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ORIGINAL ARTICLE

The Representation of Gender Stereotypes in Spanish Mathematics Textbooks for Elementary Education

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Abstract

The latest report of the Organization of Ibero-American States for Education, Science, and Culture (OEI) points out that only 13% of the Science, Technology, Engineering, and Mathematics (STEM) students in Spain are women. Numerous studies have claimed that gender stereotypes are the leading cause of women's underrepresentation in STEM. Textbooks constitute a powerful instrument in the configuration of a socio-occupational culture that could be biased if they contain sexism. This investigation examines, through Critical Discourse Analysis (CDA), the unequal representation of women and men in elementary mathematics textbooks currently used in Spain. The results indicate that even though textbooks present an equal frequency of female and male characters, there is an absence of women as real role models in STEM. Characters also reinforce traditional gender stereotypes in the embodiment of social roles. Problem-solving contexts show women using math in a limited variety of daily-life activities, while overall they are represented as insecure and unable to resolve certain mathematical issues. Our study points out that this gender gap in mathematics textbooks can affect girls' self-esteem and discourage their interest in pursuing scientific-technological careers. Consequently, our study urges teachers to adopt an egalitarian perspective in selecting and using didactic materials.

Keywords STEM · Women's studies · Gender stereotypes · Textbooks · Mathematics · Elementary education

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Introduction

For years, public discourses in science education, technology, and policymaking have focused on observing that fewer women than men enter science, technology, engineering, and mathematics (STEM) fields and more women than men leave. Indeed, the lack of women in STEM areas is a well-recognized problem all over the world. Only one in three researchers is a woman (Lewis et al., 2021), while gender balance in research and development is understood as an issue of social justice and equality (Fatourou et al., 2019). Since the 1970s, several studies have shown statistics that highlight the lack of participation of women in advanced mathematics courses, resulting in a low percentage of women in university degrees that involve significant work with mathematics (Shibley et al., 1990). This trend has been detected in the United States, the European Union, and in African and Asian countries (Charles et al., 2014). In the case of Spain, the recent report of the Organization of Ibero-American States for Education, Science, and Culture (OEI), entitled *El Estado de la Ciencia*, points out that only 13% of STEM students are women, a percentage similar to the European Union average of 12.6% (OEI, 2021). This gender disparity risks falling short of the 2030 Agenda for Sustainable Development, which aims to ensure an inclusive, equitable, and quality education (SDG-4).

International organizations such as UNESCO or the European Commission are paying special attention to the gender gap in STEM education through research and policy recommendations to promote the empowerment of girls and women in science in order to increase economic growth, improve scientific quality, and reduce the risk of social exclusion of women for the benefit of society (UNESCO, 2017; European Commission, 2020). The STEM pathway comprises a series of choices and achievements that start in childhood and adolescence. Achievement-related behaviors, such as educational and career choice, are most directly linked to expectations for success and the value attached to the various options perceived as available. According to Eccles' expectancy-value theory (Eccles, 1983, 2009), domain-specific competence and task-related beliefs are influenced by cultural norms, behavior genetics, social experiences, aptitudes, and the affective reactions of previous experiences as individuals move through adulthood. Teachers (Beilock et al., 2010), peers (Raabe et al., 2019), and parents (Hildebrand et al., 2023) —in general, all educational agencies— can create opportunities for students to become involved in various STEM and non-STEM-related activities through the experiences provided (Eccles et al. 1993; 1997). Such experiences influence students' engagement in a variety of educational activities and future occupational aspirations (Simpkins, 2006).

From the standpoint of educational equity, boys and girls should have the same access to all educational opportunities. In Spain, for example, all educational legislation since the *Ley Orgánica General del Sistema Educativo* (LOGSE) in 1990 —the first law after the Francoist Regime— upholds the duty of this educational equity between boys and girls. However, this ethical principle is not always followed by the school. According to several studies, the classroom can become a place that supports the formation of gender bias and stereotypes in different ways: classroom structures (Blatchford, 2003); curricular differentiation (Halpern et al., 2007); teachers' differential expectations, treatment, and stereotypes (Keller, 2010); and educational

materials (Commeyras & Alvermann, 1996). An essential factor is the textbook, the leading resource used by students for learning about diverse subjects.

In addition to their academic content, textbooks develop children's awareness of themselves and the world. They play a vital role in young people's socialization because they provide socially acceptable model situations that can influence children's attitudes, values, and behaviors (Lee & Mahmoudi-Gahrouei, 2020). Gender models in textbooks "may be so suggestive that they gradually shape the way students perceive the surrounding world, which strengthens the gender optics of their worldview" (Osaďan, 2018, p. 246). Therefore, gender stereotypes about the roles of females and males in these educational means will be internalized and, probably, imitated by learners.

There is another explanatory factor of the importance of textbooks in youth´s socialization: their consideration by teachers, parents, and students as reliable and authoritative (Smetáčková & Rubín, 2015). Certainly, this perception is much more pronounced in young people and increases at an early age. Children and adolescents tend to accept whatever is taught in the classroom without questioning it. At the same time, most teachers do not use the texts to provide opportunities for students to engage in a critical analysis of the social realities outside and within the classroom (Apple, 1992).

The significant amount of time that students spend reading textbooks and doing their activities is another element to consider in understanding the socialization power of this educational resource. Children read more than 32,000 textbooks pages during Elementary Education (Hamid et al., 2008). In this sense, consciously and subconsciously, repeated exposure to the written texts and visual images will cause the students' internalization of the textbook authors' gender perception (Tyarakanita et al., 2021). If such gender perception includes sexism or gender discrimination, learners could assume them (Setyono, 2018).

