., 2022). This multivariate statistical technique establishes groups with high degrees of internal homogeneity (intra-cluster) and external heterogeneity (inter-clusters) (Battaglia et al., 2017), considering the following variables: attitudes towards teaching science or math, self-efficacy in teaching science or math, and personality traits associated with gender (femininity, masculinity, machismo, and submission). To establish the number of groups, Ward's method and the dendrogram graphic were used.

The participants were selected from a universe of 52 female pre-service primary school teachers, considering three criteria: that the three mentioned profiles were represented (Navarro et al., 2022), that there was an audiovisual record of a complete science or mathematics class, and that this class had been conducted in a

Table 2. Video descriptions

Participant	Video	Profile	Level	Subject	DC	NAS	NUS	n
1	1	1	Fourth	Science	45.0	90	0	19
2	2	1	First	Science	45.0	90	0	26
3	3	1	Fourth	Science	45.0	90	0	20
4	4	1	Sixth	Science	45.0	65	25	17
5	5	1	First	Science	40.0	75	5	20
6	6	1	Fourth	Science	45.0	87	3	24
7	7	2	Third	Mathematics	45.0	90	0	15
8	8	2	Fifth	Science	45.0	88	2	34
9	9	2	Fourth	Mathematics	45.0	74	16	21
10	10	2	Fifth	Science	45.0	90	0	11
10	11	2	Fourth	Mathematics	34.5	69	0	25
11	12	3	Third	Science	45.0	90	0	39
12	13	3	Fourth	Science	45.0	90	0	28
13	14	3	Fourth	Science	45.0	90	0	27
13	15	3	First	Mathematics	38.5	77	0	24
14	16	3	Third	Science	34.0	68	0	34
15	17	3	First	Mathematics	28.0	55	1	20

Note. DC: Duration of class (minutes); NAS: Number of analyzed segments; NUS: Number of unanalyzed segments; n: Number of students

coeducational school context. The content to be taught was not a selection criterion because female pre-service primary school teachers are distributed across different courses and therefore the content varies. Finally, 15 participants were chosen, two of whom had audiovisual records for both a science and a mathematics class, which is why 17 videos in total were analyzed.

Video Encoding Procedure

Analysis material

17 videos of science and mathematics classes of pre-service primary teachers were analyzed. The classes were recorded showing a panoramic vision of the classroom, and the camera followed the future teacher whenever necessary, for example, when monitoring work in small groups. Likewise, the recording had to incorporate evidence of the work done by the students, notebook images, written productions, etc.

Observation unit

Each observation was determined to be approximately 45 minutes of class (in Chile a pedagogical hour is considered 40 to 45 minutes), the average observed class time was 42 minutes. Each recorded class was subdivided into 30-second observation segments (Degol & Bachmann, 2015). Thus, for example, a 45-minute class consisted of 90 observation or analysis segments or units. In total, 1,430 segments were analyzed; 52 of these units presented audio difficulties and were eliminated, leaving a total of 1,378 segments. The characteristics of the videos are found in **Table 2**.

Data Collection Technique

For the coding of pedagogical interactions according to gender, the coding scheme designed by Espinoza and Taut (2016), based on national and international studies (Hennessy et al., 2016; Preiss, 2009), was used.

Table 3 shows the coding scheme of the observed codes (17) and the type of interactions represented. This scheme was applied to each observation unit (30 seconds), quantifying the occurrence of the code in each segment, and distinguishing whether the teacher's intervention was directed toward or originated from a girl or boy.

Consistency of Analysis

The observation of 17 videos was carried out by four coders. To safeguard the consistency among coders, the procedure of Leyva et al. (2018) was followed.

(a) The first training phase consisted of two stages; in the first one, four videos were coded jointly (24% of the total sample). This step made it possible to unify the criteria for assigning the codes; in case of doubt, the observation was stopped, and the differences were discussed until an agreement was reached. The second stage of training consisted of independent coding of three videos (18% of the total sample). Subsequently, as a measure of consistency between coders, the intraclass correlation coefficient was calculated; the result was .95, which is considered excellent (Koo & Li, 2016). Once this level of consistency was reached, it was possible to move on to the next phase.

