

The Kingdom Fungi in Basic Education: an analysis of Mycology content in High School textbooks used in the public school system of Belém, Pará, Brazil

ABSTRACT

Esterfane Monique de Oliveira Santos

esterfane.santos@aluno.uepa.br
0009-0008-6998-4032

Instituto Evandro Chagas, Belém, Pará, Brasil.

Jandreson de Brito Oliveira

jandreson.biouepa2019@gmail.com
0009-0002-6066-5816

Universidade do Estado do Pará, Belém, Pará, Brasil.

Raynon Joel Monteiro-Alves

raynon_alves@yahoo.com.br
0000-0002-8091-4464

Universidade do Estado do Pará, Belém, Pará, Brasil.

Ana Cláudia Caldeira Tavares-Martins

tavaresmartins7@gmail.com
0000-0003-4972-036X

Universidade do Estado do Pará, Belém, Pará, Brasil.

Alcindo da Silva Martins Junior

alcindomartins@gmail.com
0000-0002-1519-6929

Universidade do Estado do Pará, Belém, Pará, Brasil.

Fungi are of social, economic, and environmental importance to society; however, the science that studies these organisms (Mycology) is generally addressed superficially and inaccurately in educational materials. In this context, this study aimed to analyze the Biology textbooks used in state public high schools in the municipality of Belém, Pará, by conducting a consistent assessment of their Mycology content. The purpose was to provide guidance to publishers participating in the Brazilian National Textbook Program (PNLD) and, consequently, contribute to improving the teaching and learning process in this field of biological knowledge. This applied research involved the analysis of six textbooks used in nine schools located in the most populous neighborhoods of Belém. The books were examined using an assessment form containing predetermined criteria and subcriteria. The item "Content and language used" was also evaluated according to four levels of coverage: insufficient, superficial, reasonable, and in-depth. The results indicated that the textbook identified as L.M.2, included in the 2018 Brazilian National Textbook Program (PNLD), received the highest rating according to the analysis criteria, particularly regarding its in-depth coverage of the content. Despite being more recent, the other textbooks included in the 2021 PNLD performed less satisfactorily than those from the 2018 PNLD. Therefore, the insufficient and superficial treatment of Mycology in most of the textbooks analyzed, as well as the absence of a specific chapter on the subject, may negatively affect students' education and their understanding of the importance of studying Mycology. Thus, changes in the coverage of fungi in recent textbooks are strongly recommended, including the expansion of existing information and the provision of more comprehensive coverage of this field of Biology.

KEYWORDS: Textbook. Mycology. High School.

1 INTRODUCTION

Microbiology is dedicated to the study of acellular, unicellular, prokaryotic, and eukaryotic microorganisms (Candido *et al.*, 2015). In Basic Education, teaching this science is considered a major challenge because of problems that limit the practical application of knowledge and, consequently, teachers' and students' learning, such as the high level of abstraction required of students and the lack of contextualization and interdisciplinarity, including in educational materials (Sodré Neto; Medeiros; Bezerra, 2023).

From this perspective, Mycology stands out as the science that studies fungi - heterotrophic, eukaryotic organisms that may be unicellular or multicellular, as well as microscopic or macroscopic (Tortora; Funke; Case, 2017). Fungi are part of human life in several fields, including ecology, biotechnology, the pharmaceutical and food industries, and agriculture (Silva; Menolli Junior, 2017). Thus, these organisms play an important role in maintaining ecosystem balance through the decomposition of organic matter. From a social perspective, they are also important for producing food, medicines, and other products, as well as for understanding diseases affecting animals and plants.

Therefore, Mycology is undoubtedly significant to society. Nevertheless, the study of fungi, which are classified under the Kingdom Fungi, does not always receive adequate attention in Brazilian education. Furthermore, the subject is generally addressed inaccurately in textbooks and other educational materials (Silva, 2019). One example is the erroneous association between Mycology and Botany, even though fungi constitute a group that is distinct from plants (Rosa, 2009; Rosa *et al.*, 2019).

Textbooks are frequently used in schools across a wide range of Basic Education curriculum components. However, their distribution did not occur periodically and effectively, nor was sufficient attention paid to the quality of these materials. For this reason, the Brazilian Federal Government established the National Textbook Program (PNLD) to ensure universal access to textbooks in schools and oversee the quality of these resources (Deitos; Malacarne, 2020). Given their importance, Silva (2019) emphasized that textbooks contain a variety of materials that support teachers in addressing classroom topics, thus promoting more effective use of the teaching and learning process.

In educational institutions, selecting textbooks is generally challenging for teachers because these resources must provide comprehensive content while maintaining coherence and connections among different topics, thereby avoiding fragmentation that might make the material superficial, vague, and unappealing to students (Rosa, 2009). Science textbooks must therefore employ accessible language and establish connections with everyday life, among other qualities, so that students can understand and retain the topics covered. They should also stimulate curiosity, hypothesis formulation, and, above all, critical thinking.

Textbooks generally address Mycology superficially, limiting their coverage to the classification of fungi according to their morphology and life cycles (Silva, 2019). Under these circumstances, little emphasis is placed on the ecological, economic, medicinal, and nutritional importance of fungi, and inaccurate comparisons with other organisms are also made. According to Freire, Oliveira and Soares (2016), Mycology is frequently included in specific chapters or sections of

general Biology textbooks in a superficial and decontextualized manner, without emphasizing the relevance of these organisms to nature and human life.