What about mathematics textbooks? Under the cloak of objectivity, "traditionally, mathematics has been presented as neutral and culture-free and as a silent, individual activity that involves completing procedures and solving traditional word problems" (Le Roux, 2008, p. 307). Nevertheless, historical, and sociological studies note that mathematical knowledge cannot be perceived solely as knowledge of a subject, given that it also contains references to social practice. Textbooks authors are selected by publishing houses, and they transmit cultural and social information, in other words, a specific worldview reflected in the material (Escolano, 2002). Generally, we can find two kinds of information in mathematics problem-solving activities: (a) explicit (mathematical knowledge: e.g., how to multiply or calculate logarithms), and (b) implicit (social messages: e.g., boys are better than girls in sports) (Subirats, 1993). This division highlights the non-neutrality of knowledge included in textbooks. Mathematics, like other subjects, is learned and used in social settings which are linked to culture, politics, and ideology (Giroux, 1984; Fairclough, 2003) identifies three types of meanings in text: "representation", what the text says about the world; "action", how the text establishes social relations; and "identification", what the text says about the attitudes, beliefs, and values of the participants. Through these meanings, a text is linked to more comprehensive sociopolitical practices. Therefore, we conduct a Critical Discourse Analysis (CDA) that reveals social norms and values that may be invis-

ible or occult to expose abuses of power, hidden dynamics of control, discrimination, and male dominance in current Spanish mathematics textbooks (Wodak, 2012). Traditionally, the math-gender stereotype emphasizes that boys are superior and more competent than girls in mathematics and, consequently, in occupations with a solid mathematical content (Bian et al., 2017). Unequal gender representation and gender-related stereotypes in mathematics textbooks cause low achievement in mathematics and may, in turn, result in girls pursuing lower-prestige careers (Plante et al., 2009).

Previous studies have focused on enrollment and students' experiences in college, whereas educational and career aspirations surface in late childhood and early adolescence (Wang, 2013). In fact, according to a recent OECD report entitled *Early Learning and Child Well-being*, gender norms are already evident in career aspirations at the age of five (OECD, 2020). This is the reason why our research analyzes the elementary education stage. On the other hand, prior investigations in mathematics textbooks have discovered that even when mathematics textbooks include an equal quantitative representation of female and male characters, they may perpetuate gender stereotypes and discriminations. For instance, men/women are usually shown in the public sphere (doing business, driving…), while women/girls are presented in the private domain linked to domestic roles (ironing, caring for babies…) (Da Silva & Oliveira, 2021; Incikabi & Ulusoy, 2019; Karama, 2020).

Our *principal objective* is that of determining to what degree current mathematics textbooks challenge or reinforce gender stereotypes through their representation of male and female characters. We do so based on the definition of gender stereotypes offered by the United Nations High Commission for Human Rights:

> A generalized view or preconception about attributes or characteristics, or the roles that are or ought to be possessed by, or performed by, women and men. A gender stereotype is harmful when it limits women's and men's capacity to develop their personal abilities, pursue their professional careers and/or make choices about their lives. (United Nations, 2022, p.1)

We also address three *specific objectives*: (1) to determine whether mathematics textbooks give a balanced presence of males and females in different occupational roles and activities, including STEM; (2) to contribute to a reflection on the degree and impact that sexist stereotypes regarding mathematical competence can have on girls at an early age; and (3) to raise teachers' awareness of the importance of selecting appropriate teaching resources that heed to coeducational principles, especially in subjects from the realm of science and technology.

Methods

In this educational study, we examine the contents of primary school textbooks used in Mathematics, a compulsory subject in the school curriculum meant to help children's development in mathematical competence. This implies the ability to apply mathematical reasoning and tools to describe, interpret and predict different phenomena in different contexts (personal, social, professional, and scientific). The school-

books used in this field are meant to prepare the student to recognize the role and the value of mathematics in their world and to apply its principles and methods to solve problems that may arise in life.

Since our study deals with social justice issues such as the transmission of gender stereotypes through school textbooks, we applied a Critical Discourse Analysis (CDA). According to Van Dijk (2003), the term "discourse" can be conceived of as a "communicative event" that includes both the written texts and the images that appear in the textbooks. Specifically, we have used a type of mixed research method called transformative design, which frames the sequential collection and analysis of quantitative and qualitative data. This combination of methods has aimed to minimize the weaknesses of quantitative and qualitative methods when considered separately, and to gain different perspectives and better understand the complex phenomenon of our study (Caro et al., 2014; Creswell, 2005; Johnson & Onwuegbuzie, 2004; Litosseliti & Sunderland, 2002).

Sample

Our analysis was carried out with six primary education textbooks approved by the Spanish Ministry of Education and published on the heels of the law *Ley Orgánica 8/2013, de 9 de diciembre, para la mejora de la calidad educativa* (LOMCE). The sample was chosen from a list of textbooks used in educational centers pertaining to the autonomous region of Andalucía (Spain) in the subject of Mathematics. More specifically, we focused on the first grades of the middle stage (third grade, 8-year-old) and the upper stage (fifth grade, 10-year-old), in which students receive approximately four hours of instruction per week. The textbooks selected are published by three major publishing houses, renowned not only in Andalucía but nation-wide (ANAYA, SM and Santillana), their greater area of influence making them more representative (see Table 1).

Data Gathering Techniques

The study analyzes a total of 1,353 pages from six mathematics textbooks. The unit of analysis is comprised mainly of the study of human characters (real and fictitious)

Table 1 *Textbooks selected for analysis*

Nº	Textbook series	Grade	Year	Publisher	ISBN	Pages	Authors
1	Matemáticas 3 Proyecto Savia	3	2014	SM	978-84-675-7675-7	235	Bernabeu, et al.
2	Matemáticas 3	3	2015	ANAYA	978-84-678-97654-4	191	Ferrero, et al.
3	Mate+Matemáticas para pensar 3 Primaria	3	2019	Santillana	978-84-9132-170-5	240	Reguera et al.
4	Matemáticas 5	5	2013	SM	978-84-675-6993-3	239	Medina et al.
5	Matemáticas 5	5	2015	ANAYA	978-84-678-9770-8	192	Ferrero et al.
6	Mate+Matemáticas para pensar 5 Primaria	5	2019	Santillana	978-84-9132-143-9	256	Almodóvar et al.

that appear in these schoolbooks, which will help us to determine if there is a balance in the representation of both genders. In their interactions and communications, these figures serve as a link between discourse and reality, constituting an essential element in the configuration of students' identities (De la Torre-Sierra & Guichot-Reina, 2022, 2023). The data gathering instruments that we use in this study and the respective categories of analysis were designed in accordance with key elements of the curriculum of primary education for the teaching of mathematics and are based on current educational legislation.

