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Women, science and society: the semiotic perspective of the female image in science textbooks

ARTICLE

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Abstract
In this study, a state-of-the-art review was conducted, mapping academic productions from 2018 to 2024 on female representation in science textbooks, using sources such as Google Scholar, Scientific Electronic Library Online (SciELO), and the *Brazilian Journal of Physics Teaching*. The aim was to evaluate changes or stagnation in the image of women in science teaching materials. Additionally, Peirce's semiotics was used to analyze the illustrations in books from the middle school from four collections of the *Plano Nacional do Livro Didático* (PNLD) of 2024. A qualitative, exploratory approach was chosen, as the invisibility of women in science manuals is still little explored in education. The studies show the evolution of the female image in science textbooks over the years. However, there are still veiled representations of the female role, reflecting the persistence of a patriarchal society in educational productions.
Keywords: Education. Women. Image. Science Teaching Materials.

Mulher, Ciência e sociedade: a perspectiva semiótica da imagem feminina nos livros didáticos de Ciências

Resumo
Neste estudo, foi realizado o estado da arte mapeando as produções acadêmicas de 2018 a 2024 sobre a representatividade feminina em livros didáticos de Ciências, usando fontes, como Google Acadêmico, Scientific Electronic Library On-line (SciELO) e *Revista Brasileira de Ensino de Física*. O objetivo foi avaliar as mudanças ou a estagnação da imagem da mulher em materiais didáticos de Ciências. Ademais, na análise em gravuras de livros dos anos finais do Ensino Fundamental de quatro coleções do Plano Nacional do Livro Didático (PNLD) de 2024, utilizou-se a semiótica peirceana para examiná-las. Optou-se por uma abordagem qualitativa, de cunho exploratório, pois a invisibilidade da mulher em manuais de Ciências ainda é pouco explorada na educação. Os estudos mostram a evolução da imagem feminina em manuais didáticos de Ciências ao longo dos anos. Apesar disso, ainda há representações veladas do papel feminino, refletindo a persistência de uma sociedade patriarcal nas produções educacionais.
Palavras-chave: Educação. Mulher. Imagem. Materiais Didáticos de Ciências.

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1 Introduction

The discussion on gender equality has gained intensity in recent years in various fields, and it's no different in the scientific sphere. The invisibility of women in the production, reflection and dissemination of scientific knowledge has been a topic of debate in academia and has motivated various research groups to investigate issues such as the presence of women in science throughout history and the challenges women face in the academic and scientific fields. According to Ribeiro and Munchen (2023, p. 1), "[...] there is a culturally constructed view that subjugates women's intellect and competence, especially in areas of the exact sciences and engineering, traditionally dominated by the male gender".

In this sense, Souza and Elias (2022) point out that sociocultural issues have a strong link with physical ability for the division of tasks, which has consolidated the idea that women are predestined to take care of the home and family, taking this thinking to activities that are not directly linked to their physical aptitude. Unfortunately, this thinking is still prevalent today.

Incorrect theories about women's intellectual capacity have emerged over the centuries, including that women cannot produce scientific knowledge. "[...] The naturalistic paradigm of the difference between the sexes caused not only differentiated access to knowledge and production, but also marginalized and demonized women who possessed knowledge (sometimes called 'witches'), [...]" (Patou-Mathis, 2020, p. 15).

The aforementioned author leads us to reflect that we need to correct this centuries-old misunderstanding that the sociocultural imaginary has forged, with the idea that women are not capable of occupying universities and laboratories.

Even with so many advances and achievements, there is still a lot of resistance to recognizing that women have the capacity to produce scientific knowledge. To justify this argument, we take a global indicator, the Nobel Prize, which officially awards five categories: chemistry, physics, physiology or medicine, literature and peace.

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The prize was awarded to a total of 901 men and 64 women, counting those who won multiple awards just once each (Nobelprize, 2023). In the words of Souza and Elias (2022, p. 431): “the prize portrays the invisibility of women in the scientific field”.