The fact that the study of fungi dates back approximately 250 years and is therefore considered a relatively new discipline (Alexopoulos; Mims; Blackwell, 1996) may be one of the factors limiting an appropriate approach to Mycology in Basic Education. Consequently, the subject is neglected by many textbook authors, and this biological group may not receive the same attention as animals and plants. However, it should be acknowledged that technological advances have greatly expanded the morphological and physiological study of fungi. This progress enables a more meaningful approach to Mycology in Basic Education, given the availability of articles and images that can enrich the subject.

In view of these considerations, the generalized manner in which Mycology is addressed and the lack of concern with presenting the subject more clearly make the critical analysis conducted in this study essential to addressing the problems associated with teaching about the Kingdom Fungi in Basic Education. Moreover, the limited coverage of the subject and the inaccurate associations involving Mycology content in textbooks may contribute to students' lack of scientific knowledge in this field of Biology, while also making teachers' work more difficult.

Accordingly, the following questions guided this study: Which textbooks address Mycology, and how is this content presented to students attending schools in Belém, a metropolitan city with an extensive public education system? Thus, this study aimed to analyze the Biology textbooks used in state public high schools in the municipality of Belém, Pará, by conducting a consistent assessment of their Mycology content. The purpose was to provide guidance to publishers participating in the National Textbook Program (PNLD) and, consequently, contribute to improving the teaching and learning process in this field of biological knowledge.

2 METHODOLOGY

This study consisted of applied research, as it aimed to produce knowledge for practical application directed toward solving specific problems (Gerhardt; Silveira, 2009). Accordingly, descriptive and critical analyses were conducted of the Mycology content found in Biology textbooks provided through the National Textbook Program (PNLD) and used in Basic Education at state public high schools in Belém.

Therefore, this study encompassed state public high schools in the municipality of Belém. According to the Anísio Teixeira National Institute for Educational Studies and Research (Inep), Belém has a total of 94 public schools at this educational level, which use textbook collections provided through the 2018 and 2021 editions of the PNLD (Brasil, 2020).

For data collection, an initial survey was conducted to identify the two most populous neighborhoods in each of the five administrative districts of the city of Belém. A total of nine schools with the highest student enrollment capacity in the neighborhoods of the selected districts were then chosen. Of these nine schools, eight used textbooks from the 2021 PNLD, while one used educational materials from the 2018 PNLD, with the latter serving as a temporal parameter for comparison.

It should be noted that the 2018 PNLD follows a subject-based structure, organized into specific school subjects and based on the National Curriculum Parameters (PCN), whereas the 2021 PNLD organizes textbooks by areas of knowledge in accordance with the guidelines established by the Brazilian National Common Core Curriculum (BNCC), in addition to including supplementary materials. As the more recent edition, the 2021 PNLD also contains a greater number of volumes per area of knowledge - up to twice as many as the previous edition. Chart 1 presents the textbook collections used by the nine schools participating in this study.

Chart 1 - Textbook collections used by the high schools participating in this study

Code	Volumes	Textbook collection	Authors	Publisher
C1	1, 2, 3, 4, 5 e 6	<i>Dialogue: Natural Sciences and Their Technologies</i>	SANTOS, Kelly Cristina dos; CHINELLATO, Éverton Amigoni; SILVA, Rafael Aguiar da; KIMURA, Marissa; FERRARO, Ana Carolina N. dos Santos; FRÓES, André Luis Delvas; OGO, Marcela Yaemi; MICHELAN, Vanessa S.	Moderna
C2	1, 2 e 3	<i>Modern Biology: Amabis & Martho</i>	AMABIS, José Mariano; MARTHO, Gilberto Rodrigues.	Moderna
C3	1, 2, 3, 4, 5 e 6	<i>Connections: Natural Sciences and Their Technologies</i>	THOMPSON, Miguel; RIOS, Eloci Peres; SPINELLI, Walter; REIS, Hugo; SANT'ANNA, Blaidi; NOVAIS, Vera Lúcia Duarte de; ANTUNES, Murilo Tissoni.	Moderna
C4	1, 2, 3, 4, 5 e 6	<i>Matter, Energy, and Life: An Interdisciplinary Approach</i>	MORTIMER, Eduardo; HORTA, Andréa; MATEUS, Alfredo; PANZERA, Arjuna; GARCIA, Esdras; PIMENTA, Marcos; MUNFORD, Danusa; FRANCO, Luiz; MATOS, Santer.	Scipione
C5	1, 2, 3, 4, 5 e 6	Natural Sciences Multiverses	GODOY, Leandro Pereira de; AGNOLO, Rosana Maria Dell; MELO, Wolney Candido de.	FTD
C6	1, 2, 3, 4, 5 e 6	<i>Natural Sciences</i>	LOPES, Sônia; ROSSO, Sergio.	Moderna

Source: The authors (2023).

The textbooks were obtained in PDF format and were either provided by teachers or retrieved from the publishers' websites. Using the Google Drive search tools to examine the files, a survey was conducted to identify the textbooks containing chapters, topics, or excerpts addressing Mycology content. Chart 2 presents information about the textbooks included in the analysis conducted in this study.