(b) the coding phase in which the ten remaining videos were independently analyzed by three coders. The videos were distributed among the

Table 3. Encoding scheme

Type of interaction	Description of the type of interaction
Pseudo-question	Teacher's questions related to classroom management, not linked to a subject or rhetorical questions, or questions to complete a word or phrase.
Simple question	Closed questions from the teacher related to the subject. They are answered with one or two words. Appeal to the memorization of isolated pieces of information, as well as known content.
Complex question	Open questions from the teacher related to the subject that require students to apply, elaborate, organize, deepen, justify, argue, relate to everyday life or personal experience, transfer, make conjectures or hypotheses, give meaning to the content of the class, among others.
Mechanical response	Rhetorical or mechanical responses from students that do not reflect reflection or elaboration, done in unison or individually. It also includes responses to complete a word or phrase that the teacher leaves partially spoken.
Simple response	Dichotomous responses from students related to the content, involving specific words or concepts. Reflect memorization of isolated pieces of information.
Complex response	Responses from students that show elaboration, organization, or deepening of disciplinary content. They include justification, argumentation, hypothesis establishment, or relate to personal experience.
Spontaneous comment or question	Comments or questions from students that do not respond to a question from the teacher or another student. They may refer to aspects of classroom management or disciplinary content.
Neutral or ambiguous comment	Teacher's response with monosyllables or does not clearly indicate if the student's comment is evaluated positively or negatively.
Blockage	The teacher blocks or ignores a question or comment from a student, changing the topic or addressing another student.
Deepening	The teacher uses a student's intervention to delve deeper into the topic.
Simple positive evaluation	Student's response or comment is evaluated by teacher as correct, through a short word or phrase.
Elaborate positive evaluation	Student's response or comment is evaluated by teacher as correct, adding justification or a comment.
Simple negative evaluation	Student's response or comment is evaluated by teacher as incorrect, through a short word or phrase.
Elaborate negative evaluation	Student's response or comment is evaluated by teacher as incorrect, adding justification or a comment.
Use of appellations	Teacher addresses a student using an appellation, name, last name, nickname, diminutive.
Stereotyped role	Use of examples, teaching materials, or assignment of roles typically associated with being a woman or a man.
Counter-stereotypical role	Use of examples, teaching materials, or assignment of roles that are atypical compared to what is typically associated with being a woman or a man.

coders, ensuring variability of the profiles of the future teachers in the classes to be analyzed.

Data Analysis

Descriptive analysis

First, descriptive analyses were conducted, such as counting and calculating means and standard deviations for each interaction type based on student gender and the prospective teacher's profile.

Inferential analyses

Second, independent samples t-tests were performed to compare pedagogical interactions based on the student's gender within each profile of the prospective primary school teachers. Third, a one-way analysis of variance (ANOVA) was conducted to compare pedagogical interactions based on gender across the different profiles of prospective primary school teachers. When ANOVA indicated differences, post-hoc tests were carried out to determine which prospective teacher profiles promoted pedagogical interactions to a greater or lesser extent based on student gender. The post-hoc tests used were Tamhane and Tukey B, to determine if there were significant differences between all possible combinations of means, controlling for Type I error. The Tamhane test assumes homogeneity of variances between groups; however, the Tukey B test is more robust when this assumption is not met, as it adjusts confidence intervals (Roni & Djajadikerta, 2021).

A significance level of $p<.05$ was used to determine statistical significance. All analyses were conducted using SPSS version 25.

