ALEXANDRIA

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Trends in Brazilian elementary science textbooks (PNLD 2020) on climate change: a look through the lens of Climate Justice

Tendências dos livros didáticos brasileiros de ciências da natureza do ensino fundamental (PNLD 2020) sobre as mudanças climáticas: um olhar à luz da Justiça Climática

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Abstract: Climate change has become an important topic of discussion in the scientific community and in society, with impacts on the educational process, including curricula and didactic materials. This research aimed to present the meanings given to the subjectof climate change in Natural Science textbooks for the final Elementary School years (PNLD 2020) in light of Climate Justice. The textbook analysis was carried out employing the Thematization methodology. Four themes were determined: 1. Climate change causes; 2. Climate change consequences; 3. Climate change mitigation strategies; and 4. Science and climate change. The results point to trends that neglect a critical approach to the topic, with an absence of historical and political perspectives and questioning of the capitalist economic model. The analyzed textbooks also do not present the Climate Justice debate and express trends that reinforce a pragmatic Environmental Education character.

Keywords: Climate emergency, critical environmental education, science teaching, final years of elementary school.

Resumo: As mudanças climáticas têm sido um importante assunto discutido tanto no meio científico como na sociedade em geral, com impactos no processo educativo, incluindo currículos e materiais didáticos. Esta pesquisa objetivou apresentar os significados conferidos ao tema mudanças climáticas em livros didáticos de Ciências da Natureza dos anos finais do Ensino Fundamental (PNLD 2020) à luz da Justiça Climática. Foi realizada a análise dos livros didáticos utilizando-se a metodologia da Tematização. Foram encontrados quarto núcleos de sentido: 1. Causas das mudanças climáticas; 2. Consequências das

mudanças climáticas; 3. Formas de mitigação das mudanças climáticas e 4. Ciência e mudanças climáticas. Os resultados apontam para tendências que negligenciam uma abordagem crítica da temática, com ausência das perspectivas históricas, políticas e do questionamento do modelo economic capitalista. Os LD analisados também não apresentam o debate sobre Justiça Climática e expressam tendências que reforçam um caráter pragmático da Educação Ambiental.

Palavras-chave: Emergência climática, educação ambiental crítica, ensino de ciências, anos finais do ensino fundamental.

Introduction

Climate change (CC) has become a central topic of discussion both in the scientific community and in broader society, with implications for educational processes aimed at preparing future generations to engage with environmental issues (Jacobi et al., 2011). Historically treated as controversial and contentious, CC is often addressed superficially and in a content-centered manner in textbooks, overlooking the complexity of climatic phenomena and the associated social dimensions (Rumenos, 2016; Serantes-Pazos & Cartea, 2016; Liotti & Campos, 2021; Diez et al., 2022; Batista et al., 2023). A more responsible approach should consider the current state of planetary climate emergency, which has numerous consequences for both human health and the environment.

From aCritical Environmental Education (CEE) perspective, CC arises from an emergency triggered by a civilizational crisis, both social and environmental in nature, driven by a capitalist development model that disregards planetary boundaries in its pursuit of maximum profit (Guimarães, 2018).

Environmental Education (EE) is frequently identified in the literature as a viable path for addressing environmental challenges, including CC (Jacobi et al., 2011; Mello-Silva & Guimarães, 2018; Guimarães & Cartea, 2020; Huguenin et al., 2022). Within the diversity of EE approaches, Critical CEE (Loureiro, 2004) is regarded as the framework that most comprehensively integrates social dimensions into environmental discourse, incorporating key concepts such as citizenship, democracy, emancipation, environmental justice, and social transformation, which are also keyto the discussion (Layrargues & Lima, 2014).

A healthy and ecologically balanced environment is a universal and constitutional right (Brazil, 1988), yet environmental degradation impacts disproportionately affect socially vulnerable groups, particularly in Brazil, where Black populations, Indigenous communities, and Quilombola groups bear the brunt. The

term “climate justice” has gained traction in the literature as an extension of the Environmental Justice (EJ) debate, used to highlight the specific vulnerability of these groups to CC (Acselrad et al., 2008; Robinson, 2021). Given the urgency and pace at which these communities are being affected, it is paramount that educational approaches to CC incorporate EJprinciples. This justifies the emphasis on this concept in the present study and its link to CEE.

In 2017, Brazil implemented the National Common Curricular Base (NCCB), a national curriculum framework designed to standardize the content taught in public and private basic education across the country (Brasil, 2017). In addition to the pressing need to integrate the climate crisis into school curricula, this study is also justified by the NCCB implementation, which requires thorough and original analyses of its application. Given NCCB shortcomings in addressing environmental topics (Ferreira et al., 2023; Roehrig et al., 2023; Antunes & Uhmann, 2024), and the need to advance research in EE from a critical perspective, it is necessary to examine the tendencies present in textbooksregarding environmental issues, and, particularly, CC, considering the paradoxical context in which EE initiatives coexist with ongoing environmental degradation (Guimarães, 2016).

Therefore, this study aims to examine the meanings attributed to CC in middle school science textbooks (PNLD 2020), through a climate justice lens. The following research question was applied to guide this investigation: What trends do the science textbooks listed in the 2020 National Book and Teaching Material Program (*Programa Nacional do Livro e do Material Didático*, PNLD) guide for middle school discuss in their CC treatment, considering the current society-nature relationship and EJ principles?

The Climate Change Issue in Science Textbooks: Global and National Perspectives

Climate change has drawn the attention of researchers from a variety of disciplines. Diez and colleagues (2022) report that, among the 280,000 texts indexed in the Scopus database containing the terms “climate change” or “global warming,” over 75% are related to experimental sciences, engineering, or health, and that studies from the social sciences have begun to gain CC discourse traction only in the last decade. The most prevalent studies among publications focused on CC in the field of education comprise those exploring students’ CC perceptions, which reveal

significant knowledge gaps among primary and secondary school students (Diez et al., 2022).

Also according to Diez and colleagues (2022), four main areas structure the international research project in which the authors participate, entitled Educational and Social Responses to Climate Change (*Respostas Educativas e Sociais à Alterações Climáticas,* RESCLIMA), bringing together research teams from Spain, Portugal, Mexico, and Brazil (Cartea et al., 2019). These four areas include the integration of educational dimensions into climate policy, the inclusion of climate education in secondary curricula, the treatment of CC in educational materials, particularly textbooks, and the implementation and evaluation of innovative pedagogical practices (Diez et al., 2022). Regarding textbooksspecifically, the authors argue that analyzing these materials provides insight into how CC is addressed in schools, given their widespread use in classrooms(Diez et al. 2022).