In the field of physics, for example, this inequality is even more divergent, with only five awards going to women since the prize was created in 1901 to the present day. The 2023 Nobel Prize for physics went to L'Huillier. The French scientist was awarded for her experimental methods, which help to study electronic dynamics in matter. At the same time, she highlights the global disparity in gender representation in physics, given that only 2.2% of the winners of the prize since its creation have been female.

What is needed for more women to make a breakthrough in physics, chemistry, engineering, technology and other areas? Inspiration, opportunity? When talking about science and technology, could teachers and parents encourage women to choose a scientific career? Can textbooks with examples of successful female scientists contribute to choosing the field of science?

A common denominator in all areas of knowledge and one that covers the life of an individual in their intellectual development phase and in their construction of knowledge is the textbook, which is present from kindergarten to higher education. It is a learning tool guaranteed to be a reliable source of information. The textbook is the subject of this study, because this manual is one of the main sources of teaching and learning and scientific dissemination, and the most widely used material in education in general, by students and teachers.

From what perspective is the image of women in science defined today? How is the female figure portrayed in science textbooks? Simone de Beauvoir (1949, p. 222) asserts that “the entire history of women has been written by men”, in the sense of recognizing women's written production. Almost a century after the feminist author's words, we want to know: how are women represented in written productions, such as textbooks, which are mostly authored by men?

In this study, therefore, the proposal is to map current scientific productions that have focused on studying the representation of the female figure in textbooks used in Basic

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Education, in order to discuss and reflect on this genesis, thus bringing a refined state of knowledge regarding the art explored, and contributing to an education based on gender equality. On the other hand, the objective is also to analyze how women are illustrated in the images in the 8th and 9th grade textbooks of the Araribá Conecta, Ciências Naturais, SuperAção and Teláris Essencial Collections, included in the PNLD/2024 for the science curriculum component used in the middle school, using Peircean semiotic procedures. Finally, an explanation is given of what was researched regarding the representation of women in science textbooks, in order to stimulate scientific production and reflection on gender relations in the country, and to promote the participation of women in the field of science and academic careers.

2 Methodology

The research approach is characterized as qualitative, despite the presentation of graphs in the research results, the authors Strauss and Corbin (2008, p. 24), in their studies of the technique and procedures for the development of grounded theory, classify that:

> [...] some researchers gather data through interviews and observations, techniques normally associated with qualitative methods. However, they code the data in a way that allows it to be statistically analyzed. This is actually quantified qualitative data. When we talk about qualitative analysis, we are not referring to the quantification of qualitative data, but rather to the non-mathematical process of interpretation, aimed at discovering concepts and relationships in the raw data and organizing these concepts and relations into a theoretical explanatory scheme.

Organizing the data systematically in tables or graphs is important for the reader's clear interpretation and does not disqualify the research as qualitative, according to the authors of the aforementioned quote.

In terms of objective, the research is characterized as exploratory, as it was developed to provide a broad, approximate view of a given fact. “This type of research is carried out especially when the chosen topic is little explored and it is difficult to formulate precise and operationalizable hypotheses about it” (Gil, 2019, p. 26).

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The subject of this study is the semiotic perspective from which the female image is represented in science textbooks, which is still little explored in the scientific field of education and therefore meets the characteristics of an exploratory study. In the words of Gil (2002, p. 41), this type of work aims to provide:

> Greater familiarity with the problem, with a view to making it more explicit or building hypotheses. It can be said that the main aim of this research is to improve ideas or discover intuitions. Its planning is therefore quite flexible, so that it can take into account the most varied aspects relating to the fact being studied. In most cases they involve: a) bibliographic survey; (b) interviews with people who have had practical experience with the research problem; and (c) analysis of examples that "stimulate understanding" [...].

Sharing Gil's (2002) understanding of the construction of this work, the theoretical references were selected in order to offer information or prior knowledge to support discussions similar to the theme of analyzing science textbooks and the sacred feminine; advances and setbacks in the PNLD; the invisibility of the female figure in the scientific community over time; in order to develop an analysis of the images presented in science textbooks for the middle school.