Instruments Used for Quantitative Analysis

In order to analyze the textual content of mathematics textbooks we followed several of the study variables proposed by López-Navajas in her Doctoral Thesis (2015). First, we counted the *appearances* of male and female characters mentioned in the textual discourse of each textbook, noting as well whether these characters were real or fictitious. We then went on to scrutinize the way these characters appeared by means of the category *mode* (profiled, cited, work), which allowed us to determine the level of representation and recognition given to them in the textbooks. In addition, we quantitatively examine the occupational roles assigned to female and male characters in the textual content of the textbooks (De la Torre-Sierra & Guichot-Reina, 2022).

For our quantitative analysis of the iconographic content, we performed an in-depth study of each of the characters appearing in the textbook images. Among the variables of analysis and indicators (De la Torre-Sierra, 2022; Guichot-Reina & De la Torre-Sierra, 2020) were the following: (a) *Character's gender* (man, woman, undetermined); (b) *Economic renumeration* (yes, no); (c) *Economic sector* (primary, secondary, tertiary); and (d) *Services* (protection and security, transportation, teaching, culture and leisure time, STEM, administrative, commerce, representation, media, hospitality services, maintenance, justice, religious).

Instruments Used for Qualitative Analysis

Given that the purpose of our study is to identify sexist stereotypes that are reproduced in school textbooks, we believe that quantifying of the frequency with which male and female characters appear in these teaching materials is not enough, and that a qualitative analysis is called for. As Subirats (1993) points out, women may appear more frequently than men, but the problem is that their representation is fraught with sexist prejudices. This makes the Critical Discourse Analysis (CDA) an ideal theoretical and methodological tool for our research (Lazar, 2007; Mills & Mullany, 2011). We intend, by means of CDA and our categories of analysis, to determine whether the characters represented in mathematics textbooks reproduce or break gender stereotypes (see Table 2).

Table 2 *Gender stereotypes in mathematics textbooks*

Gender Stereotypes	Description
1. Counter-Stereotype (CS)	The representation of male and female characters challenges traditional gender stereotypes and fosters the inclusion of women in the field of mathematics.
1.1. Social roles	The visibility of characters shows them in a variety of activities including raising children, caretaking, leisure activities, educational and labor activities (including STEM), regardless of the characters' gender.
1.2. Use of mathematics	The characters apply mathematical principles and procedures in a variety of situations arising in daily life and recognize the value of mathematics for dealing with professional activities of all sorts.
1.3. Attitudes towards mathematics	The characters display egalitarian attitudes and interest in the learning and teaching of mathematics. Both men and women show initiative, autonomy, talent, and self-confidence when searching for solutions to mathematical problems.
2. Supporting Stereotype (SS)	The representation of male and female characters in the textbook content reinforces traditional gender stereotype and discourages women's participation in mathematics.
2.1. Social roles	Occupational and social activities show the persistence of differentiated, discriminatory roles attributable to the gender of the characters and to traditional sexist stereotypes.
2.2. Use of mathematics	Characters use mathematical principles and procedures only in circumstances that conform to traditional gender roles. The use of mathematics in daily life reveals gender differences.
2.3. Attitudes towards mathematics	Girls and women show a lack of interest and motivation for the learning and teaching of mathematics. They become baffled and insecure and may resort to asking a male character for help.

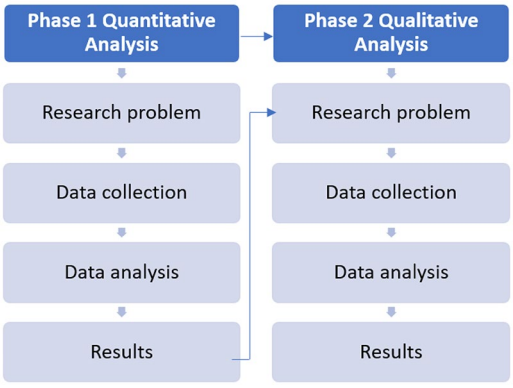

Fig. 1 *Proposal of data analysis of mathematics textbooks*

Data Analysis

The mixed investigation designed for this study is of a transformative sequential explicative nature (Creswell, 2009; Creswell & Plano Clark, 2017; Jiménez-Cortés, 2019). It, therefore, involves two phases or stages for the gathering of data and information analysis (see Fig. 1). For the quantitative analysis, we perform a descriptive statistical analysis using the IBM Software SPSS Statistics. With the data obtained we then calculate the *Gender Parity Index* (GPI) (UNESCO, 2020) in order to detect the presence of gender bias in the material. For this, we resort to the scale proposed

by Covacevich and Quintela-Dávila (2014) in which the values ($0.0 < IPG \leq 0.7$) correspond to a *masculine bias*; ($0.8 < IPG \leq 1.3$) indicate *parity*; and values over 1.3 indicate the presence of a *feminine bias.* This is followed by our using CDA, in the qualitative analysis, to examine further in depth the gender stereotypes conveyed by the characters shown in the textbooks.

Results

Phase 1: Quantitative Analysis Results

Gender Bias in Characters Portrayed in Textual Content

Appearance of Characters We analyzed a total of 2,035 characters of which 1,028 were women (50.52%) and 1,007 men (49.48%). While the appearance of females is slightly superior to that of men, the index comes very close to perfect parity ($GPI = 1.02$). If we separate the data by school grade, we find that, as an average, the third-grade textbooks contain a slightly higher proportion of female characters (2.12%) (see Table 3). In general, the fifth-grade textbooks contain the same number of male and female characters, attaining an apparent perfect parity. However, in examining the fifth-grade textbooks individually we do come across two gender biases (Covacevich & Quintela-Dávila, 2014). On the one hand, book 4 evidences a *masculine bias*, where for every one hundred men represented there are only seventy women. On the other hand, book 6 contains a *feminine bias*, with the proportion of women being considerably higher than that of men (21.12%).