Several authors have conducted CC content analyses concerning Brazilian textbooks, guided by curriculum documents predating the NCCB (Barreto, 2009; Lobato et al., 2009; Meneguzzo & Meneguzzo, 2010; Cecchin & Limberger, 2012; Delaqua & Bassoli, 2013; Santos & Silva, 2013; Rumenos, 2016; 2017; Baumgratz et al., 2020; Cesario & Mansilla, 2020). Those studies were conducted at both primary and secondary levels (mostly the latter) across disciplines such as Physics, Chemistry, and Biology, with the highest frequency found in Geography textbooks.

In the context of the NCCB implementation, few studies have addressed textbook analyses. In one example, Geminiano, Oliveira, and Garcia (2020) analyzed environmental issues in 2019 Geography middle school textbooks (grades 6–9), reporting that, although these books present accurate definitions of the greenhouse effect and global warming, they lack in-depth discussions of the impacts of human activities. Carneiro, Mello, and Junior (2020) examined how the climate crisis is addressed in Biology textbooks for high school from the PNLD 2018–2020 cycle, focusing on first- and third-year books from six textbook collections. While the authors noted a critical approach to climate-related topics, they also pointed out a tendency toward individual blame in environmental discussions. Batista, Donato, and Pinto (2023) evaluated Natural Sciences textbooks from the PNLD 2021 guide (high school level), concluding that CC treatment lacks regional relevance and fails to encourage critical thinking, with limited quantitative representation within the analyzed collection.

Despite the growing body of educational research on CC, Diez and colleagues (2022) emphasize the disconnect between the increasing volume of research and the limited attention the topic receives in curricula and educational practice. This mismatch is concerning given that CC is an urgent environmental issue requiring the mobilization of all available educational resources, especially within formal education, where it should be made a central curricular focus (Diez et al. 2022).

In addition to reinforcing the need for a more comprehensive and multifaceted approach to the subject, Serantes-Pazos and Cartea (2016) propose ten principles aimed at making the populations most affected by CC visible and fostering student responsibility. These principles are particularly relevant when analyzing textbooks that connect CC to environmental justice, and should be considered in such evaluations, as depicted below:

1. Present scientifically established CC facts, beginning with its anthropogenic origin.
2. Highlight selected agreements and recommendations from Intergovernmental Panel on Climate Change (IPCC) reports.
3. Correlate lifestyle (and consumption) and CC. Emphasize the asymmetry between those who contribute most to CC and those who suffer its consequences most severely, introducing concepts such as climate justice and carbon debt. Establish connections between climate change and everyday aspects of life, *i.e.,* health, food and water availability, among others.
4. Expose the unequal CC effects, addressing biases related to gender, social class, ethnicity, nationality, among others.
5. Convey the complexity of the issue by identifying power structures that sustain diverging positions. Emphasize the need for global governance to address the problem.
6. Personalize the issue by including images of individuals directly affected by CC, particularly in student-relevant contexts.
7. Employ a didactic approach, highlighting successful and sustainable experiences, as well as initiatives focused on degrowth and other social movements. Highlight positive compensation policies.
8. Include images of young people of similar age to the students, portraying both pro-environmental and sustainable habits or the opposite, allowing students to either recognize themselves in them or reject them.

9. Encourage research and critical reflection using diverse sources, fostering plural and critical thinking among students.
10. Increase the prominence of CC within schoolcurricula especially by emphasizing its social, economic, ethical, cultural, and political dimensions (Serantes-Pazos & Cartea, 2016, p. 167, our translation).

The studies cited in this section indicate thatBrazilian textbooks selected through the PNLD and analyzed in research conducted over the past fifteen years (guided by both National Curricular Parameters and the NCCB) have typically shown conceptual progress in addressing CC. They do, however, continue to prioritize a predominantly physico-chemical perspective, with limited discussions onboth political and social dimensions. Thus, this study investigates how CC is presented in science textbooks approved by the PNLD 2020, already aligned with the NCCB, through the lens of CEE-groundedtheoretical frameworks, drawing on epistemological foundations such as Historical and Dialectical Materialism (Marx, 1844; Andrioli, 2009; Loureiro et al., 2009; Trein, 2012), Paulo Freire's Pedagogy of Liberation (Freire, 2002; 2005; Costa et al., 2021), Morin's Theory of Complexity (Morin, 2015; Saheb & Rodrigues, 2017; Mello-Silva & Guimarães, 2018), and the framework of Environmental Justice (Acselrad et al., 2008; Herculano, 2008; Loureiro & Layrargues, 2013).

Methodological Approach

Data collection

Data were gathered from science textbooks from collections approved by the PNLD 2020 for the final elementary education years (grades 6–9). These textbooksare used in public schools in Brazil for four years following the approval of each collection. The National Fund for Educational Development (*Fundo Nacional de Desenvolvimento da Educação*, FNDE) website provides an online guide to the approved materials. In total, 12 science textbook collections are currentlyapproved for this educational stage, comprising 48 individual books. This elementary education segment was chosen for the analysis because much of the existing research on environmental topics focuses on high school (Rumenos, 2016). Of the 12 identified collections, nine were analyzed, as only these were accessible for consultation.

Some PNLD 2020 collections were available for download as teacher editions in PDF format directly from the publishers' websites. Other collections were obtained from a virtual biology teacher and student community on Facebook, where science-related materials are shared. Additional books were accessed in municipal schools in the city of Rio de Janeiro through partnerships with collaborating teachers affiliated with the city's Department of Education.

Textbook Analysis: Texts and Images

This study adopts a qualitativetheoretically-oriented approach (Minayo, 1993) employing a Thematic Analysis as described by Fontoura (2011), a method commonly applied to interviews, testimonies, or written materials. As this method proposes, the aim is not to uncover hidden "truths" within the texts but to interpret the presented discourse considering the contexts in which they are produced, with theoretical frameworks serving as analytical lenses (Fontoura, 2011).

Recognizing that scientific understanding involves the joint interpretation of verbal and visual texts, a descriptive analysis of images associated to CC in the analyzed textbooks was conducted. The images were categorized under the same thematic axes used to analyze the written content, allowing for an integrated examination of text and imagery in light of the theoretical references.

Of the 12 collections listed in the PNLD 2020 guide, nine were retrieved and included in this study, totaling 36 textbooks forming the analysis dataset (see Table 1). To facilitate identification, each collection was labeled with the letter "A" followed by a number. The analyzed versions were teacher editions, but only content intended for students was considered, with teacher notes and commentaries excluded from the analysis.