For this work, we carried out a state-of-the-art study, which, according to Romanowski and Ens (2006, p. 40), "aims to survey what is known about a particular subject based on research carried out in a given area". For the authors Romanowski and Ens (2006), the core of state-of-the-art research is problematization and methodology, the interest of which is mapping in order to justify the vacuum that the research aims to fill. According to Bento (2012) and Silva *et al*. (2021), literature reviews are essential to the research process and contribute to a methodological overview of academic research.

Silva *et al*. (2021, p. 3) consider the use of this methodology to be "[...] important for keeping up with changes in the sciences, demarcating the different strands and facets on which scientific knowledge has been built".

Considering the aforementioned authors, the research criteria and procedures were organized as follows:

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The database used for the research was Google Scholar, with nine papers, since the search for academic articles/productions on the pages of SciElo and *Revista Brasileira de Ensino de Física* (*Brazilian Journal of Physics Teaching*) did not result in substantial papers of the magnitude required for this study. The following descriptors were used: textbook; science; invisibility; female image; semiotics. The following filters were also used: Portuguese language and the periodicity of the publications covered the years 2018 to 2024.

We tried to gather as much information as possible for this analysis because, according to Marconi and Lakatos (2011, p. 43), bibliographical research "aims to bring the researcher into direct contact with all the written material on a given subject, helping the scientist to analyze their research or manipulate their information". In this sense, the search for works that could provide a theoretical framework for this study was wide-ranging and careful, as relevance and scientific rigor were taken into account.

The methodological analysis of the manuals was organized in four stages:

1) Selection of textbooks. Based on the PNLD/2024 Guide, available on the Ministry of Education (MEC) website. From the list of books available on the MEC website, four collections were selected, including one for the 8th grade and another for the 9th grade, making a total of eight books for analysis.

2) Mapping fragments of the female presence in textbooks. For this stage, pictures were cataloged that could be accurately said to be female, even with props such as goggles, helmets and other equipment identified in the images. This image classification was based on Charles S. Pierce's semiotic triad, or trichotomy, described in Santaella's (2002) work, *Applied Semiotics*, which follows the line of reasoning shown in figure 1, adapted for this study.

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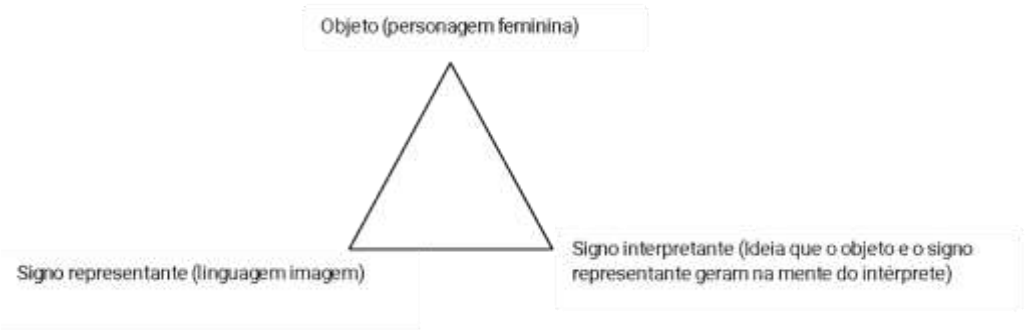
Figure 1



Source: Elaborated by the authors (2024).

3) Reflection and interpretation of mentions of female figures. For this stage, it was necessary to draw up a table to organize the signs into categories. It was then possible to analyze which category featured the female image most prominently. According to Strauss and Corbin (2008, p. 114), “categories are concepts, derived from the data, which represent the phenomena, because with the accumulation of concepts it is necessary to group them and the best way is by categorizing”.

4) The final stage of this work involved systematizing the studies carried out after reading the researched articles on the subject and analyzing the figures, which was broken down into a systematically organized manuscript. Once compiled, they were cut out for this work in question.

3 Results and Discussion

3.1 State of the art

The results obtained showed that investigating textbooks is an important tool for reflecting on gender roles, and bringing these reflections to light is extremely useful. Silva and Rotta (2023) therefore consider that scientific journals tend to be relevant as vehicles for academic communication, since publication in an internationally or nationally renowned

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journal guarantees academic recognition and validates science. In this sense, we have listed other works similar to this study in box 1 and what stood out most in the perception of each work.