RESULTS

Frequency of Pedagogical Interactions by Student Gender

Figure 1 provides a breakdown of the types of pedagogical interactions promoted by pre-service primary education teachers in the subjects of science and

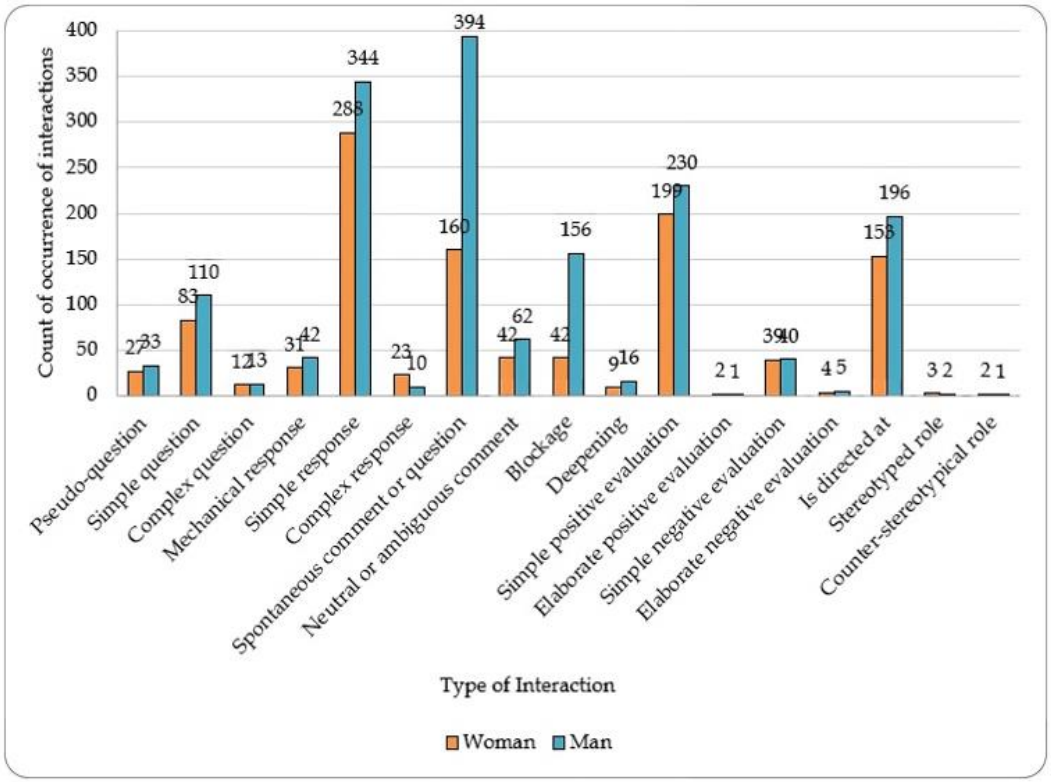

Figure 1. Count of interaction types by student gender (Source: Authors' own elaboration)

mathematics that had the highest occurrence, distinguishing by gender of the students.

In **Figure 1**, it can be observed that there were interactions with greater occurrence than others, such as the simple type student response, spontaneous comments or questions from a student, simple positive evaluation by the pre-service teacher, who the pre-service teacher addresses more frequently (male or female students), the pre-service teacher's blocking reaction towards a student, simple questions directed to a student, and so on. In all these interactions, those directed towards or initiated by boys were more frequent than those directed towards girls.

Additionally, some types of interactions were very infrequent (≤25 observations), including complex-type questions from the pre-service teacher to the students, the depth of the pre-service teacher's response to a student's intervention, stereotyped or counter-stereotyped roles in the teaching material or in the roles assigned by the pre-service teacher, and elaborate positive evaluation in response to a student's answer.

Pedagogical Interactions by Gender Within Each Pre-Service Teacher Profile

A comparison was conducted between the pedagogical interactions directed toward or performed by male students and those related to female students, distinguishing among the different types of pre-service teacher profiles (**Table 4**). For these analyses, pedagogical interactions that occurred with a frequency greater than 25 were considered to ensure analytical consistency.