Collections A10, A11, and A12 (Time for Science - *Tempo de Ciências* – Editora do Brasil; Convergences of Sciences – *Convergências Ciências* - and and Alpha Generation Sciences - *Geração Alpha Ciências* – Editora SM) could not be found through online searches or in physical form in schools, highlighting a broader issueregardinglimited public access to materials approved through the National Textbook Program.

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Table 1.

Brazil's National Book and Teaching Material Program2020 natural science textbook collections.

Collection	Author(s)	Title	Publisher	Link
A1	CANTO, E. L.; CANTO, L. C.	Natural Sciences learning from everyday life (CiênciasNaturaisaprendendo com o cotidiano)	Moderna	https://pnld.moderna.com.br/ciencias/ciencias-naturais-aprendendo-com-o-cotidiano/
A2	CARNEVALLE, M. R. (Organizerl)	More Araribá -Sciences (*Araribá Mais – Ciências*)	Moderna	https://pnld.moderna.com.br/ciencias/araribamais/
A3	THOMPSON, M.; RIOS, E. P. (Organizers)	Science Observatory (*Observatório de Ciências*)	Moderna	https://pnld.moderna.com.br/ciencias/observatorio-de-ciencias/
A4	GEWANDSZNAJDER, F; PACCA, H. M.	Teláris Sciences (*TelárisCiências*)	Editora Ática	https://www.edocente.com.br/pnld/2020/
A5	GODOY, L. P.	Life Sciences & Universe (*Ciências Vida & Universo*)	Editora FTD	https://pnld2020.ftd.com.br/colecao/ciencias-vida-e-universo/
A6	HIRANAKA, R. A. B; HORTENCIO, T. M. A.	Inspire Sciences (*Inspire Ciências*)	Editora FTD	https://pnld2020.ftd.com.br/colecao/inspire-ciencias/?1=inspire-ciencias
A7	LOPES, S. G. B. C; AUDINO, J. A.	Innovate Natural Sciences (*InovarCiências da Natureza*)	Saraiva Educação	https://www.edocente.com.br/pnld/2020/
A8	USBERCO, J.; MARTINS, J. M; SCHECHTMANN, E; FERRER, L. C; VELLOSO, H. M.	Company of Sciences (*Companhia das Ciências*)	Saraiva Educação	https://www.edocente.com.br/pnld/2020/
A9	PEREIRA, A. M. S; BEMFEITO, A. P. D; PINTO, C. E. C; FILHO, M. A; WALDHELM, M. C.V.	Apoema Sciences (ApoemaCiências)	Editora do Brasil	https://www.editoradobrasil.com.br/apoema-ciencias-9o-ano/
A10	SOUZA, C. R.; OLIVEIRA, M. P. P; FAGIONATO, S.	Science Time (Tempo de Ciências)	Editora do Brasil	_____
A11	ANGELO, E. A.; MICHELAN, V. S.	Science Convergences (ConvergênciasCiências	Editora SM	_____
A12	NERY, A. L. P.; CATANI, A; AGUILAR, J. B.	Alpha Generation Sciences (Geração Alpha Ciências)	Editora SM	_____

Source: The authors, 2022.

Initially, the documentary *corpus* was defined by searching the textbooks for the following terms: “climate,” “greenhouse effect,” “global warming,” “climate change,” “climatic alterations,” and “climate emergency.” The identified excerpts were copied or transcribed into a Microsoft Excel spreadsheet and organized by textual content along with any accompanying images. A preliminary, open reading of the material was then conducted to capture initial impressions.

Tables were then created in Microsoft Word to record each textbook collection,context units (excerpts selected to highlight the theme),units of meaning (the excerpt core message or concept), and, finally,the core meaning (theme) for each data cluster. Thecore themes were defined according to coherence, similarity, relevance, exhaustiveness, and exclusivity criteria, as recommended by the Thematic Analysis method (Fontoura, 2011). Identified images were also included under the corresponding thematic categories.

Results and Discussion

A total of 254 textual excerpts and 110 images were identified across the 36 analyzed textbooks. A clearpredominance of CC-related content aimed at the 7th grade textbooks was observed, followed by those aimed at the 8th grade.

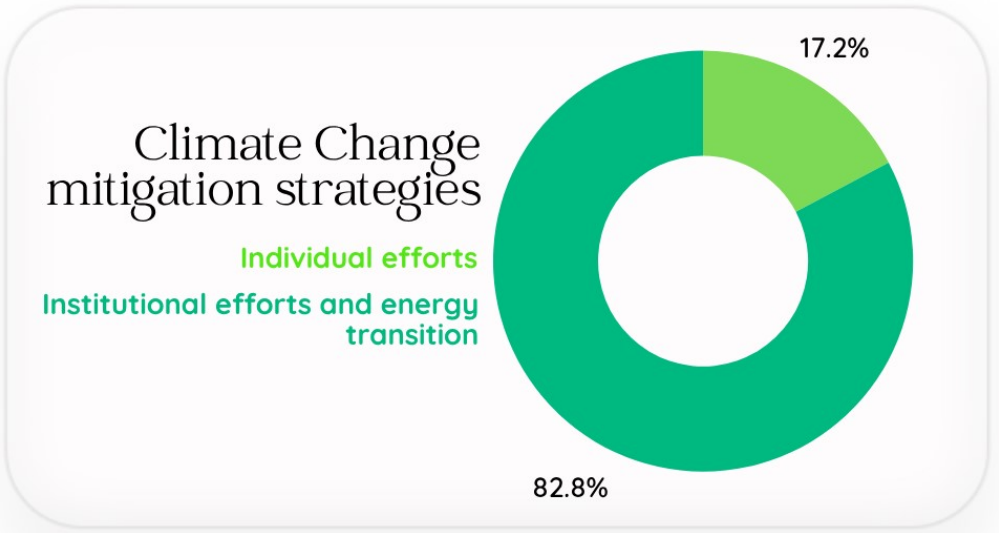
Four primary core themes were identifiedfollowing the Thematic Analysis (Fontoura, 2011), namely (1) Climate Change Causes (106 excerpts), (2) Climate Change Consequences (50 excerpts), (3) Climate Change Mitigation Strategies (58 excerpts) and (4) Science and Climate Change (40 excerpts).