Chart 2 – Textbooks containing chapters, topics, or excerpts related to fungi

Code	Volume	Grade*	Title
L.M. 1	2	1° ano	<i>Dialogue: Natural Sciences and Their Technologies – Life on Earth: How Is It Possible?</i>
L.M. 2	2	2° ano	<i>Modern Biology: Amabis & Martho</i>
L.M. 3	1	1° ano	<i>Connections: Natural Sciences and Their Technologies – Matter and Energy</i>
L.M. 4	2	1° ano	<i>Matter, Energy, and Life: An Interdisciplinary Approach – Evolution, Biodiversity, and Sustainability</i>
L.M. 5	1	1° ano	<i>Natural Sciences Multiverses – Matter, Energy, and Life</i>
L.M. 6	4	2° ano	<i>Natural Sciences – Pollution and Motion</i>

*The indicated grade level refers to the official recommendation for using the volume, as specified by the publisher.

Source: The authors (2023).

To evaluate the selected textbooks, an assessment form was developed for the chapters or topics related to Mycology content. The form was based on adaptations of the assessment techniques and methods described by Vasconcelos and Souto (2003), Rosa (2009), Silva and Menolli Junior (2017), and Lehrbach, Rosa and Drechsler-Santos (2019). Accordingly, criteria and subcriteria were established to assess the textbook volumes and describe how each criterion was addressed in the selected works (Chart 3).

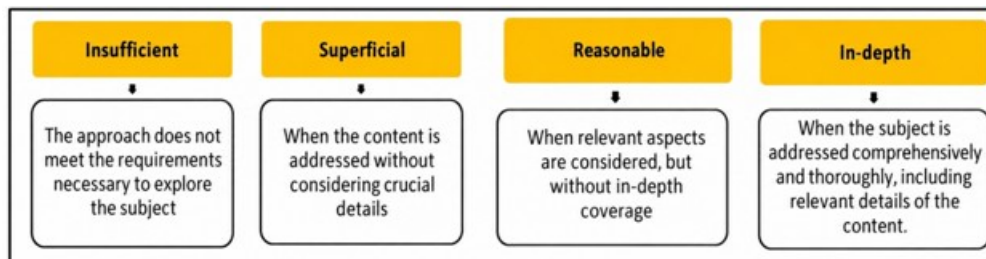
Chart 3 – Criteria and subcriteria used to analyze the selected volumes specifically regarding Mycology content

Code	Criterion	Subcriterion
CR1	Characterization of the presence of the subject	- Contains a chapter exclusively devoted to fungi; - Contains a topic exclusively devoted to fungi; - Addresses the content in connection with another subject.
CR2	Content and language used	- Depth of content; - Level of association with other living organisms; - Level of connection between the content and students' everyday lives; - Level of association between fungi and human beings; - Level of coverage of technical terminology; - Presence of a glossary; - Presence of supplementary materials.
CR3	Use of figures and illustrations	- Type of image; - Image quality; - Relationship between the image and the content addressed; - Presence of scales.
CR4	Practical activities and proposed exercises	- Type of activities proposed; - Purpose of the activity; - Presence of reflective activities.

Source: Authors (2023).

Furthermore, the subcriteria included under the criterion entitled “Content and language used” were assessed according to four levels of content coverage, as shown in Figure 1.

Figure 1 – Description of the levels of content depth



Source: Authors (2023).

The aforementioned framework enabled a more accurate and organized analysis of the content presented in each textbook, based on the levels described by Esposito and Azevedo (2010): insufficient, superficial, reasonable, and in-depth.

3 RESULTS

Among the collections included in the New Brazilian High School curriculum, the first-year volumes from collections C1, C3, C4, and C5 were those that best met the main analysis criterion, namely, the presence of a chapter or topic addressing Mycology content. Also included were a second-year volume from collection C2, which belongs to the former standard High School curriculum and is used by one of the schools participating in the project, and the second-year volume from collection C6. These textbooks were therefore selected for a more detailed assessment of their Mycology content.

In this context, among the six selected collections, three textbooks (L.M.1, L.M.2, and L.M.4) contained a chapter or specific topic on fungi. The remaining textbooks (L.M.3, L.M.5, and L.M.6) only contained a considerable number of occurrences of the word “fungus” compared with the other volumes in their respective collections, and these references were associated with other subjects. The criteria based on Chart 3 and used as parameters for the critical analysis of the High School textbooks adopted by the schools in Belém - the focus of this study - are presented below.

3.1 Characterization of the presence of the subject

Regarding the presence of the subject in the textbooks analyzed, only one textbook (L.M.2) contained an exclusive chapter devoted to the Kingdom Fungi. This was also the only textbook included in the 2018 PNLD. Two textbooks (L.M.1 and L.M.4) contained a topic dedicated to Mycology, whereas three textbooks (L.M.3, L.M.5, and L.M.6) mentioned fungi in connection with other subjects.

Textbook L.M.2 contained a 23-page chapter covering fungi, algae, and protozoa, of which five pages were devoted exclusively to the Kingdom Fungi. Textbooks L.M.1 and L.M.4 contained only specific topics on fungi, associating them with broader subjects. In L.M.1, the discussion of the Kingdom Fungi

extended over three pages and was included in Chapter 4, "Diversity of Living Organisms I." In L.M.4, fungi were mentioned on only one page of Chapter 2, "History of Life and Biodiversity."