Box 1 – Results of similar work titles obtained between October 2023 and April 2024

Keywords	textbook; science; invisibility of women; image of women; semiotics	
Filters	In Portuguese; published between 2018 and 2024	
Author	**Work title**	**Database**
Ribeiro and München (2023)	As mulheres cientistas em uma coleção de livros didáticos de ciências da natureza do novo ensino médio	Google Scholar
Schactae *et al.* (2023)	Representações dos femininos em livros didáticos de física do Ensino Médio: em foco livros da década de 2010	
Silva and Rotta (2023)	Ensino de ciências e o feminismo em pesquisas brasileiras: possíveis interlocuções	
Souza and Elias (2022)	Que mulher é essa? A representação da mulher nos livros didáticos de ciências e biologia	
Lopes Neto *et al*. (2022)	Ensino de biologia e racismo: representações de corpos negros em coleções didáticas de ciências da natureza e suas tecnologias	
Hendges and Santos (2022)	Obstáculos epistemológicos em livros didáticos de física: o gênero na ciência-tecnologia	
Matos and Soja (2021)	Mulheres e os novos livros de projetos integradores em ciências da natureza	
Cardoso and Melo (2021)	Construção do critério gênero no Programa Nacional do Livro Didático (2006-2020)	
Jansen *et al*. (2019)	Lugar de mulher é na ciência: estudo sobre representatividade feminina em livros didáticos de química	

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—	—	SciELO

Source: Elaborated by the authors (2024).

In the work by Ribeiro and München (2023), the materials analyzed were high school biology, physics and chemistry textbooks used in a state public school in Rio Grande do Sul and approved by the PNLD/2021. Specifically, books from Editora FTD were examined, from the Ciências da Natureza e suas Tecnologias (Sciences of Nature and its Technologies) collection, from the year 2021. The study counted the presence of scientists in images and quotes, revealing a total of 89 men and only ten women, which represents 8.9% of female scientists. These results highlight the low representation of this segment in textbooks, indicating a worrying disparity in relation to the male presence.

In the analysis by Schactae *et al*. (2023), the images evaluated were included in textbooks for different subjects used in the 10th grade and made it possible to identify the inclusion of women in traditionally male spaces. However, these representations are scarce and have not demonstrated equal roles for men and women. The different and unequal representations of gender in textbooks reinforce the perpetuation of gender inequalities.

Although they are not capable of radically transforming social relations, textbooks can suggest new paths and promote gender equality. The article therefore highlights the importance of problematizing the images in physics textbooks, which often reproduce gender, class and racial identity relations. It is up to education professionals to adopt a critical and reflective approach to these representations in teaching materials.

In the articles by Silva and Rotta (2023) and Souza and Elias (2022), the authors highlight the importance of didactic works also featuring black women scientists, thus enabling reflection and the dismantling of historical sexism and racism, in order to build a new way of thinking free of racial prejudice and sexism.

The authors state that doubts about the intellectual capacity of women, who are often seen as inferior to men, have resulted in their scientific invisibility, denying them

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recognition for their achievements. In this context, the school, as an environment for building and discussing knowledge, must demystify stereotypes about both the profile of scientists and the scientific abilities of women, starting with their representation in textbooks.

The aim of the study by Lopes Neto *et al*. (2022) was to understand how the idea of race and racism is dealt with in illustrations in the textbook collections of Ciências da Natureza e suas Tecnologias (Natural Sciences and their Technologies) for high school, accepted by the PNLD/2021. Four collections were analyzed, totaling 24 books. The authors noted that most of the images of black people collected were of women; however, they considered this to be an under-representation compared to the number of images of white women in the seven collections analyzed in their study.

Hendges and Santos (2022) consider that, in a society aimed at being more democratic and inclusive, promoting reflection on gender issues is an important step towards achieving this goal. The school environment, as a training ground for citizens, is the ideal place for this, as many different people live there on a daily basis. The authors also point out that textbooks play a significant role in teaching and learning processes and can be used as a reference for students to construct their identities and position themselves in social spaces.

It is worth noting that the textbook in Brazil is still the primary source of documentation and consultation used by teachers and students, despite the advance of digital technologies. As such, this pedagogical tool has an impact on educational work and everyday life in the classroom.