Table 4. Comparison of classroom interactions by gender

Profile	Type of interaction	n	Woman		Man		t	df	p
			Mean	SD	Mean	SD			
Profile 1	Pseudo-question	497	0.014	0.13	0.016	0.13	-0.24	992	0.81
	Simple question	497	0.038	0.20	0.058	0.24	-1.42	992	0.16
	Mechanical response	497	0.022	0.17	0.026	0.18	-0.36	992	0.72
	Simple response	497	0.203	0.51	0.213	0.53	-0.30	992	0.76
	Complex response	497	0.008	0.11	0.000	0.00	1.64	992	0.10
	Spontaneous comment or question	497	0.066	0.30	0.175	0.47	-4.31	992	0.00**
	Neutral or ambiguous comment	497	0.038	0.19	0.048	0.25	-0.71	992	0.48
	Blockage	497	0.016	0.14	0.076	0.35	-3.61	992	0.00**
	Simple positive evaluation	497	0.117	0.37	0.121	0.39	-0.17	992	0.87
	Simple negative evaluation	497	0.032	0.18	0.038	0.20	-0.50	992	0.62
	Is directed at	497	0.078	0.29	0.119	0.36	-1.94	992	0.05*

Note. SD: Standard deviation; *p<.05; & **p<.01

Table 4 (continued). Comparison of classroom interactions by gender

Profile	Type of interaction	n	Woman		Man		t	df	p
			Mean	SD	Mean	SD			
Profile 2	Pseudo-question	411	0.029	0.20	0.051	0.23	-1.47	820	0.14
	Simple question	411	0.095	0.34	0.131	0.47	-1.28	820	0.20
	Mechanical response	411	0.032	0.18	0.041	0.20	-0.74	820	0.46
	Simple response	411	0.224	0.54	0.277	0.67	-1.26	820	0.21
	Complex response	411	0.027	0.16	0.012	0.11	1.52	820	0.13
	Spontaneous comment or question	411	0.212	0.52	0.443	0.83	-4.77	820	0.00**
	Neutral or ambiguous comment	411	0.024	0.17	0.071	0.28	-2.84	820	0.00**
	Blockage	411	0.066	0.28	0.185	0.55	-3.90	820	0.00**
	Simple positive evaluation	411	0.200	0.46	0.180	0.49	0.59	820	0.56
	Simple negative evaluation	411	0.022	0.16	0.034	0.18	-1.01	820	0.31
	Is directed at	411	0.141	0.39	0.158	0.44	-0.59	820	0.56
Profile 3	Pseudo-question	470	0.017	0.15	0.009	0.09	1.07	938	0.28
	Simple question	470	0.053	0.24	0.057	0.24	-0.27	938	0.79
	Mechanical response	470	0.015	0.12	0.026	0.17	-1.10	938	0.27
	Simple response	470	0.202	0.52	0.264	0.60	-1.68	938	0.09*
	Complex response	470	0.017	0.13	0.011	0.10	0.84	938	0.40
	Spontaneous comment or question	470	0.085	0.31	0.266	0.65	-5.48	938	0.00**
	Neutral or ambiguous comment	470	0.028	0.18	0.019	0.14	0.82	938	0.41
	Blockage	470	0.015	0.14	0.089	0.35	-4.33	938	0.00**
	Simple positive evaluation	470	0.126	0.35	0.204	0.49	-2.82	938	0.00**
	Simple negative evaluation	470	0.030	0.17	0.015	0.17	1.36	938	0.17
	Is directed at	470	0.119	0.40	0.153	0.45	-1.24	938	0.22

Note. SD: Standard deviation; *p<.05; & **p<.01

Statistically significant differences were found in all three pre-service teacher profiles, indicating that the pedagogical interactions directed toward or performed by male students were consistently greater than those directed toward or performed by female students. Some of these interactions were statistically significant across all three profiles (p<.01). For instance, spontaneous comments or questions were more frequently made by male students than female students. Likewise, blocking reactions by pre-service teachers were predominantly directed towards boys rather than girls. In profile 2, a statistically significant difference was observed, t(411)=-2.84 and p<.01, favoring male students in neutral or ambiguous comments. Finally, in the case of profile 3, two statistically significant differences favoring boys were observed: simple response t(470)=-1.68 and p=.09 and simple positive evaluation t(470)=-1.24 and p<.01.

Comparison on Interactions Among Pre-Service Teacher Profiles Based on Student Gender

Using variance analysis, **Table 5** displays the effect of the type of profile of pre-service primary school teachers on different types of interactions, distinguishing by gender.