Regarding textbooks that addressed the content in connection with other subjects, L.M.3 discussed fungi in only two paragraphs of Chapter 4, "Life and Energy," associating them with Ecology and their importance as decomposers. These organisms were also briefly mentioned in Chapter 6, "Recycling and Transformation of Matter and Energy in Living Organisms," in connection with the fermentation process involved in cheese production. In L.M.5, the subject was mentioned in four paragraphs in the Cross-Cutting Contemporary Themes section, with an emphasis on Science and Technology, Health, and the Environment. Fungi were also briefly mentioned in the Biochemistry content when discussing the fermentation process. In L.M.6, fungi received only a brief mention in Chapter 1, "Ecosystem Structure, Energy Flow, and the Matter Cycle," where they were associated with Ecology through their role as decomposers.

3.2 Content and language used in the text

L.M.2 presented the most in-depth content on the subject. It described the general characteristics of fungi, including their cellular structure, reproduction, nutrition, major phyla, and their respective characteristics, except for the phylum Glomeromycota, for which no information was provided. The textbook adequately explained the associations between fungi and other living organisms, such as lichens, including their functioning, asexual reproduction through soredia, and ecological relevance. Mycorrhizae were similarly addressed. The text also clearly highlighted the role of fungi as decomposers, producers of substances useful to society, and raw materials for the pharmaceutical and food industries. Furthermore, it contextualized the subject in relation to human health by discussing the importance of fungi as pathogens and as resources in pharmaceutical production.

Regarding technical aspects, L.M.2 employed specific terminology to describe the characteristics, reproduction, and classification of fungi. It also used recurring technical terms, such as hyphae, mycelium, asci, basidia, and spores, providing appropriate explanations for them. However, this textbook contained a conceptual error in its use of the term "fruiting bodies," which has fallen into disuse as part of the effort to dissociate fungi from plants; the term sporome is currently adopted. Furthermore, the textbook did not contain a glossary or recommend additional materials, such as supplementary readings or practical activities.

L.M.4 was the next most noteworthy textbook. It provided a more detailed discussion of the evolution of living organisms and addressed their organization throughout geological time. The text also presented the relationship between fungi and algae in a condensed and superficial manner, although it adequately addressed the trophic mutualistic relationship between fungi and plant roots (mycorrhizae). However, unlike L.M.2, the textbook did not contextualize the subject in relation to students' everyday lives or address the relationships between fungi and human beings.

From a technical perspective, the topic on fungi in L.M.4 presented clearly and accurately explained terms, such as hyphae, mycelium, mycorrhizae, and spores.

The general characteristics and nutrition of fungi were also explained appropriately. However, only macroscopic fungal species were presented, while microscopic species - which are equally important for understanding the Kingdom Fungi and its ecological and social significance - were disregarded. The textbook did not contain a glossary. As a positive feature, however, it recommended supplementary reading through a link concerning fungal infections that affect humans and proposed a practical activity at the end of the topic.

L.M.1, in turn, addressed the general characteristics of fungi, the differences between fungi and plants, and their relationship with human beings, although generally in a brief and concise manner. Despite the superficial coverage, information on the nutrition of these heterotrophic organisms was presented appropriately. One negative aspect was that the textbook mentioned microscopic species while neglecting macroscopic ones. It also presented topics such as fungal classification, reproductive cycles, and life cycles separately, while lichens and mycorrhizae were defined only in the glossary. Nevertheless, the content was satisfactorily connected to students' everyday lives by relating the subject to their routine experiences and activities. Regarding technical terminology, the terms hyphae, mycelium, and spores were used appropriately. L.M.1 did not recommend any additional materials.

The remaining textbooks contained only excerpts about fungi presented in connection with other subjects. Among these, L.M.3 did not address fungal morphology, physiology, life cycles, or reproduction. Instead, it merely explained the importance of these organisms as decomposers and their role in cheese fermentation, without establishing in-depth connections with other content or employing technical terminology. From a technical standpoint, it also lacked supplementary elements important to learning, such as a subject-related glossary and recommendations for additional materials, including practical activities and supplementary readings.

In L.M.5, the text discussed microorganisms and their importance to industry, presenting some general, morphological, and physiological characteristics of the yeast species *Saccharomyces cerevisiae* and briefly explaining its metabolic processes. However, it did not address its life cycle or reproduction. The text subsequently presented brief facts about the genus *Penicillium* and its relationship with antibiotics. It also made brief references to fungi as decomposers within the subject of Ecology. The association between fungi and students' everyday lives was addressed briefly and concisely through a reference to bread fermentation. This textbook contained neither a glossary nor additional materials.

In L.M.6, the content on fungi was associated with Ecology because of their role as decomposers. However, the textbook did not address the general, physiological, reproductive, or classificatory characteristics of these organisms. Furthermore, the text presented inaccurate information by defining fungal "fruiting bodies" as non-reproductive structures. Thus, the subject lacked depth and did not establish relationships between fungi and other living organisms, including humans, or present contextualized situations. From a technical perspective, L.M.6 used terms such as hyphae and mycelium but did not explain these concepts in depth, including through a glossary, nor did it provide a supplementary activity on the subject.