Role Models The next phase of our study involved determining which of these characters corresponded to real men and women, people relevant to our history and culture who could potentially constitute role models for students (see Table 4). In a tabulation of total appearances, we find 66 cultural references, of which 24 are women (36.36%) and 42 are men (63.64%), evidencing a *masculine bias* ($GPI = 0.57$).

Upon closer scrutiny of the previous results, we find that of the 66 total appearances, 48 are (absolute) cultural references, 13 of them feminine and 35 masculine. Women are only represented in two areas: *literature* (María Isabel Molina, Begoña Oro, Mónica Rodríguez and Anna Cerasoli) and *sports* (Natalia Antiuj, Anna Chicherova, Shelly-Ann Fraser-Pryce, Mary Keitany, Paula Radcliffe, Britney Reese, Olga Rypakova, Barbora Spotakova and Jennifer Suhr). As for the men, we find a greater variety

Table 3 *Appearance of characters according to their gender*

	Women	Men	%Women	%Men	GPI
Third grade	507	486	51.06	48.94	1.04
1	143	145	49.65	50.35	0.99
2	202	166	54.89	45.11	1.22
3	162	175	48.07	51.93	0.93
Fifth grade	521	521	50	50	1.00
4	149	212	41.27	58.73	0.70
5	134	154	46.53	53.47	0.87
6	238	155	60.56	39.44	1.54

Table 4 *Appearance of role models*

	Women	Men	Total	%Women	%Men	GPI
Third grade	7	8	15	46.67	53.33	0.88
1	7	2	9	77.78	22.22	3.50
2	-	1	1	-	100	-
3	-	5	5	-	100	-
Fifth grade	17	34	51	33.33	66.67	0.50
4	4	18	22	18.18	81.82	0.22
5	7	15	22	31.82	68.18	0.47
6	6	1	7	85.71	14.29	6.00

Table 5 *Modes of characters' appearance*

	Mode	Women	Men	Total	% Women	% Men	GPI
Total	Profiled	715	711	1,426	50.14	49.86	1.01
	Cited	281	272	553	50.81	49.19	1.03
	Work	18	12	30	60	40	1.50
Third grade	Profiled	324	328	652	49.69	50.31	0.99
	Cited	163	148	311	52.41	47.59	1.10
	Work	14	4	18	77.78	22.22	3.50
Fifth grade	Profiled	391	383	774	50.52	49.48	1.02
	Cited	118	124	242	48.76	51.24	0.95
	Work	4	8	12	33.33	66.67	0.50

of references in different fields. These include *literature and humanities* (Aristóteles, Charlie Dogson and Carlos Olalla Linares), *sports* (Usain Bolt, Filípides, Rénaud Labillenie, Greg Rutherford, Féliz Sánchez, Christian Taylor, Ivan Újov, Keshorn Walcott), *arts* (Mario Campos Pérez, Maurits Cornelis Escher, Salvador Dalí, Jesús Gabán,, JKjartan Poskitt, Xavier Salomó), and *history and politics* (Julio César, Cristóbal Colón, Felipe II, Benjamin Franklin, Luis XVIII of France), *STEM* (Mohamed Al Juwarizmí, Leonardo Da Vinci, Carlos Frabetti, Alexander Fleming, Alexander Graham Bell, Johann Müller Regiomontano, José Muñoz García, Pythagoras, Rafael Ramírez Uclés, Santiago Ramón y Cajal, Sosígenes, James Watt), and *religion* (Jesus of Nazareth).

The Mode of Characters' Appearances In a third phase, we studied the mode in which characters appeared in textual content (see Table 5). In general, we observed that, to a small degree, women were represented in a higher proportion in each of the possible forms of appearance (profiled, cited, work) (López-Navajas, 2015). A disaggregation of the data by school grade shows that in third-grade textbooks a large number of women appear *cited*, a position connoting lesser privilege and representation. However, in the same grade we also encounter, as reflected in the GPI index, a *feminine bias* in the *works* with authorship, with almost all of the works included in the mathematics textbooks having been created by women. Additionally, fifth-grade textbooks contain a greater percentage of female characters *profiled* than males, whereas most of the characters *cited* in this grade are males. On the other hand, the number of *works* by men is double that of women, giving us a clear *masculine bias*.

Table 6 *Range of occupational roles by gender in textual content*

Male occupations (62)	Female occupations (33)
Abbot, Alpinist, Archer, Artist, Astronomer, Athlete, Author, Baker, Beekeeper, Boss, Broker, Butcher, Cab Driver, Caliph, Captain, Carpenter, Carrier, Chief Executive, Composer, Confectioner, Construction Worker, Craftsman, Cyclist, Dancer, Dentist, Detective, Director, Doctor, Driver, Emperor, Engineer, Farmer, Gambler, Gardener, Greengrocer, Gym Teacher, Inventor, Journalist, Judge, King, Lawyer, Librarian, Mailman, Mathematician, Mayor, Merchant, Monk, Painter, Pediatrician, Pilot, Plumber, Policeman, Politician, President, Researcher, Sales Clerk, Scientist, Soldier, Surgeon, Teacher, Waiter, Writer.	Administrative Worker, Artist, Biologist, Computer Scientist, Cook, Courier, Craftswoman, Dancer, Director, Doctor, Farmer, Florist, Fashion Designer, Greengrocer, Librarian, Manager, Mathematician, Mayor, Meteorologist, Nurse, Painter, Pediatrician, Physicist, Pilot, Queen, Scientist, Shop Assistant, Teacher, Singer, Technician, Trainer, Acrobat, Writer.