Regarding interactions directed towards female students or performed by them, differences were found in simple questions (F[2, 1,376]=18.50; p<.01; η^2=.01); spontaneous comments or questions (F[2, 1,376]=5.47; p<.01; η^2=.03); blocking (F[2, 1,376]=9.61; p<.01; η^2=.01); simple positive evaluations (F[2, 1,376]=5.76; p<.01; η^2=.01); and whom the future teacher addresses (F[2,

Table 5. ANOVA & post-hoc tests for profile type & comparison between women & men

Gender	Type of interaction	Mean			df	F ratio	p	η^2	Observed power	Post-hoc tests
		1	2	3						
Woman	Pseudo-question	0.014	0.029	0.017	2	1.121	0.326	0.002	0.248	
	Simple question	0.038	0.095	0.053	2	5.469	0.004**	0.008	0.850	1=3<2
	Mechanical response	0.022	0.032	0.015	2	1.235	0.291	0.002	0.270	
	Simple response	0.203	0.224	0.202	2	0.238	0.788	0.000	0.088	
	Complex response	0.008	0.027	0.017	2	2.210	0.110	0.003	0.452	
	Spontaneous comment or question	0.066	0.212	0.085	2	18.495	0.000**	0.026	1.000	1=3<2
	Neutral or ambiguous comment	0.038	0.024	0.028	2	0.756	0.470	0.001	0.179	
	Blockage	0.016	0.066	0.015	2	9.608	0.000**	0.014	0.981	1=3<2
	Simple positive evaluation	0.117	0.200	0.126	2	5.761	0.003**	0.008	0.869	1=3<2
	Simple negative evaluation	0.032	0.022	0.030	2	0.438	0.645	0.001	0.122	
	Is directed at	0.078	0.141	0.119	2	3.610	0.027*	0.005	0.669	1=3; 2=3; & 1<2

Note. *p<.05 & **p<.01

Table 5 (continued). ANOVA & post-hoc tests for profile type & comparison between women & men

Gender	Type of interaction	Mean			df	F ratio	p	η^2	Observed power	Post-hoc tests
		1	2	3						
Man	Pseudo-question	0.016	0.051	0.009	2	9.072	0.000**	0.013	0.975	1=3<2
	Simple question	0.058	0.131	0.057	2	7.350	0.001*	0.011	0.939	1=3<2
	Mechanical response	0.026	0.041	0.026	2	1.024	0.360	0.001	0.230	
	Simple response	0.213	0.277	0.264	2	1.483	0.227	0.002	0.318	
	Complex response	0.000	0.012	0.011	2	2.883	0.056	0.004	0.565	
	Spontaneous comment or question	0.175	0.443	0.266	2	19.097	0.000**	0.027	1.000	1=3<2
	Neutral or ambiguous comment	0.048	0.071	0.019	2	5.566	0.004**	0.008	0.856	1=3; 1=2; & 3<2
	Blockage	0.076	0.185	0.089	2	8.768	0.000**	0.013	0.971	1=3<2
	Simple positive evaluation	0.121	0.180	0.204	2	4.267	0.014	0.006	0.746	
	Simple negative evaluation	0.038	0.034	0.015	2	2.156	0.116	0.003	0.443	
	Is directed at	0.119	0.158	0.153	2	1.260	0.284	0.002	0.275	

Note. *p<.05 & **p<.01

1,376]=3.61; p<.05; η^2=.01). According to post-hoc tests, in most cases, profile 2 displayed higher means than profile 1 and profile 3, and generally, no differences were observed between the latter two.

Regarding interactions directed towards male students or performed by them, differences were found in pseudo-questions (F[2, 1,376]=9.07; p<.01; η^2=.01); simple questions (F[2, 1,376]=7.35; p<.05; η^2=.01); spontaneous comments or questions (F[2, 1,376]=19.10; p<.01; η^2=.03); neutral or ambiguous comments (F[2, 1,376]=5.57; p<.01; η^2=.01); and blocking (F[2, 1,376]=8.77; p<.01; η^2=.01). According to post-hoc tests, and like what occurred with interactions towards females, in most cases, profile 2 displayed higher means than profile 1 and profile 3, with no differences observed between these latter two.