Matos and Soja (2021) investigated the visibility of women in books on integrative projects in the natural sciences from the PNLD/2021. Using a qualitative-quantitative approach, they examine gender equality using five indicators: representation in the images, in the number of female authors, in the references, in the citations and in the technical team. The results were positive for images, authorship and technical team and highlighted the role of women in social and environmental activism.

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However, contradictions persist, especially in the lack of conformity of bibliographic recommendations and citations of women, despite the fact that academic production has already achieved equity. Thus, the authors have shown that, although progress has been made, the discussion on gender equality must continue until it is fully achieved.

Cardoso and Melo (2021) address problems related to curriculum, gender and textbooks. They investigate how the gender category is constructed in the criteria for inclusion or exclusion in the PNLD notices. Sometimes gender is included in the criteria of citizenship or human rights, while at other times it is openly linked to women and related to constructions of femininity and masculinity.

In their analysis, the authors examined the legal documents regulating the PNLD and the public notices for the period from 2006 to 2020, available for digital consultation, and detected that the evaluation items on gender diversity issues are not very specific, sharing space with other analytical categories, such as race and ethnicity. Depending on the political position on the subject, this evaluation can result in the silencing or imprisonment of gender in textbook collections.

Jansen *et al*. (2019) presented an analysis of chemistry textbooks in the Proceedings of the 6th edition of the National Education Congress (Conedu). Although they don't explore women's contributions to science in depth, the books don't exclude them as individuals with enormous potential for doing science. The authors conclude that historiography consistently demonstrates the presence of profound gender inequalities over the centuries, most of which have marginalized women in various aspects of social life. It is essential to critically analyze the contemporary situation through the lens of gender, questioning the power structures that continue to underestimate women's contributions to the advancement of humanity. The history of science and technology, for example, reveals that women have always been present, although their work has often been silenced or attributed to men.

It is therefore crucial that educators discuss issues of this breadth in the classroom, encouraging reflection through discussions on gender inequality in educational works, seeking to develop a critical understanding of their historical and social impact. By

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addressing this issue in the classroom, teachers can make a significant contribution to planning the construction of more equitable and inclusive teaching materials, fostering the formation of aware citizens capable of transforming reality.

3.2 Understanding the semiotics of images in textbooks

In order to understand the data analysis of this study and the generation of its results, the main concepts of Charles Sanders Peirce's semiotics are presented. Semiotics, as a science that investigates the production of meaning in all possible forms of verbal and non-verbal languages, offers a fundamental theoretical framework for analyzing the phenomena in question. By adopting a Peircean perspective, this study seeks to unveil the processes of meaning present in the data. This approach allows for a more in-depth understanding of images, as it enables the identification of signs, interpretants and the dynamics of meaning production, as explained by Santaella (2018).

These processes of generating meaning are mediated by a sign which, according to Peirce (2005, p. 46), is “that which, in a certain aspect or way, represents something to someone”; in other words, the sign (the representative) has the capacity to represent something (the object) to a mind (the interpretant). It must be emphasized that an illustration can awaken different meanings for the interpreter, depending on the context of the image, just as the same image seen by several interpreters at the same time can generate different meanings for each one. It's important to note that, in this study, the word “sign” stands for images.

This concept makes it possible to analyze any phenomenon, be it a word, a sound or an image, as in this study, making Peircean semiotics an effective method for investigating various signs. Unlike an applied science, Peircean semiotics adopts a phenomenological perspective, seeking to understand the immediate experience of signs and the processes by which we attribute meaning to them. In this way, it investigates the ontological and epistemological aspects that underpin the production and interpretation of signs in the world (Peirce, 2005).

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The proposal for semiotic analysis presented in this study demonstrates the potential of Peircean semiotics for the training of science teachers. By understanding how signs are constructed and interpreted, teachers can develop more effective teaching materials and promote more inclusive learning in the context of girls and women in science. The dynamic and interrelational nature of Peircean categories offers a solid theoretical framework for analyzing various visual resources that can be used in the classroom.