Regarding the depth of the content on fungi, only L.M.2 received an “in-depth” rating for all assessed items, except for the criterion “relationship with human beings” (Chart 4). L.M.4 was classified as “reasonable” regarding both content depth and technical terminology. L.M.1 also received a “reasonable” rating for its use of technical terminology, although it did not adequately address the relationship between fungi and human beings (Chart 4). The remaining textbooks received only “superficial” or “insufficient” ratings for the assessed criteria, demonstrating that they exhibited the greatest deficiencies in their coverage of fungi (Chart 4).

Chart 4 – Classification of the assessment subcriteria for “Content and language used in the text” in the textbooks evaluated

Level of coverage	Depth of content	Technical terminology	Relationship with other living organisms	Connection with students' everyday lives	Relationship with human beings
In-deph	L.M.2	L.M.2	L.M.2	L.M.2	-
Reasonable	L.M.4	L.M.1; L.M.4	L.M.1	-	L.M.2
Superficial	L.M.1; L.M.5	L.M.6	L.M.4; L.M.5; L.M.6	L.M.1; L.M.3; L.M.5	L.M.1
Insufficient	L.M.3; L.M.6	L.M.3; L.M.5	L.M.3	-	-

Source: Authors (2023).

3.3 Use of figures and illustrations

The textbooks containing a chapter (L.M.2) or a specific topic (L.M.1 and L.M.4) on fungi used high-quality, clear images, including drawings and photographs, which were appropriate and closely related to the corresponding text. L.M.2 contained a drawing illustrating the reproduction of ascomycetes; however, it included a conceptual error by referring to “fruiting bodies” and a “basidiocarp” instead of a “sporome.” L.M.1 contained only one representative drawing of lichens and a few photographs, whereas L.M.4 used a drawing to represent the morphology of only a multicellular fungus, disregarding unicellular fungi. It should also be noted that the drawing in L.M.1 did not include a scale bar. L.M.2 included scale bars in some images, while in L.M.4 this information was provided in the captions.

The remaining textbooks (L.M.3, L.M.5, and L.M.6), which mentioned fungi in connection with other subjects, contained few photographs. Nevertheless, the photographs were of high quality and appropriately related to the corresponding texts. The chapter in L.M.3 contained only one photograph related to fungi, L.M.5 contained two photographs, and L.M.6 contained only one photograph, whose caption included a conceptual error through the use of the term “fruiting bodies.” Furthermore, the photographs in both L.M.3 and L.M.5 included scale bars, whereas the photograph in L.M.6 did not.

3.4 Practical activities and exercises proposed in the textbooks

In this category, L.M.1, L.M.2, and L.M.4 presented different but contextually appropriate activities designed to encourage students' reflection and engagement with the subject. For example, L.M.1 proposed individual activities containing both open-ended and objective questions, as well as a group-based investigative activity. All these activities encouraged students to reflect on current issues and apply the knowledge acquired in their everyday lives. L.M.2 presented objective questions and one open-ended activity that encouraged students to relate fungi to everyday life. L.M.4 provided both open-ended and objective exercises and proposed a practical activity designed to engage students in investigating fungal contamination in food, also including bacteria.

Conversely, among L.M.3, L.M.5, and L.M.6 - which contained only excerpts about fungi in connection with other subjects - only L.M.5 presented a practical activity. In this activity, students were instructed to observe the decomposition of organic matter in different everyday situations and environments and formulate hypotheses to explain the appearance of fungi on the products. L.M.3 and L.M.6 did not contain any activities related to fungi.

4 DISCUSSION

The analysis of Mycology content in the selected textbooks revealed several critical and unsatisfactory aspects, such as the absence of a chapter devoted to fungi, except in L.M.2, which belongs to the 2018 PNLD. The other textbooks, all of which belong to the 2021 PNLD, did not contain chapters exclusively devoted to Mycology. This finding is concerning because this field of science must be addressed with appropriate relevance and depth, given that fungi perform essential roles in ecosystems and establish symbiotic relationships with various living organisms. Therefore, the absence of a dedicated chapter relegates Mycology to a secondary position and may reduce students' interest in the subject.

Regarding their importance, fungi perform crucial functions in nature and in people's everyday lives. They are responsible for the decomposition cycle of organic matter and are used as food and sources of medicines. They can also parasitize animals and plants and cause diseases in humans and agricultural crops (Sheldrake, 2021). However, a considerable number of textbook analyses, particularly those conducted since 1990, have shown that Mycology is rarely or not at all explored in Basic Education, despite the considerable interest in these organisms from biological, environmental, health-related, and economic perspectives, as well as their presence in students' everyday lives (Rosa; Mohr, 2010).

The limited depth of the content in the textbooks included in the 2021 PNLD was an evident problem. For Mycology to be studied effectively, textbooks must address the subject consistently, thereby enabling a more complete and accurate understanding of the content. As observed in most of the textbooks, the failure to address fundamental topics - such as fungal taxonomy, cellular structure, reproductive cycles, and metabolism - considerably limits the depth of the subject and may compromise students' learning about these organisms. According to Amorim *et al.* (2001), the absence of a taxonomic approach in educational materials, in particular, prevents teachers from developing an evolution-based

understanding of biological diversity and reinforces an essentialist view that the biological world is immutable.

The failure of the evaluated textbooks to employ technical terminology and the presence of conceptual errors in some textbooks, such as L.M.2 and L.M.6, were equally concerning. In this regard, it should be considered that failing to explain technical terms leaves students dependent on memorizing words and may make it difficult for them to relate concepts to their empirical knowledge of the subject, resulting in an inaccurate or superficial understanding of these concepts (Macedo, 2017).