The first three themes were pre-established based on previous climate-related content analyses concenringtextbooks from earlier PNLD cycles, as noted by Liotti and Campos (2021) and Rumenos (2017), also noted in this study. The fourth theme, “Science and Climate Change,” emerged from the data itself, having been identified through repeated associations between context units and units of meaning in the documentary corpus.

Specific units of meaning were identified in the textual content within each core themeand are presented and discussed according to the charts depicted in Figures 1 to 4.

Figure 1.

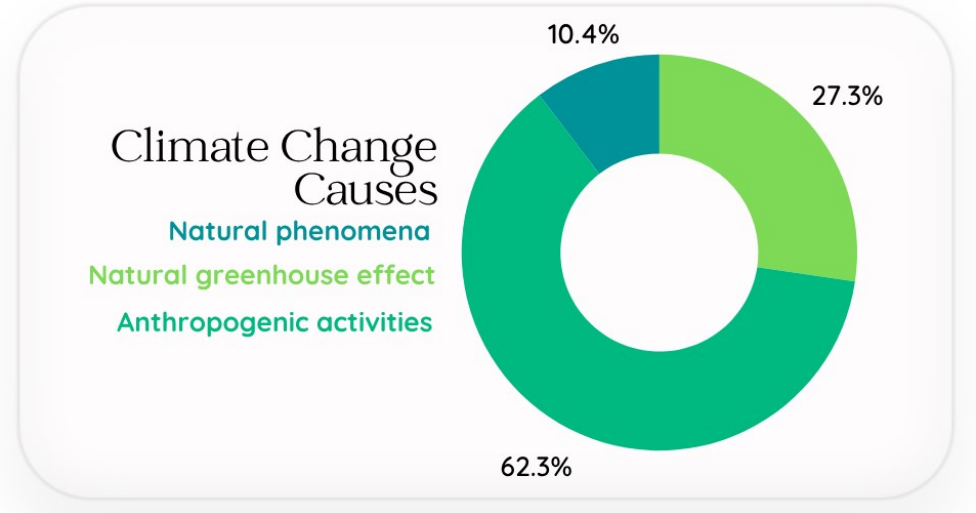
Number of units of meaning for the theme "Climate Change mitigation strategies" raised in the textual content of the investigated textbooks, categorized as individual efforts (light green) and institutional efforts and energy transition (dark green).



Source: Research data, 2022.

Figure 2.

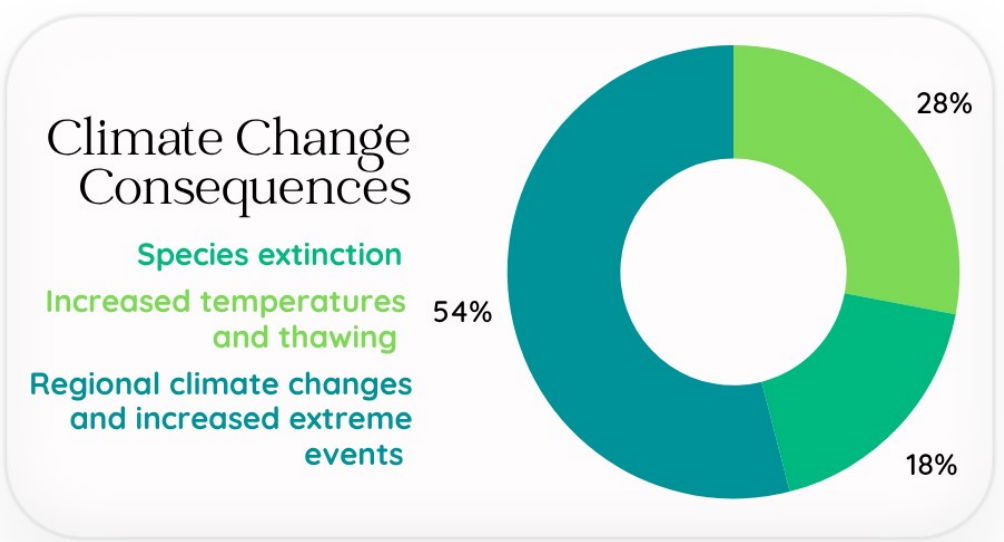
Number of units of meaning of the theme "Climate Change Causes" raised in the textual contents of the investigated textbooks, categorized as Natural greenhouse effect (light green), Anthropogenic activities (dark green) and Natural phenomena (blue).



Source: Research data, 2022.

Figure 3.

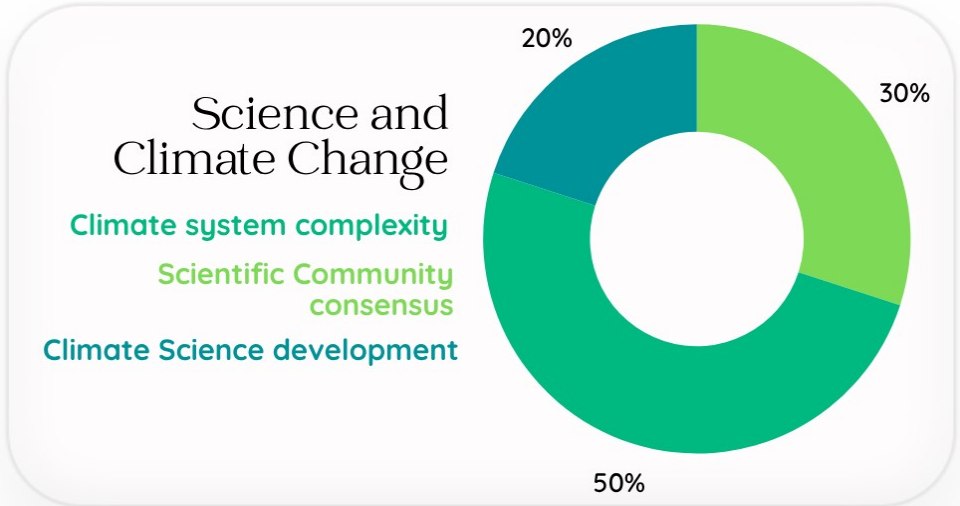
Number of units of meaning of the theme "Climate Change Consequences" raised in the textual contents of the investigated textbooks, categorized as Increased temperatures and thawing (light green), Species extinction (dark green), and regional climate changes and increased extreme events (blue).



Source: Research data, 2022.

Figure 4.

Number of units of meaning on the theme "Science and Climate Change" raised in the textual contents of the investigated textbooks, categorized as Scientific Community consensus (light green), Climate system complexity (dark green) and Climate Science development (blue).



Source: Research data, 2022.