Table 7 *Characters shown in images, by gender*

	Women	Men	Total	%Women	%Men	GPI
Third grade	733	841	1,574	46.57	53.43	0.87
1	238	284	522	45.59	54.41	0.84
2	241	241	482	50	50	1.00
3	254	316	570	44.56	55.44	0.80
Fifth grade	629	545	1,174	53.58	46.42	1.15
4	145	243	388	37.37	62.63	0.60
5	220	98	318	69.18	30.82	2.24
6	264	204	468	56.41	43.59	1.29

Occupational Roles Of the characters presented in terms of their professional role in the textual content (N=218), only 31.19% are women. Thus, we find only forty-five female workers for every one hundred male workers (GPI=0.45), and we observe that the range of occupations assigned to men (N=62) could be almost double that of women (N=33) (see Table 6). Furthermore, textbooks show *vertical segregation* as male characters occupy higher occupational positions, such as bosses, directors, or presidents, 69.23% of the time (N=18). In comparison, female characters occupy these positions 30.77% of the time (N=8).

Gender Bias in the Images of Characters

Disparities in the Representation of Men and Women We examined a total of 2,748 characters in images, of which 1,362 were women (49.56%) and 1,386 men (50.44%), reflecting —despite a slightly higher proportion of men—considerable parity in the representation of genders (GPI=0.98). The books used in the third grade contained a smaller proportion of women than men (6.86%), whereas in the fifth-grade textbooks feminine representation is greater by a measure of 7.16% points (see Table 7). In

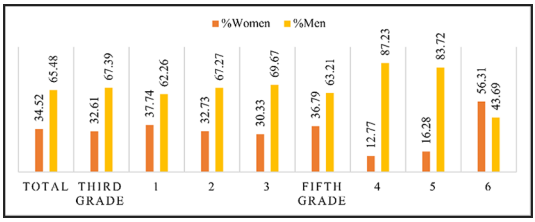

Fig. 2 *Proportion of characters receiving economic remuneration, by gender*

Table 8 *Types of services in which characters from mathematics textbook images work*

Type of service	Women	Men	Total	%Women	%Men	GPI
Protection	10	21	31	32.26	67.74	0.48
Transportation	5	13	18	27.78	72.22	0.38
Teaching	3	2	5	60	40	1.50
Leisure/entertainment	43	126	169	25.44	74.56	0.34
STEM	10	7	17	58.82	41.18	1.43
Administrative	8	3	11	72.73	27.27	2.67
Commerce	29	26	55	52.73	47.27	1.12
Representation	0	3	3	0	100	0.00
Communication/media	20	20	40	50	50	1.00
Hospitality	11	11	22	50	50	1.00
Maintenance	1	4	5	20	80	0.25
Justice	0	0	0	-	-	-
Religion	0	2	2	0	100	0.00

book 2 we find exactly the same number of male and female characters, a case of absolute parity.

Occupational Roles Our study then proceeds to examine how many of the characters receive an *economic remuneration* (see Fig. 2). Altogether, of the 423 characters shown carrying out a professional activity, 146 are women, as compared to 277 men. These results show a clear *masculine bias* (*GPI*=0.53), where for every one hundred men only fifty women are represented (Covacevich & Quintela-Dávila, 2014). The fifth-grade textbooks are those with the smallest proportion of female characters in a professional capacity; book 4 includes only six women (*GPI*=0.15), and book 5, seven women (*GPI*=0.19). Book six from the same grade constitutes an exception, with a larger percentage of feminine characters (*N*=58) than masculine characters (*N*=45) receiving a salary.

These occupational roles were classified by *economic sectors* based on the characters' gender. The most pronounced differences in favor of men were in the *secondary sector* (52.94%). However, the majority of characters, both feminine (35.41%) and masculine (64.59%), engage in paid employment in the *tertiary sector*, an area with such professional diversity that we have broken it down into the different types of activities referred to (De la Torre-Sierra, 2022; Guichot-Reina & De la Torre-Sierra, 2020) (see Table 8). The greatest presence of characters appears in services relating to *culture and leisure activities* (athletes, actors, painters, dancers…), followed by *commerce* (small businesses, salespeople…). In services linked to the *media* (journalists…) and to *hospitality* (waiters, cooks…) we find exactly the same number

of males and females. In fields pertaining to *STEM* the proportion of women is on average slightly higher than that of men, by a difference of 17.64%. The roles carried out by women in images linked to STEM are astronaut, scientist, nurse, doctor and forest ranger; whereas each of the masculine characters has a different occupation (doctor, nurse, mathematician, engineer, computer scientist, inventor, and astronaut). As regards the GPI, we find *masculine bias* in the services *protection*, *transportation, leisure activities* and *maintenance*; *parity* in *communication (media), hospitality*, and *commerce*; and a *feminine bias* in *teaching, STEM, administrative work.* All together, we observe 88 different professions practiced by male characters and 84 by females, a remarkable diversity of occupations for both genders.

Phase 2: Qualitative Analysis Results

Social Roles

The male and female characters in the mathematics textbooks reproduce gender-based stereotyped activities in different areas (*family, leisure and entertainment, education* and *work*). In *family* settings, the role of taking care of children or other dependent persons is associated exclusively with women who, furthermore, are those who display compassion and empathy. Occupations that include taking care of others only portray men when they involve remunerated work in the area of health care, for instance: Marcos has not been to school in three days. He has a bad cold and fever. The [male] doctor saw him and prescribed cough medicine and some pills (Ferrero et al., 2015a) (SS). Women stand out in the mathematics textbooks for their role carrying out domestic duties such as shopping or preparing meals. An exception can be found in an activity (book 1) that attempts to break the gender stereotype and convey to the student the importance of sharing roles within the family with the slogan: shared co-responsibility unites the family (Bernabeu et al., 2014) (CS).

In the context of *leisure and entertainment*, the male characters show a preference for practicing sports in their free time. The textbooks reinforce the stereotype "men are better at sports than women", based on the idea that they generally get better scores or are the first to reach the finish line. Masculine characters convey ambition, personal drive, and competitiveness in their practice of sports. Women show an interest in attending cultural events (circus, plays, concerts, films…), traveling and touring, reading, and shopping. To a marginal degree we find instances that refute stereotypes, such as with girls winning at sports: On Saturday, Mónica and Ángel played a tennis match. Mónica won and was congratulated by her rival (Ferrero et al., 2015a) (CS).