Another noteworthy aspect was the lack of a connection between Mycology and human health in the textbooks. Ignoring this connection constitutes a serious error because it neglects the relevance of fungi to the prevention and treatment of human diseases. Regarding this importance, fungi found in unsuitable environments may cause human diseases, such as mycoses and respiratory infections, which can affect the healthcare system (Trujillo, 2015; Lehrbach; Rosa; Drechsler-Santos, 2019). Rosa *et al.* (2019) found that the absence of an interrelationship between fungi and human health in High School Biology textbooks reduces Mycology topics to an approach disconnected from students' realities.

Regarding the use of figures and illustrations, the appropriateness and quality of the images in relation to the text stood out in the textbooks containing a chapter or topic on fungi. Figures and illustrations can potentially enhance learning by establishing an effective visual connection with the narratives or information presented in textbooks, thereby facilitating content comprehension. These resources can also stimulate students' interest in the subject (Silva; Menolli Junior, 2017). Furthermore, visual resources can help make ideas more concrete when images or illustrations are appropriately arranged and include suitable captions and scales (Sodré Neto; Medeiros; Bezerra, 2023).

The absence of scales in the figures and illustrations in L.M.1 and L.M.6, as well as in some images in L.M.2, should also be highlighted. This omission may create an additional obstacle to students' accurate understanding because scale is a significant aspect when representing objects or phenomena with specific dimensions. Therefore, images without scales may raise questions about the reliability of the data presented and hinder an appropriate understanding of the concepts addressed. According to Espinola (2007), the absence of scales in textbook figures may lead students to misinterpret specific content, seriously distorting the actual sizes and shapes of the structures represented.

Regarding activities and exercises, four of the textbooks analyzed (L.M.1, L.M.2, L.M.4, and L.M.5) adopted a more interactive and engaging approach, whereas this approach was absent from the remaining textbooks. In the former group, the proposed activities encouraged students to reflect and engage directly with the topics studied through open-ended, objective, and investigative activities. Furthermore, this approach promotes a deeper understanding of the concepts because students have the opportunity to experience the situations they are studying and apply their acquired knowledge in practice. In this regard, Miranda, Leda and Peixoto (2013) stated that most students agree that diverse activities that depart from their usual routines improve their learning of a given subject.

Conversely, it is important to emphasize that textbooks lacking activities and exercises related to fungi may compromise effective learning. Such omissions limit students' ability to apply and integrate general content with Mycology and connect Mycology content to the real world. This finding demonstrates the importance of adopting a more comprehensive and inclusive approach in educational materials through diverse and contextualized activities intended to promote richer and more effective learning. According to Costa and Batista (2017), educational practices can encourage creativity, critical thinking, and reflection during the teaching and learning process, resulting in more meaningful education for students.

A comparison between the textbooks from the 2018 and 2021 editions of the PNLD showed that both contained strengths and weaknesses in their approaches to Mycology in High School. The textbook included in the 2018 PNLD (L.M.2) demonstrated an effort to address Mycology in greater detail within a specific chapter, although this chapter was shared with algae and protozoa. However, because it is a relatively old textbook developed in 2016, conceptual errors and obsolete terminology remained, including the expression "fruiting bodies" instead of "sporome," the term currently accepted to designate the reproductive structure of macroscopic fungi, such as mushrooms and bracket fungi (Santana *et al.*, 2023). Nevertheless, L.M.6 contained the same error despite being more recent, indicating that textbook authors must remain attentive to the conceptual changes that occur in every field of science.

Regarding the textbooks included in the 2021 PNLD, some authors attempted to contextualize the study of fungi by connecting it with other disciplines in the field, such as Ecology, Biochemistry, and Evolution. However, this contextualized approach resulted in omissions of crucial content, including reproductive cycles and taxonomic classification. Furthermore, the explanations of the morphology and physiology of these organisms were considerably limited and nonspecific, which may hinder students' understanding and create gaps that compromise effective learning in Mycology. According to Umbelino and Zabini (2014), interdisciplinarity - when properly implemented - is highly important because it enables an examination of the pertinence and relevance of the various areas of knowledge to be taught and promoted within the school curriculum.

5 FINAL CONSIDERATIONS

The data obtained in this study revealed that, among the High School textbooks used in Belém's public school system and included in the analysis, L.M.2 received the most satisfactory assessment across most of the criteria, although it belongs to the 2018 PNLD and is no longer used by most schools. Conversely, the analyzed textbooks from the 2021 PNLD performed below expectations compared with those from the 2018 PNLD, despite being more recent. Under these circumstances, the insufficient and superficial treatment of Mycology in most of the textbooks analyzed, as well as the absence of a specific chapter on the subject, may negatively affect students' education and their understanding of the importance of studying fungi, both within and beyond the context of their everyday lives.

Based on this analysis, Mycology content remains scarce in textbooks, probably because most of the works analyzed address the subject through short

topics and excerpts presented in connection with other themes. Furthermore, some inaccurate associations involving fungi remain. Supplementary resources, such as glossaries explaining technical terms and recommendations for further reading, are generally absent. The few existing images neither represent the diversity of the Kingdom Fungi nor include scales indicating the actual dimensions of the organisms and their structures. Moreover, there are very few activities designed to enable students to apply their knowledge of fungi through different types of tasks, particularly reflective activities that promote critical thinking and the development of skills and competencies.