A free descriptive analysis was conducted for images accompanying the investigated textual content, which were categorized under the same themes established in the thematic analysis, as **Climate Change causes** (56 images); **Climate ChangeConsequences** (13 images); **Climate ChangeMitigation strategies** (37 images); **Science and climate change** (four images).

Images are widely used in textbooks, primarily serving an anchoring function, creating a chain of meaning with the written text. When not accompanied by critical engagement, they enter the viewer's mind unfiltered, without time for reflection, which highlights the need for autonomous interpretation. It is essential to understand both the representations and the appearances of these images, as they are often influenced by agents of the prevailing economic system and tend to obscure the importance of an ecologically balanced environment (Freitas & Vermelho, 2021). It is precisely in CEE that a path to counter distorted representations of reality, comprising images that mask inequality and the suffering generated by a system that has failed in its ethical commitment to humanity, is noted.

The following section presents and discusses the identified core themes, interpreted through the theoretical frameworks that guide this study. Underlined phrases or words in the selected excerpts highlight the themes identified through thematic analysis. Bolded phrases in the text draw attention to additional points addressed in the discussion. Some of the images used in the analysis are also included.

Climate Change Causes

The first unit of meaning identified under this theme was **"The greenhouse effect as a natural phenomenon, whose intensification leads to global warming and climate change"**, appearing in all analyzed collections. These excerpts describe the greenhouse effect as a natural and necessary process for life on Earth, maintaining global average temperatures. It is frequently compared to the structure of a greenhouse used for cultivating plants, as in the example below:

> A3/7th Grade:
> (...) However, not all the heat is absorbed: part of it is reflected and would be lost to space if not for the presence of certain gases (such as carbon dioxide, ozone, and methane) in the atmosphere. These gases trap part of the heat within the planet's atmosphere. (...) Because it functions similarly to plant greenhouses, this natural phenomenon became known as the greenhouse effect. It is essential, as it maintains the Earth's temperature at levels suitable for life as we know it. Without the

> greenhouse effect, the average temperature of Earth would be approximately –18 °C, rather than the current 15 °C (A3, 2018, p. 55, our emphasis).

In addition to addressing the natural greenhouse effect, this theme includes excerpts that link the rise in global temperatures to the intensification of this phenomenon:

> A2/ 7th Grade:
> Scientists call global warming the gradual increase in atmospheric temperature that has occurred over the past 100 years. Global warming is the intensification of the greenhouse effect caused by the rise in carbon dioxide and other greenhouse gases (A2, 2018, p. 192, our emphasis).

The textbooks present scientifically accurate discussions on the greenhouse effect and global warming. These definitions appear consistently across all analyzed collections. The primary framework for understanding climate change is that of the IPCC, which aligns with the findings of Barreto (2009) in his analysis of the PNLD 2008, which was still based on Brazil's National Curriculum Parameters. However, Barreto (2009) noted conceptual errors in distinguishing between "global warming" and "greenhouse effect" in textbooks. Similar concerns were raised by Cecchin and Limberger (2012) in their analysis of Geography textbooks. Such conceptual inaccuracies were not found in this investigation, nor byRumenos (2017) and Geminiano, Oliveira, and Garcia (2020), which may suggest an improvement in the quality of information presented in more recent textbooks.

The unit of meaning concerning the greenhouse effect is directly related to the second unit under this theme: **"Anthropogenic activities intensifying the greenhouse effect and causing climate change."** To explain greenhouse effect intensification and increased global temperatures, textbooks consistently cite human activities, especially regarding the emission of greenhouse gases following the Industrial Revolution, as the main cause. This unit appears in all analyzed collections:

> A1/ 7th Grade:
> Over the last 100 years, the planet's average temperature has increased by approximately 1 °C. Many researchers attribute this rise to increased carbon dioxide concentration in the atmosphere. In other words, human activity is causing global warming by intensifying the greenhouse effect (A1, 2018, p. 214, our emphasis).

> A6/ 7th Grade:
> Global warming coincides with the period of the Industrial Revolution (second half of the 18th century) (...) (A6, 2018, pp. 112–113, our emphasis).

Figure 5 depicts images from different historical periods accompanying the textual content, illustrating the development and expansion of capitalism to sustain urban-industrial society. They do not, however, include deeper discussions on how this system has destroyed social structures in the name of productivity and profit, nor on how it disregards nature and excludes people to sustain itself. There is also no mention or visual representation of “sacrifice zones”, areas that are especially vulnerable to environmental threats, nor the identities of the affected populations. It is necessary to challenge and reconstruct cultural criticism so that images are not used merely to support capitalism as a social structure, but also to expose its many harms (Freitas & Vermelho, 2021).

Figure 5.

Screenshots of textbook images showing old and recent photographs depicting industrial and transportation activities, which are sources of greenhouse gas emissions.

Source: A6, 2018, p. 112-113.

Critical Environmental Education encourages the questioning of simplistic approaches to understanding human-nature relationships, allowing for political critique of the notion of nature solely as a resource (Loureiro et al., 2009). When this discussion is absent, environmental balance is treated as secondary, and any proposed change merely seeks to preserve current social, political, and economic structures. These structures regenerate themselves through successive crises, sustaining a societal model based on the continuous expansion of consumption,

unequal and predatory by nature. In this process, the domination of humans over nature has been naturalized, alongside the increasing commodification of both the environment and people, framed through the logic of profit (Andrioli, 2009; Trein, 2012).

By failing to name the underlying causes of this civilizational crisis that has led to CC, society and the environment are dissociated, making it difficult to redefine relationships with ourselves, others, and the planet (Loureiro, 2004; Mello-Silva & Guimarães, 2018). Consequently, EE tends to assume a conservationist character by avoiding criticism of the prevailing social order and separating individual, society, and nature (Layrargues& Lima, 2014; Lima, 2011). Within this framework, textbooks often adopt a pedagogical approach that contrasts with what Freire (2002) proposed, namely a pedagogy of emancipation that enables individuals to understand their own reality. It is through this process of awareness that individuals can act to transform situations of social dissatisfaction and dehumanization (Freire, 2005).