In the selected textbooks, the gender stereotypes observed in the interests of male and female characters are reflected in the educational context through their subject preferences. Book 3, for example, presents gender differences in students' preferred subjects: A survey has been carried out on 34 boys and 34 girls. A total of 68 students participated. The subject that girls like the most is English. The one that boys like the most is Physical Education (Reguera et al., 2019) (SS).

In the *work* context, we also encounter role segregation, with males holding most of the professional positions. We can observe *horizontal segregation*, in other words,

jobs carried out almost exclusively by males: construction workers, drivers, plumbers, policemen, butchers, gym teachers, etc. Women, on the other hand, are shown prominently as teachers, librarians, administrative workers, florists, green-grocers, fashion designers, and in fields associated with STEM: A [female] biologist has observed that the animals in a certain area of the jungle have a total of 11 heads and 20 legs (Almodóvar et al., 2019) (CS). However, we can find no biographical data of a *real* feminine *reference* in STEM fields in the mathematics textbooks, whereas a number of male references in these areas are referred to: Mohamed Al Juwarizmí, presented as "the greatest" of all excellent mathematicians (Medina et al., 2013), Pythagoras, presented as a Greek philosopher and mathematician (Ferrero et al., 2015b), Santiago Ramón y Cajal, winner of the Nobel Prize in medicine (Ferrero et al., 2015b), and Alexander Graham Bell, inventor of the telephone (Medina et al., 2013). The textbooks also reveal gender inequalities and hierarchies in the professional realm, particularly in the textual content. In all the excerpts from the textbooks in which male and female characters work, it is men who occupy the highest and most socially prestigious positions in the different professional sectors (*vertical segregation*) (directors, mayors…). For instance: The teacher and the [male] director took the third grade students to the park (Reguera et al., 2019) (SS); The [female] florist suggests to the [male] mayor how to replant the green spaces in the city (Ferrero et al., 2015a); The [male] patient goes to the hospital for his appointment with the [male] doctor, but the [female] nurse informs him that the medical consultation will be delayed (Ferrero et al., 2015b).

In one exceptional example of counter-stereotype, a character of each sex is portrayed working in the same profession (as nurses), while promoting egalitarian values in terms of their pay: Íñigo and Andrea are nurses. Each makes €14 per hour. This week they both have work 28 h. How much did they make together? (Reguera et al., 2019).

Use of Mathematics

Gender stereotypes can also be found in the way that feminine and masculine characters make use of mathematics in the school textbooks. In the case of men, mathematics are used constantly, as a part of everyday life, although they are given special importance in areas such as construction: Vicente has spent nine days building a house in the country 50 km away from the city. This is where his family will live. Each day Vicente lays 50 bricks. How many bricks has he laid? (Reguera et al., 2019) (SS). In a similar sense, mathematics are used by male characters to establish comparisons with other men about material possessions and goods: Dani has 54 cars and his [male] cousin has 4 more. How many cars does his cousin have? (Reguera et al., 2019) (SS); height: The shortest [male] basketball player on the national team is 1 m, 90 centimeters high. He is 22 centimeters shorter than the tallest player. How tall is the tallest player? (Reguera et al., 2019) (SS); and results of sporting competitions: Gregorio has scored 58 goals this season and his brother has scored 35. How many goals has Gregorio scored in each game? How many goals has his brother scored? How many fewer goals has his brother scored? (Reguera et al., 2019) (SS).

In contrast to this, one of the activities in which female characters most often make use of mathematics is in keeping track of their weight. This shows a perpetuation of dangerous gender stereotypes regarding girls and their body image. There are numerous examples of girls comparing their weight to that of other girls in their class, and the textbooks resort to terms that can have decidedly negative connotations, such as "putting on weight": Last year, María weighed 38.15 kilos. If she weighs 41.80 kilos now, how much weight has she put on? (Ferrero et al., 2015b) (SS).

Feminine characters tend to use mathematical skills for a limited number of activities linked to traditional gender stereotypes such as: (1) taking measurements for sewing garments: Cristina's mother took her measurements in order to make her a dress. Observe the measurements that she has taken (Bernabeu et al., 2014) (SS); (2) keeping track of the household budget: Every month Yolanda's mother spends 400 euros on fruit, vegetables, meat and fish, and another 200 euros on other food products. How much money does Yolanda's mother spend on food every six months? (Reguera et al., 2019) (SS); or (3) improving cooking skills and recipes by keeping close track of the ingredients used and their measures: Susana is very proud of the way her cake came out. She has taken a liking to baking, and after this initial success she is preparing three more cakes to share with her friends (Ferrero et al., 2015) (SS).

Both men and women are represented as clients who make use of their mathematical knowledge to figure out their shopping expenses, calculate discounts and sales bargains, etc. While this use of mathematical skills may appear egalitarian, we should point out that the mathematical problems that arise in the textbooks actually reinforce gender stereotypes in several ways. To begin with, the products acquired by men and women are different, for instance: Antonio buys two computers that cost €893 each. How much does he have to pay all together? (Reguera et al., 2019); Miriam bought a washing machine for €287, an oven for €412 and a dishwasher for €194. How much did she spend all together? (Almodóvar et al., 2019). Females tend to buy household appliances, clothing, jewelry, books, food, and tickets to shows, with their greatest expenditures being for appliances and furniture. Men are shown purchasing vehicles and electronic devices such as telephones, computers and video games, goods that in general are more expensive. Women are associated with greater budget control and saving in their purchases: Sandra put the 50 euros that she was given today for a present in her piggy bank. She now has 456 euros. How much money did she have before she got this present? (Reguera et al., 2019) (SS).

In a counter-stereotyped way (CS), we find feminine and masculine characters whose mathematical skills have helped them be successful in the professional world. For example: Pythagoras, the Greek mathematician and philosopher, discovered the musical scale with the help of fractions (Medina et al., 2013) (CS); or: Alba designed the scenery for a video game. She did so by transferring, turning, and creating symmetries with the figures (Medina et al., 2013) (CS). What's more, the books teach boys and girls the importance of using mathematics in the world of labor and for calculating, for example, daily pay or salaries, independently of the characters' gender: Last year Juana made €25,600. They have raised her salary, so this year she will make €300 more. For the two years together, she will make a total of €50,900 (Almodóvar et al., 2019) (CS).