Therefore, authors and publishers participating in the PNLD must develop educational materials containing more in-depth, up-to-date, interdisciplinary, and contextualized Mycology content. Appropriate visual resources are also needed to help students draw conclusions and establish accurate connections, as are additional materials such as games, practical activities, and contextualized examples. These resources can facilitate students' understanding of the content and familiarize them with the relevant concepts. Furthermore, changes are recommended in the development of fungal content in recent textbooks by expanding the existing information and seeking the broader coverage required by the field of Mycology.

O REINO FUNGI NO ENSINO BÁSICO: UMA ANÁLISE DO CONTEÚDO DE MICOLOGIA EM LIVROS DIDÁTICOS DO ENSINO MÉDIO DA REDE PÚBLICA DE ENSINO NO MUNICÍPIO DE BELÉM, PARÁ, BRASIL

RESUMO

Os fungos possuem importância social, econômica e ambiental para a sociedade, mas, geralmente, a ciência que estuda esses organismos (Micologia) é abordada nos materiais didáticos de maneira superficial e equivocada. Neste sentido, este trabalho objetivou analisar os livros didáticos de Biologia utilizados nas escolas estaduais de ensino médio da rede pública do município de Belém-PA, promovendo uma avaliação consistente dos conteúdos de Micologia, a fim de proporcionar um direcionamento para as editoras participantes do PNLD e, conseqüentemente, contribuir com a melhoria no processo de ensino-aprendizagem nesta área do conhecimento biológico. Trata-se de uma pesquisa de natureza aplicada a partir da análise de seis livros didáticos, que são utilizados em nove escolas de bairros mais populosos de Belém. A análise desses livros foi conduzida por meio de uma ficha de avaliação contendo critérios e subcritérios predeterminados, sendo que o item “Conteúdo e linguagem utilizada” também foi avaliado com base em quatro níveis de abordagem: insuficiente, superficial, razoável e aprofundado. Os resultados indicaram que a obra intitulada L.M.2, pertencente ao Programa Nacional do Livro Didático (PNLD) de 2018, foi a mais bem avaliada em relação aos critérios de análise, especialmente, quanto à abordagem aprofundada do conteúdo. As demais obras do PNLD de 2021, apesar de serem mais recentes, tiveram um desempenho inferior aos livros do PNLD 2018. Com base nisso, o conteúdo de Micologia insuficiente e superficial, na maioria das obras analisadas, assim como a ausência de um capítulo específico, pode prejudicar a formação dos estudantes e a compreensão da importância de se estudar a Micologia. Então, recomendam-se fortemente mudanças na abordagem sobre os fungos nas obras recentes, incrementando informações já existentes e buscando maior abrangência sobre essa área biológica.

PALAVRAS-CHAVE: Livro didático. Micologia. Ensino Médio.

BIBLIOGRAPHIC REFERENCES

ALEXOPOULOS, C. J.; MIMS, C. W.; BLACKWELL, M. **Introductory mycology**. 4. ed. New York: John Wiley & Sons, 1996.

AMORIM, D. S.; MONTAGNINI, D. L.; CORREA, R. J.; CASTILHO, M. S. M.; NOLL, F. B. Diversidade biológica e evolução: uma nova concepção para o ensino de zoologia e botânica no 2º grau. *In*: BARBIERI, M. R.; SICCA, N. A. L.; CARVALHO, C. P. C. **A construção do conhecimento do professor**. Ribeirão Preto: Holos Editora, 2001. p. 41-49.

BRASIL. Ministério da Educação. **Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira**. Catálogo de escolas. Brasília, MEC/SEB, 2020. Available at: <https://inepdata.inep.gov.br/analytics/saw.dll?Dashboard>. Access on: March 15, 2023.

CÂNDIDO, M. S. C.; SANTOS, M. G.; AZEVEDO, T. M.; SODRÉ-NETO, L. Microbiologia no ensino médio: analisando a realidade e sugerindo alternativas de ensino numa escola estadual paraibana. **Revista Ensino, Saúde e Ambiente**, v. 8, n. 1, p. 57-73, 2015. Available at: <https://periodicos.uff.br/ensinosaudeambiente/article/view/21199/12671>. Access on: April 16, 2025.

COSTA, G. R.; BATISTA, K. M. A importância das atividades práticas nas aulas de ciências nas turmas do ensino fundamental. **REVASF**, v. 7, n. 12, p. 6-20, 2017. Available at: <https://www.periodicos.univasf.edu.br/revasf/article/view/20/28>. Access on: March 10, 2025.

DEITOS, G. M. P.; MALACARNE, V. Experimentação no ensino de ciências: um olhar para os livros didáticos do ensino fundamental. **Revista Brasileira de Ensino de Ciência e Tecnologia**, v. 13, n. 1, p. 1-15, 2020. Available at: <https://periodicos.utfpr.edu.br/rbect/article/view/7596>. Access on: April 10, 2025.

ESPINOLA, C. R. R. **Aves na escola**: análise de livros didáticos do Ensino Fundamental. 2007. 63 f. Trabalho de Conclusão de Curso (Curso de Graduação em Ciências Biológicas) – Universidade Federal de Santa Catarina, Florianópolis, 2007. Available at: <https://periodicos.utfpr.edu.br/rbect/article/view/7596>. Access on: January 15, 2025.