Attributing the rise in greenhouse gas emissions solely to the Industrial Revolution neglects earlier historical processes, especially relevant in the Brazilian context, where deforestation and land-use change have acted as the primary emission contributors. These processes date back to the colonial period, from the exploitation by Portuguese colonizers to the recent expansion of agribusiness across different biomes (Huguenin & Meirelles, 2022). In this regard, Morin's Theory of Complexity, which also reinforces CEE, emphasizes the importance of anthroposocial phenomena in fostering a non-fragmented understanding of the physical world (Morin, 2015). Therefore, knowledge of the historical dimensions of local social realities can support a more integrative view of socio-environmental issues, an approach that should be addressed in textbooks. However, none of the analyzed textbooks include a historical perspective on forest exploitation in Brazil, which began and was broadly disseminated during the colonial era and has contributed significantly to greenhouse gas emissions and, by extension, CC.

The third and final unit of meaning within the theme "Climate ChangeCauses" is **"Natural phenomena as climate changedrivers,"** identified in six of the nine analyzed collections (A2, A3, A4, A7, A8, and A9). In general, textbooks that present the link between natural phenomena and climate change clarify that such changes occurred in the past and may still occur as part of Earth's intrinsic dynamics. However, when addressing anthropogenic climate change, they

emphasize the role of human activity and the rapid pace of changes not caused by natural processes.

Climate Change Consequences

This core theme encompasses the main outcomes resulting from climate alterations. Many of these consequences are interrelated and sometimes overlap in the excerpts identified, although three main units of meaning could be established: (1) Changes in regional climates, ocean conditions, and the frequency of extreme weather events, with impacts on human health and the economy, (2) Species extinction and (3) Increases in average global temperature, glacier melting, and sea level rises.

The unit "Changes in regional climates, ocean conditions, and the frequency of extreme weather events, with impacts on human health and the economy" was the most predominant in representative textual excerpts, present in eight out of the nine analyzed collections (A1, A2, A3, A4, A5, A6, A7, and A8). It addresses climate change impacts primarily at the regional level, although ocean-related changes, such as coral bleaching, were also included in some textbooks.

Concerning human health, the analyzed textbooks mention consequences such as respiratory issues, increased vector-borne diseases, and deaths linked to extreme weather events like droughts, heatwaves, and floods. However, it is important to note that only some textbooks meaningfully engage with the issue of human health in the context of climate change. The topic appears in more depth in only a handful of excerpts, such as the following example:

> A4/ 8thGrade:
> This global warming has triggered numerous phenomena on Earth, and others are projected to occur if the planet's temperature continues to rise. Inhaled pollutants primarily affect respiratory systemorgans, such as the lungs, and may lead to illnesses like pneumonia, asthma, emphysema, bronchitis, among others (A4, 2018, p. 236, our emphasis).

In this sense, the analyzed textbooks reflect a conception of health as human well-being, focusing on diseases that directly affect people. This approach, however, fails to encompass a broader understanding of health, namely one that includes environmental and animal health, envisioning a planetary, complex, and interconnected perspective aligned with Edgar Morin's principles, aimed at improving the quality of life of the entire living community on Earth (Mello-Silva & Guimarães, 2018). The school environment should foster critical thinking alongside environmental

knowledge, so that the variables sustaining community vulnerabilities are acknowledged. One cannot exclude individuals from debates about the environment, health, education, and citizenship when aiming to achieve both individual and collective well-being (Santos & Meirelles, 2021). Such integration can foster the understanding that health only exists within collectivity and in an ecologically and socially balanced environment, as defended by CEE.

Still within a health and CC context, only four excerpts provided significant insights that represent some of the few contributions in the analyzed textbooks that link health, CC, and EJ notions, exemplified below:

> A7/ 7th grade:
> "(...) According to IPCC data, regarding South America, there have been changes in the Amazon River's flow, increased mortality of plants and animals caused by fire and deforestation, degradation caused by pollution and land use, **greater vulnerability of indigenous ways of life** due to water scarcity and increased social and economic stress. Additionally, rising air temperatures also raise water temperatures, affecting the balance of aquatic ecosystems." (A7, 2018, pp. 153–155, our emphasis)

Populations in vulnerable situations, such as traditional peoples and communities, including Indigenous groups, Quilombolas, rubber tappers, nut gatherers, riverside dwellers, hillside residents, among others, generally lack the conditions necessary to withstand CC impacts or relocate from disadvantaged areas. This is due to the intersections of racism, sexism, and prejudice against the poor (Robinson, 2021). These issues highlight the urgent need to break with the common-sense narrative that treats global warming and other environmental degradation phenomena as "democratic" or equally experienced by all (Acselrad et al., 2008).

It is also worth to briefly highlight a discriminatory and ableist expression found in the excerpt below. Critical Environmental Education calls for the elimination of all forms of oppression, including those perpetuated through language. In this sense, the phrase "pretend to be deaf" associates deafness with ignorance or lack of awareness, which is discriminatory.

> A8/8th grade:
> "The effects of global warming (...) cannot yet be fully measured. But they can already be felt and observed (...) It's as if the planet, in its own way, is showing symptoms of a serious illness and pleading for our help. **Will we listen to it, or pretend to be deaf**?" (A8, 2018, p. 246, our emphasis)

The unit of meaning **"Species extinction"** brings discussions about the current decline of certain populations and past extinctions that occurred naturally throughout Earth's geological history, while warning of a new, ongoing mass extinction that is unnatural and caused by human activity. This topic, however, was only found in five out of the nine analyzed collections (A1, A3, A4, A5, and A6), indicating the need to expand and update the coverage of biodiversity loss associated to CC.

Finally, the unit of meaning **"Increase in average global temperature, melting glaciers, and sea level rises,"** present in eight of the analyzed collections (A2, A3, A4, A5, A6, A7, A8, and A9), outlines the most immediate consequences associated with the rise in the planet's average temperature, such as polar ice cap melting and the consequent rise in sea levels.

Figure 6. Textbook image depicting a polar bear on a melting glacier in the Arctic

Source: A7, 2018.

The excerpts and images highlighted from the analyzed textbooks predominantly address issues related to the rise in global average temperatures by focusing on territories, environmental contexts, social realities, fauna, and flora that are distant from the everyday experiences of Brazilian students. This disconnection between the presented content and students' local realities is consistent with the findings reported by Liotti and Campos (2021), who, in their iconographic textbook analysis also point to the frequent use of generic and iconic imagery of global CC, such as polar bears on melting ice. These images rarely depict people, and when they do, they typically represent individuals whose characteristics differ considerably from those of the students using the textbooks, a pattern also observed in the present study.