Attitudes Towards Mathematics

The mathematics textbooks often include feminine and masculine characters who explain different mathematical rules and figure in the situations and maths problems. We can see here how the attitudes shown by the characters reproduce gender stereotypes implying that "boys are better at maths, and they like it more": I'm Frank. I'm 10 years old and I have 2 dogs. My favorite subjects are maths and music. I'm really good at them (Medina et al., 2013) (SS). The male characters show an interest in mathematics from a very early age; from the time they were young they dreamed of great achievements like building a robot that would one day walk on the surface of Mars (Bernabeu et al., 2014) (SS). In addition to this vocational ambition, men convey an attitude of enjoyment and satisfaction with learning mathematics. They also have an entire network of male references that includes family members, teachers, classmates, and brilliant mathematicians who serve as role models. In contrast, the lack of interest and rejection of maths by girls constitutes a feminine stereotype: Alicia is an 11-year-old girl who can't stand mathematics (Medina et al., 2013) (SS). Textbook contents often include female characters who are incapable of solving certain mathematical problems by themselves. They are attributed passive attitudes, shown as mere "spectators" who watch on while their male classmates perform experiments and solve mathematical problems.

Only female characters are shown faltering when trying to resolve certain problems or explain rules of mathematics: Is the divisor greater than or less than 1? (Almodóvar et al., 2019) (SS). This conveys an attitude of insecurity or lack of self-confidence in the subject instead of promoting feeling of self-confidence. In a Figure of book 3, we observe a group of students on a field trip and an image with a boy and a girl. In a speech bubble over the boy's head, we see him talking about the distance remaining: Come on, we only have 1000 m to go!!! (Ferrero et al., 2015a). The type of speech bubble and the exclamation marks show how confident he is about his calculation. The speech bubble over the girl is quite different, showing a "thought cloud": Well then, it's… 1 km (Ferrero et al., 2015a). In other words, she actually has the correct answer in her head, but she refrains from saying it out loud to her classmates (SS). Meanwhile, the only characters who ask for help in solving mathematical problems are female: How many cubes does Inés need to form a cube with a side dimension of 3? – Can you help me? (Medina et al., 2013) (SS).

Although we come across some examples where girls do show initiative and self-assurance in maths, we believe that these are sometimes accompanied by more subtle, veiled sexist messages (SS), for example: María, an 11-year-old girl, and her father decide to walk home instead of taking the bus. María makes a deal with her father: if she can figure out how much they are saving by not buying bus tickets, then she gets to use the money saved however she wants. —Let's see, if one ticket costs €1.20—María thinks out loud—then two tickets cost €2.40. So, we are saving €2.40.—Are you cheating? —asks her father —. I thought you hadn't yet learned to multiply decimal numbers. I haven't – answers María—. But I know how to add decimal numbers and since multiplying by 2 is the same as adding, all I had to do was add 1.20 and 1.20.—How clever! [astute] —exclaims her father —. So, tell me, how much will we save over the twenty days that you have class this month?—Do you

think I cannot add 2,40 twenty times? Well, you're in for a surprise. We will save €48 this month (…)—You're right! You really surprised me. But I think that even if you can figure out these calculations like a great mathematician, you're still too young to spend that amount of money. What a shame! - María exclaims —. I was going to surprise you with a present (Medina et al., 2013).

This example is full of insinuations. It shows that when girls display an interest in an area like mathematics, they need to show it to others and be excellent at it. In this case, a father accuses his daughter of cheating due to her getting the answer right and he challenges her and shows an attitude of incredulity towards the mathematical skills of his daughter. And he resorts to the word "clever" [astute] instead of "intelligent". Whereas intelligent refers to a person who chooses the best options for resolving problems, clever —or astute— can have negative connotations, including the ability to deceive others in order to achieve one's objectives.

Finally, as a case of counter-stereotype (CS), we would like to call attention to an activity in which a boy and a girl are shown trying to resolve a division problem. The following question is posed: Which of the children is right? (Bernabeu et al., 2014). It is the girl who gets the correct answer here, showing that she is better able to solve the problem that her classmate, an example of how girls can also be proficient at maths.

Discussion

The field of mathematics has traditionally been considered neutral, and the study of its curriculum, from a gender perspective, has gone practically unnoticed (Giroux, 1984). In this study, we have approached school curriculum in the area of mathematics through the examination of textbooks used in primary schools in recent years. The textbook as a didactic resource is a fundamental tool in the process of gender socialization, helping to mold attitudes regarding students' educational opportunities (Salami & Ghajarieh, 2016). Textbooks reflect social, cultural, and historical norms, and in heteronormative, patriarchal societies, they transmit gender stereotypes (Ruiz-Cecilia et al., 2021).

The idea that both genders have equal math abilities and performance is widely accepted among social scientists (Kersey et al., 2019; Lindberg et al., 2010). However, according to the largest official study carried out until now in Spain, *Radiografía de la brecha de género en la formación STEAM*, gender stereotypes form an implicit part of the gender gap in the vocational choices of boys and girls (MEFP, 2022). One of the most deeply rooted stereotypes in our society is "girls don't do maths" (Cvencek et al., 2011). A U.S. study showed how women with an equally strong background as men in mathematical ability scored lower when the stereotype of women being bad at maths was presented, and scored the same as men when the stereotype was removed (Spencer et al., 1999). The persistence of gender stereotypes and prejudices persuade girls that scientific studies are not for them, despite their tremendous potential (Chestnut et al., 2021; UNESCO, 2017). Precisely it is in the area of mathematics where the gender gap has grown considerably in recent decades. In the school year 1985/86 women represented 50.68% of matriculations in