After cataloguing the images in the 8th and 9th grade science textbooks from the Araribá Conecta, Ciências Naturais, SuperAção and Teláris Essencial Collections, indicated in the PNLD/2024, Peirce's (2005) sign analysis was applied, with the images organized into categories, which are better explained in the following section.

3.3 Image analysis: the image of women in textbooks

At this point, in order to make it easier to understand what or why the female figure is more related in the science textbooks used in the middle school (PNLD/2024), a table was created with 11 figures based on semiotic theory: art and culture; professional advancement; domestic activity; science; education; sport; family; hygiene and beauty; inclusion; health; technology. Table 1 and graph 1 below show the data expressed as a percentage.

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Table 1 – Data collected and categorized

Livro	Arte e cultura	Ascensão profissional	Atividade doméstica	ciência	Educação	Esporte	Família	Higiene e beleza	Inclusão	Saúde	Tecnologia	Quantitativo de imagens por obra
I	_	2	1	3	1	_	3	_	2	13	6	**31**
II	1	1	3	9	_	_	1	_	_	2	_	**17**
II	_	2	3	_	_	2	6	_	_	5	1	**19**
IV	3	_	_	5	1	_	1	_	_	2	1	**13**
V	1	1	1	4	1	1	1	_	_	1	1	**12**
VI	3	_	_	4	1	1	2	_	_	3	_	**14**
VII	_	2	1	1	1	_	7	3	_	7	_	**22**
VIII	4	1	_	3	3	1	3	1	1	2	0	**19**
Total	**12**	**9**	**9**	**29**	**8**	**5**	**24**	**4**	**3**	**35**	**9**	**147**

Fonte: Autoria própria,2024 ***Observação: I, III, V e VII LD 8º ano e II, IV, VI e VIII LD 9º**

Graph 1 – Data expressed as a percentage

Source: Elaborated by the authors (2024).

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The data in table 1 shows that three categories stand out: health, science and family, which will be analyzed separately. The image of women is probably associated with health because it is social behavior for women to be more concerned about their health than men. This behavior is reinforced in the textbook, because this object of learning, according to Schactae *et al*. (2023), is the mirror of behaviors related to reality and is inserted in that space/time, tending to present ruptures or permanence of social behavioral relations of gender.

Science is the second most quoted item in the analysis and has a positive connotation, in this article, for Souza and Elias (2023), this is due to the prominence of female participation in scientific production and this has been fundamental for the transformation of traditional research paradigms. Interdisciplinarity, which is increasingly present, and the influence of the second wave of feminism have contributed to the inclusion of women's experiences and perspectives in research, resulting in greater diversity and representativeness in the production of scientific knowledge.

In the eyes of a patriarchal society, it's no surprise that, in the third item, the image of women is more associated with the concept of the family, as they are seen as the perpetuators of the human species and the ones who look after the home and the children. Both the authors Souza and Elias (2023) and Hendges and Santos (2022) corroborate that the social construction of gender, which begins in childhood, imposes limited expectations and roles on girls, directing them towards traditional activities and keeping them away from the areas: science, technology, engineering and mathematics. This differentiated socialization, which associates women with care and the domestic sphere, results in a lower representation of women in science and makes it difficult to reconcile work and family life.

4 Conclusions

In this work, we have listed, with the voices of current authors who, like us, had the concern to investigate the image of women in comprehensive exact sciences textbooks,

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the essentiality of the meaning and potentialization of the image of women extracted from textbooks, particularly from the middle school.

The textbook is a very important pedagogical support, which accompanies the student in their schooling, helps educators in the bibliographic basis of their lesson plans, which is why it is so relevant to analyze, reflect and make notes of improvements, since the visual helps students to understand new concepts, connect ideas and practice their critical thinking. Therefore, there needs to be representation, so that girls can identify with women scientists and be inspired by them to pursue scientific careers.

In this way, the analysis of images in science teaching materials highlights the importance of an education that promotes critical visual literacy. By denaturalizing the gender stereotypes present in the images in these books, it is possible to build more inclusive and equitable teaching practices. This work seeks precisely to contribute to the training of science teachers capable of promoting an education that values diversity and promotes debate on gender issues.

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