DISCUSSION

Regarding the first question: What pedagogical interactions are promoted, with frequency, by pre-service primary teachers in the subjects of science and math, according to student gender? It was found that the interactions directed towards or initiated by boys were far more numerous than those directed towards girls. In fact, boys were asked more questions, received more feedback, and pre-service teachers addressed them more often. This result is consistent with reviewed literature suggesting that classroom interactions are gender-differentiated, with teacher-boy interactions being more prevalent than teacher-girl interactions (Espinoza & Taut, 2016; Mamnoun & Nfissi, 2023; Minasyan, 2017; Ortega et al., 2020).

This gender-differentiation was also observed in the types of questions asked by pre-service primary school teachers and the responses provided by students, both being of a simple nature. This type of interaction refers to questions involving memorization of isolated information, answered very briefly and dichotomously, and involving specific words or concepts. Both types of simple interactions, questions, and responses occur more frequently with boys than with girls. Additionally, simple questions and responses are associated with evaluative reactions by pre-service teachers, which also occurred more frequently with boys, especially positive evaluations. This ultimately reflects Espinoza and Taut's (2016) assertion that girls receive less feedback compared to boys.

Interactions involving complex-type questions demand higher-level cognitive skills from students, such as application, argumentation, correlation, real-life application, prediction, etc. These were observed with minimal occurrence, without significant differences between boys and girls. This differs from what some authors have reported, finding such interactions predominantly directed towards boys (Espinoza & Taut, 2016; Mamnoun & Nfissi, 2023). Similarly, interactions involving complex-type responses, i.e., student responses involving elaboration, organization, or deepening of disciplinary content, also showed low occurrence. This is logical given that they are unlikely to arise spontaneously, in the absence of stimulation from pre-service teachers that would encourage these types of responses and skills in students.

All interactions that required more elaboration on the part of pre-service teachers, such as deepening (using a student's intervention to delve deeper into the content being covered), elaborate positive or negative evaluations (adding justification or commentary to a student's response or comment, for a correct or incorrect answer, respectively), showed little occurrence. This could be explained by the condition of pre-service teachers, who may have less experience than a practicing teacher in posing more complex questions or providing richer feedback.

Another type of interaction with a high occurrence was spontaneous comments or questions from students, interventions that are not in response to a teacher's or another student's proposal and may or may not be related to class content. It was observed that male students make 2.5 times more of these interventions than female students. This is consistent with what has been reported by some authors (Espinoza & Taut, 2016;

Fournier et al., 2020; Mamnoun & Nfissi, 2023; Minasyan, 2017; Ortega et al., 2020). According to Minasyan (2017), this behavior may be because boys are more participative than girls. In contrast, Fournier et al. (2020) suggest that girls adhere more to participation norms, such as raising their hands to speak, and hence do not spontaneously speak or respond to questions that are not directly addressed to them.

As for blocking-type interactions, i.e., interactions in which the pre-service teacher ignores a student's question or comment, changes the subject, or addresses another student; these also had a high occurrence. In this study, 3.7 times more blocking was observed directed at boys than at girls; this type of interaction is related to the higher occurrence of spontaneous comments or questions made by male students. In this sense, blocking could be a way to regulate boys' behavior, as they are more likely than girls to disregard speaking turn norms in the classroom (Fournier et al., 2020; Minasyan, 2017).

Regarding the second question: What are the characteristics of the pedagogical interactions based on student gender, considering socio-affective variables and gender biases, of pre-service primary education teachers? The following findings were observed: considering the three profiles (see **Table 1**) of pre-service primary school teachers (Navarro et al., 2022), statistically significant differences were observed within each profile for the various types of interactions analyzed, all of which favored boys. However, a clear difference between profiles was not evident, in the sense that all profiles promoted interactions that were more prevalent with boys. Nonetheless, some interesting results can be discussed.