the Mathematics Degree in Spanish public universities; in the 2019/20 school year this percentage had shrunk to 36.26%. The International Association for the Evaluation of Educational Achievement (IEA), in its study *Tendencias en Matemáticas y Ciencias* (TIMSS) warns that girls are beginning to distance themselves from the area of mathematics beginning in the stage of primary education (MEFP, 2020). For this reason, we have tried in this study to determine the extent to which mathematics textbooks used in schools challenge or reinforce gender stereotypes. In the latter's case, textbooks may influence girls from an early age and discourage them from pursuing a scientific and technological future (Huyer & Westholm, 2007; Wang & Degol, 2013). The way female and male characters are represented in textbooks conveys explicit and implicit messages to both boys and girls about male and female roles and abilities in STEM (Eurydice, 2010). Several researchers have called attention to the way that exposure to biased content is a potential danger in the field of mathematics. In addition to producing a negative impact in their performance in the subject (Sekaquaptewa & Thompson, 2003), it can also affect their capacity for mathematical learning (Appel et al., 2011), diminish the value that they attribute to success in maths (Eccles, 2011), and affect the likelihood of their choosing mathematics as a career path (Davies et al., 2002).

The exhaustive analysis carried out in this study on 4,783 characters with the use of a mixed method leads us to conclude that, at a quantitative level, the school textbooks used in primary school mathematics classes have, in general, a balanced numerical representation of male and female characters. This is an essential first step in promoting gender equality in textbooks (Incikabi & Ulusoy, 2019), but it does not mean their portrayal is free of gender stereotypes. For instance, we found a lack of female characters as cultural references for students (30.36%), especially in STEM; and a masculine bias in the professional world, where the occupation of women is a mere 31% in the textual content and 34% in the iconographic content.

A critical mathematical education depends on discourse analysis (Frankestein, 1983), and it is at this qualitative level that the characters represented in the textbooks evidence serious gender stereotypes relating to expectations of success (Eccles, 2011); enjoyment of mathematical tasks (Eccles, 1983); appreciation of the importance of maths (Eccles et al., 1997); and prejudices involving mathematical abilities (Bussey & Bandura, 1999). In this regard, the social roles carried out by men and women in the textbooks analyzed in our study show evidence of traditional gender stereotypes such as "girls are better caretakers" or "girls are not as good at sports" (Táboas-Pais & Rey-Cao, 2012). An unequivocal inequality is patent in the activities that they perform, especially in the labor market. The textbooks convey a double occupational segregation; on the one hand, a horizontal segregation limits female characters to only a few types of jobs in the service sector. Women tend to work in fields related to the care of others, while men work as drivers, mechanics, in the armed forces or in sports. These results coincide with gender norms and match the professional preferences of boys and girls from the age of five (OECD, 2020). On the other hand, women are also subject to vertical segregation, especially in the textual content, where male characters occupy the highest professional positions. An essential step, if we want to promote gender equity in textbooks, is to design an egalitarian distribution of the social roles of men and women, in particular in those roles tradi-

tionally stereotyped as "unsuited for their gender" (Midgley et al., 2021). Despite the fact that the mathematics textbooks examined here include a greater proportion of female than male characters in the STEM sphere, there is not a single real feminine reference. This constitutes an unacceptable discrimination towards female contributions to the historical development of mathematics. Numerous studies and experiments have demonstrated the benefits for women of having visible feminine STEM references; these benefits include increased self-sufficiency, concept of oneself, identification interest and commitment to STEM (Shin & Levy, 2016). To attain such rewards, it is crucial that school textbooks recover the voices of female mathematicians. This is the only way to achieve a real connection and a feeling of belonging to this group of references (Hoffman et al., 2021). Girls need to see themselves reflected in such roles and feel that careers and professions in this field might suit them.

Mathematics help us in analyzing phenomena and situations that form part of the world around us. Yet the functional contexts shown as being appropriate for women to apply their mathematical knowledge are very limited. They invariably involve stereotypically feminine activities such as shopping, making clothes, using recipes, calculating their weight, etc. Males on the other hand apply their mathematical skills in a host of situations occurring in daily life, including at work. What's more, only the female characters in these textbooks show attitudes of rejection or lack of interest towards maths. This allows stereotypes such as "boys are better at math and like it more" to persist. 28.3% of 9- and 10-year-old girls report that they do not like learning math (MEFP, 2020), and girls have reported greater feelings of tension and anxiety related to math performance and assessments than boys (Alam, 2013; Andre et al., 1999; OCDE, 2015). In fact, the effects of math anxiety have been linked to lower performance and may drive girls away from STEM studies and careers (Beilock & Maloney, 2015; OECD, 2015). In this sense, the female characters in these textbooks also appear at times insecure and incapable of solving certain problems, adopting passive attitudes, giving up or asking for help to find the right answer. This can lead to a loss of self-esteem and even reproduce prejudices about their intellectual capacity (Bian et al., 2017). In fact, 36.7% of girls in fourth grade do not feel sure of themselves when tackling mathematical problems (MEFP, 2020), making it crucial that we address this matter as soon as possible.

Mathematics are the door to technology. Today, the rate of increase in work opportunities in STEM is three times that of non-specialized work, and these occupations are often referred to as the jobs of the future, driving innovation, social well-being and sustainable development (MEFP, 2022; UNESCO, 2017). Our primary education needs to encourage female talent in the service of science, technology, research, and progress, advancing towards greater equality. This study addresses the complex relationship between school textbooks and gender stereotypes regarding mathematics. The aim of eliminating gender bias in learning materials is to ensure that girls and boys, in all their diversity, are free to follow their chosen path in life, have equal opportunities to thrive, and participate and lead equally in our society (European Commission, 2020).

Given the nature of the study, we were unable to observe the reactions of the students themselves to partial representation. Nor were we able to assess the interaction between the didactic material and the teachers during lessons. These are two funda-

mental questions that we must examine if we wish to identify the actual influence that these gender stereotypes have on students, and we believe that future research needs to be done in this direction. Finally, we can only hope that our study, in addition to its implications for editors and researchers, will serve to raise teachers' awareness about the importance of carrying out a careful selection of textbooks. Their choices must be free of sexist stereotypes and help in the construction of a more just and egalitarian society —and therefore a more democratic one— that respects the academic choices and life projects and professions of our youth.

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