It is undoubtedly important that textbooks also present students with CCimpacts in other regions, although they should primarily focus on the Brazilian and South American reality, contextualizing CC effects within the environments in which students live and in their daily social and political contexts. As Freire (2002) argues, it is essential to build on students lived experiences and the concrete realities they face, associating them to curricular knowledge.In the current climate crisis, cultural, social, economic, and political norm hegemony promotes a thought and knowledge monoculture that positions the epistemologies, environments, representations, and imaginaries of the Global North as universal. This also shapes the way CC is represented. Creating space for horizontal manifestations of insurgent epistemologies allows for the emergence of new representations, solutions, and alternatives grounded in previously marginalized contexts (Braz &Galhera, 2023).

Forms of Climate Change Mitigation

Two main units of meaning were identifiedin this thematic core: "**Individual Pragmatic Solutions"** and **"Collective Governmental and Institutional Actions and Energy Transition,"** with the latter appearing more frequently (Figure 1).

The unit "**Individual Pragmatic Solutions**," present in eight of the nine analyzed textbook collections (A1, A2, A3, A4, A5, A6, A7, and A9), includes excerpts and images describing individual actions intended to compensate for the failures of a consumer society based on the accumulation and disposal of goods, aligned with the pragmatic macro-trend in environmental education (Layrargues & Lima, 2014). The main objective of the solutions presented in this unit comprises behavioral change within society. Suggested actions include reducing consumption, promoting the use of public transportation, recycling, decreasing the intake of products such as meat, milk, and soy, avoiding waste and disposable items, and encouraging the use of "sustainable" products, among others. These actions are often portrayed as easy to adopt in everyday life and effective in mitigating the effects of climate change, relying on the idea that "everyone just needs to do their part."

> A6/ 7thGrade:
> Caring for the atmosphere is something everyone can do. Below are actions that can reduce air pollution and global warming: Conscious meat, milk, and soy consumption. (...) Reducing the consumption of meat and milk (...). Buying only certified wood. (...) Conscious consumption (...). Buying sustainable forest products. (...) Proper waste disposal (...) Using less cars (...). (A1, 2018, p. 122, our emphasis).

The actions presented as solutions within this unit of meaning identified through the textbookanalysis do not engage with alternatives that propose structural changes to the root causes of the climate crisis. They, instead, overlook the social inequalities produced by the “development” model of urban-industrial society and instead place individual responsibility on citizens for environmental degradation, as illustrated by the excerpts and images promoting behavioral change. This approach aligns with an EEmodel favored by the neoliberal market, as it demands individuals to adjust their personal comfort levels.

In addition, this conservative approach, which embraces both conservationist and pragmatic perspectives (the latter derived from the former and adapted to new social contexts), is marked by a depoliticized discourse on socio-environmental relations. It advocates for a “sustainable future”, but only within the boundaries of maintaining the existing economic model (Layrargues& Lima, 2014). By failing to identify the social groups and countries most responsible for greenhouse gas emissions, this framework holds society as a whole accountable for the current climate emergency, thereby weakening discussions around environmental justice.

The unit of meaning labeled “**Collective Governmental and Institutional Actions and Energy Transition,**” found in eight of the nine analyzed collections (A2, A3, A4, A5, A6, A7, A8, and A9), focuses primarily on energy transition, the development of new technologies for CC mitigation, deforestation reduction, and discussions on international climate agreements and their emissions reduction targets. The narrative within these materials positions technology as the main tool to address the climate crisis.This technological solutionism is reinforced in textbook excerpts such as: “a change in the way we produce the energy that powers our economies” (A2, 2018, p. 166), “These technologies are important for fighting global warming and pollution” (A4, 2018, p. 240), and “This shows that a problem created by technology can sometimes be solved through technological development itself” (A4, 2018, p. 241). This reflects a paradigm shaped by political and economic narratives grounded in “the myth of growth as a prerequisite for sustainable human development” (Guimarães & Cartea, 2020, p. 32). Such perspectives, rooted in the worship of progress, aspirations for “development,” and technological optimism, constitute significant barriers to ecological transition in a society that places hope in technology as a universal solution.In this view, the textbooks suggest changes in production methods that serve to preserve the continuity of the economic system, even if it remains reliant on the exploitation of people. The underlying logic of

economic development and the reproduction of inequality remains intact, merely rebranded as “sustainable development” and “eco-technologies.”

A reflective scientific perspective, essential to CEE, does not reject the advances and benefits of technology but emphasizes that such developments also carry environmental, social, economic, and ethical consequences. The integration of technology with a critical lens represents a new approach to confronting severe socio-environmental challenges, an approach grounded in an ethic of “reconnecting” (Kataoka et al., 2022), particularly in a context of the climate emergency.

All analyzed textbook collections contain texts that, to varying extents, address the history of environmental conferences and highlight the agreements reached during United Nations meetings as part of the solution to the climate crisis. The key conferences mentioned include the Stockholm Conference (1972), the United Nations Conference on Environment and Development (Rio-92, 1992), and the Conferences of the Parties under the United Nations Framework Convention on Climate Change (COPs), with particular emphasis on the COP 3 (1997), where the Kyoto Protocol was adopted, and the COP 21 (2015), where the Paris Agreement was signed. These texts mostly describe initiatives focused on decarbonizing the economy, carbon markets, and emissions offset schemes.

Manfrinate, Sato, and Serantes-Pazos (2019) argue that, while these mitigation proposals based on damage compensation have significant value, they do not reach the level of political debate within EE, as they rarely address the structural processes responsible for environmental degradation and often fail to genuinely engage with the lived realities of communities or recognize their traditional knowledge (Manfrinate et al., 2019).

Only two excerpts found in the analyzed textbooksand their accompanying images (Figures 7 and 8)refer to popular collective actions as a form of CC resistance, with the latter featuring a group from Latin America:

Figure 7.

Photograph of a children's protest during the Convention on Climate Change 23 opening.

Crianças seguram faixa com os dizeres em inglês "Salvem o mundo" durante a sessão de abertura da COP23, na Alemanha, em 2017.

Source: A8, 2018, p. 37.

Figure 8.

Protest in Mexico City pressuring the government to take stronger action on climate change.

Manifestação na Cidade do México reivindicando maior comprometimento do governo com as questões das mudanças climáticas. A frase escrita no balão diz: "O tempo está acabando: salvem o clima!", em 28 de agosto de 2009.

Source: A9, 7th Grade, p.158.

The promotion of Climate Justice necessarily involves the political organization of social movements. This was true during the emergence of the EJ movement and remains so as socio-environmental issues have triggered uprisings among

populations most affected by the inherent consequences of capitalism, leading to resistance movements across various countries (Stortti& Sánchez, 2018). These movements seek the construction of a new post-capitalist way of life. Within this framework, Environmental Education for Climate Change (EECC) appears as a "constitutive and highly relevant element for thinking about a pedagogy that emerges from social struggles alongside an emerging epistemology; that is, the emerging epistemologies of social movements bring with them emerging pedagogies, allowing us to broaden the critical dimension of environmental education (…)" (Stortti & Sánchez, 2018, p. 184).