In all profiles, a higher occurrence of spontaneous questions and blocking-type interactions was observed. In profile 1, characterized by high masculinity and low submissiveness traits (Navarro et al., 2022), i.e., pre-service teachers with attributes traditionally considered masculine, such as competitiveness, self-confidence, and leadership, differences were observed only in these types of interactions. This is intriguing given that, as suggested by Fournier et al. (2020), these pre-service teachers could be regulating boys to generate greater equity in pedagogical interactions that occur in science and mathematics classes, allowing or balancing the participation of both boys and girls. At the same time, as proposed by Navarro et al. (2022), primary school teachers with high masculinity and low submission could serve as good role models for girls, due to their positive traits traditionally associated with the male gender, which may also be favorable characteristics for scientific work (Szabó et al., 2021).

Next, a second analysis compared interactions among the three profiles, distinguishing by the gender of the students. The overall result shows that, in both girls and boys, it is the future teachers in profile 2 who promote more interactions, without much difference between future teachers in profile 1 and profile 3. However, a within-profile comparison revealed that pre-service teachers in profile 2 promote more interactions with boys.

In conclusion, further evidence is needed to determine whether these profiles do or do not impact the promotion of more or less equitable interactions from the perspective of the student's gender.

CONCLUSIONS & IMPLICATIONS

In conclusion, based on the analysis of these science and mathematics classes, it can be observed that pre-service primary school teachers promoted more interactions towards male students: more questions were directed at them, more responses elicited, they received more feedback, and pre-service teachers addressed them more using various types of nicknames. Furthermore, male students were found to initiate interactions more often through spontaneous comments or questions; possibly for this reason, there were more instances of blocking reactions towards them from the pre-service primary education teachers.

Additionally, interactions with the highest degree of occurrence were simple in nature, suggesting that they do not promote complex cognitive skills in students. Instead, they mostly consist of simple questions leading to responses of the same kind. Similarly, the feedback provided by the pre-service teachers was found to lack depth or an explanation of why a response may align with or deviate from the expected answer. This could be attributed to the condition of being a pre-service teacher still in the process of learning and should be addressed in initial teacher preparation.

Finally, the analysis of the profiles, which constitute a combination of socio-affective variables and beliefs regarding gender, showed some degree of influence in the gender-based differentiation of pedagogical interactions in science and mathematics classrooms. Profile 1, characterized by traits of high masculinity and low submission, appeared to be the most promising in promoting interactions with greater gender equity. In contrast, pre-service teachers in profile 2, characterized by traits of indecision, passivity, who feel insecure teaching science or mathematics, or consider them difficult, promoted more interactions than the other two profiles, but with a higher occurrence towards boys.

The implications of these findings highlight the need to address the importance of gender-equitable pedagogical interactions in the preparation of pre-service primary school teachers, particularly in courses related to the teaching of science and math. Examining interactions, their types, and who they are directed towards should be a focal point of reflection in initial teacher preparation. These guidelines can contribute to the creation of school environments that promote greater

gender equity in science and mathematics classrooms from an early age.

Limitations & Projections of Study

One limitation of the study is the distribution of segments analyzed for each subject: in mathematics 365 segments were analyzed compared to 1,013 in the case of science. This is because many of the collected mathematics videos were recorded in single-sex schools, and hence did not meet the minimum requirement to analyze differentiated interactions based on student gender. This limitation could introduce a bias toward science classes in the conclusions. However, it can be seen as a contribution to the field given that most studies on gender-differentiated interactions have been conducted in mathematics classes. In addition, it was impossible to control other variables that may have influenced the results, such as class climate, differences in methodology or curriculum, influence of the mentor teacher, among others.

Regarding potential projections, it is necessary to conduct similar studies with a larger number of analysis segments and classes to derive more robust conclusions regarding the analysis of pre-service female teacher profiles and their impact on interactions based on student gender. Furthermore, a broader analysis would allow better control over other variables such as the curriculum content being taught or the educational level/age of the children, which could influence the interactions between future teachers and girls and boys.

Finally, a second projection would be to complement quantitative studies, like this one, with qualitative techniques. For example, in-depth interviews could be conducted with future teachers to explore the interactions they promote concerning the gender of the students and the implications of this for gender-equitable teaching in science and mathematics.

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