It is also important to note that, within the thematic nucleus discussed in this section (Climate Change Mitigation Strategies), the images extracted from the textbooks portray predominantly white individuals (Huguenin, 2023). Given that about 56% of the Brazilian population is Black according to the Brazilian Institute of Geography and Statistics (IBGE, 2022), the exclusive representation of white individuals in these textbooks fails to reflect and connect with the lived realities of the students who use them. It also illustrates the presence of structural racism, which permeates all spheres of society, including education.

Science and Climate Change

Three main thematic units were identified in this nucleus: **(1) "Scientific consensus on anthropogenic causes of climate change and climate denialism"; (2) "Climate system complexity";** and **(3) "Climate science development."**

The unit **"Scientific consensus on anthropogenic causes of climate change and climate denialism,"** present in six of the nine analyzed textbook collections (A2, A4, A5, A6, A7, and A9), includes passages that affirm broad agreement among scientists regarding the CC phenomenon. The unit "**Climate system complexity**," found in eight of the nine collections (A2, A3, A4, A5, A6, A7, A8, and A9), discusses climatologyelements, particularly in 7th and 8thgrade materials, and provides clarification of key concepts such as "weather" and "climate," along with the factors that influence climate. The unit "**Climate Science development**" was less frequently observed (Figure 4), appearing in six of the nine collections (A2, A3, A4, A5, A7, and A9). This unit includes discussion of technological tools used to measure climate variables, how climate and weather forecasting studies are conducted, and how scientists manage climate data.

The examined textbooks do not present climate change as a scientifically controversial topic. In fact, they reinforce the existing consensus within the scientific community regarding its causes, consistent with what is reported in the scientific literature. For example, a study by Lynas, Houlton, and Perry (2021) indicates that the scientific consensus on anthropogenic CC, expressed as a percentage of total peer-reviewed publications, exceeds 99%.

Previous research into CC treatment in textbooks has pointed to a lack of engagement with CC as a scientific controversy (Barreto, 2009; Santos & Silva, 2013; Delaqua & Bassoli, 2013; Dourado et al., 2015; Santos, 2017; Rumenos, 2016; Liotti & Campos, 2021; Batista et al., 2023). However, in the case of CC, one must ask: who benefits from maintaining the issue within a controversyframework? This study aligns with one of the principles proposed by Serantes-Pazos and Cartea (2016) for discussing CC, namely to include the scientific certainties about its anthropogenic origin as a starting point.

Rajão and colleagues (2022) discuss the dangers of artificially manufactured controversies by denialist actors, which can have detrimental impacts on public health and environmental conservation. While the authors acknowledge that disagreement is part of scientific development, they warn against disputes deliberately constructed to create the false appearance of a lack of scientific consensus and thus delay or obstruct public policy implementation. Continuing to treat CC as a scientific controversy may obscure and diminish the role of capitalism in causing the socio-environmental crisis. It may also conceal the material conditions denounced by historical-dialectical materialism, namely, the ideology of progress and the exploitative and dominant social relations that define this societal model (Loureiro et al., 2009).

The findings reported herein indicate that the critical perspective in textbooks is limited. Instead, most materials emphasize compensatory mechanisms and promote a narrative of “sustainable development.” These tendencies also appear in the way CC is taught, even though the urgency of the issue calls for deeper and more transformative approaches. Both initial and continuing teacher education should incorporate climate justice as a central component to address this new layer of exclusion in one of the greatest challenges facing humanity.

Final Considerations

The main trends identified in Brazilian science textbooks in this study highlight the need to further develop EE, particularly through critical perspectives that address Climate and Environmental Justice. Key findings include:

- None of the 36 textbooks analyzed across the nine collections use the term "climate emergency." The term "global warming" is still predominant, followed by "climate change." The term "climate justice" does not appear in any of the textbooks.
- The analyzed textbooks contain scientifically accurate content and CC explanations consistent with IPCC reports regarding causes, impacts, and mitigation.
- Although human activity is identified as the CC cause, the analyzedtextbooks do not address the motivations behind these actions, nor do they question the economic model responsible for this. The capitalist model of production, consumption, and exploitation remains unchallenged, with solutions offered only within the confines of this same system.
- Climate Justice is not significantly addressed. Only some textbooks explore CCconsequences in an EJ context.
- The concept of health is framed primarily in terms of individual human well-being, focusing on diseases that may affect individuals.
- The analyzedtextbooks recognize the ongoing mass extinction of species as a result of human activity, but there is a lack of updated and comprehensive content on biodiversity loss as related to climate change.
- The textual and visual materials present problems associated with increases in the average global temperature in territories, environments, realities, as well as fauna and flora that are dissociated from what Brazilian students experience in their local contexts, in addition to images rarely depicting people.
- Collective institutional and governmental actions for CC mitigation are largely presented through technological advancement and energy transition, aiming to maintain current lifestyles while offsetting harm. It is important to note that, while technology is essential, it must be

accompanied by structural social changes.

- The mitigation forms presented in the analyzedtextbooks referring to individual actions tend to blame individuals for their actions and do little to encourage engagement in collective movements for environmental causes and social pressure on political representatives.
- Climate change-related images do not reflect Brazil's social, cultural, racial, or environmental diversity. Local and regional contexts are underrepresented in favor of foreign, mostly white, populations.
- The materials do not highlight CC impacts on Brazil's most vulnerable communities, such as those living in hillsides, riverine populations, quilombolas, and Indigenous peoples.
- While the scientific consensus on anthropogenic CC is commonly acknowledged, only three collections (A4, A6, and A9) address climate denialism and related political disputes. Most textbooks avoid treating CC as a scientific controversy.

These findings highlight the urgent need to strengthen the role of CEE in Brazil as a pathway for reflective action in response to the current climate emergency. It is paramount not only to revise curricula and textbook contents to foster critical and active engagement among students but also to deploy additional tools in light of the severity and immediacy of the crisis. Suggested actions include incorporating CEE into teacher training, using didactic sequences, workshops, documentaries, and supplementary educational materials that center on social CC dimensions.

It is hoped that this analysis and critique of CC content in Brazilian education will encourage further research and collective action to address socio-environmental injustices in this climate emergency period.

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