ESPOSITO, E.; AZEVEDO, J. C. **Fungos - Uma Introdução à Biologia, Bioquímica e Biotecnologia**. 2 ed., v. 1, Caxias do Sul, EDUCS, 2010.

FREIRE, M. V. OLIVEIRA, K. K. S. SOARES, F. P. A. **Ensino-aprendizagem de Micologia em livros de Ciências do Ensino Fundamental: análise de conteúdo.** In: CONGRESSO DE MEDICINA TROPICAL, 52., 2016, Maceió. **Anais [...]**. Maceió: SBMT, 2016. Available at: <https://sbmt.org.br/anais-medtrop/>. Access on: April 10, 2025.

GERHARDT, T. E.; SILVEIRA, D. T. **Métodos de pesquisa.** Universidade Aberta do Brasil, Porto Alegre, Editora da UFRGS, 2009.

LEHRBACH, D. A.; ROSA, M. D. A.; DRECHSLER-SANTOS, E. R. Micologia nos livros didáticos do ensino médio: a concepção dos estudantes e a necessidade de práticas pedagógicas complementares. **Ciências em Foco**, v. 12, n. 2, p. 67-85, 2019. Available at: <https://econtents.sbu.unicamp.br/inpec/index.php/cef/article/view/12199>. Access on: April 10, 2025.

MACEDO, E. C. **O ensino de fungos e a abordagem de conteúdos conceituais, procedimentais e atitudinais nos livros didáticos de biologia aprovados pelo PNLD 2015.** 2017. 88 f. Dissertação (Mestrado Profissional em Ensino de Ciências e Matemática) - Instituto Federal de Educação, Ciência e Tecnologia de São Paulo, São Paulo, 2017. Available at: <https://repositorio.ifsp.edu.br/items/edff58d1-1b2d-4aba-80ec-be2a002f087b/full>. Access on: April 10, 2025.

MIRANDA, V. B. S.; LEDA, L. R.; PEIXOTO, G. F. A importância da atividade prática no ensino de Biologia. **Revista de Educação, Ciência e Matemática**, v. 3, n. 2, p. 85-101, 2013. Available at: https://www.researchgate.net/publication/317014204_IMPORTANCIA_DA_ATIVIDADE_PRATICA_NO_ENSINO_DE_BIOLOGIA. Access on: March 10, 2025.

ROSA, M. D. A.; OLIVEIRA, M. C. A.; DUARTE, A. A. G.; ANTUNES, C. M. M.; SOUZA, D. B.; ABREU LEHRBACH, D.; DRECHSLER-SANTOS, E. R. A Micologia como conteúdo da disciplina de biologia no ensino médio: uma análise dos livros didáticos aprovados no PNLD-2018. **Revista Thema**, v. 16, n. 3, p. 617-635, 2019. Available at: <https://periodicos.ifsul.edu.br/index.php/thema/article/view/1163/1264>. Access on: December 9, 2024.

ROSA, M. D. A. **Os fungos na escola: análise dos conteúdos de micologia em livros didáticos do ensino fundamental de Florianópolis.** 2009. 53 f. Monografia (Bacharel em Ciências Biológicas) - Universidade Federal de Santa Catarina, Santa Catarina, 2009. Available at: <https://repositorio.ufsc.br/xmlui/handle/123456789/132379>. Access on: December 9, 2024.

ROSA, M. D. A.; MOHR, A. Os fungos na escola: análise dos conteúdos de micologia em livros didáticos do ensino fundamental de Florianópolis. **Experiências em Ensino de Ciências**, v. 5, n. 3, p. 90-98, 2010. Available at: <https://if.ufmt.br/eenciojs/index.php/eenci/article/view/366>. Access on: December 6, 2024.

SANTANA, M. D. F.; KOMURA, D. L.; COUCEIRO, D. M.; CAMPOS, C. S.; COUCEIRO, S. R. M. **Fungos silvestres da Amazônia Paraense: É de comer?** Manaus: Editora INPA, 2023.

SHELDRAKE, M. **Trama da vida: como os fungos constroem o mundo**. São Paulo: Fósforo Editora/Ubu Editora, 1ª ed., 2021. 368 p.

SILVA, A. C.; MENOLLI JUNIOR, N. Análise do conteúdo de fungos nos livros didáticos de biologia do ensino médio. **Revista Ciências & Ideias**, v. 7, n. 3, p. 235-273, 2017. Available at: https://fernandosantiago.com.br/analise_fungos_LD.pdf. Access on: December 6, 2024.

SILVA, G. K. S. **Análise do conteúdo de Micologia em livros didáticos do ensino médio utilizados em escolas de referência de Vitória de Santo Antão - PE**. 2019. 47 f. Trabalho de Conclusão de Curso (Curso de Graduação em Ciências Biológicas) – Universidade Federal de Pernambuco, Pernambuco, 2019. Available at: <https://repositorio.ufpe.br/bitstream/123456789/32127/1/SILVA%2c%20Gleyce%20Keller%20Santos.pdf>. Access on: December 6, 2024.

SODRÉ NETO, L.; MEDEIROS, K. S. C.; BEZERRA, R. N. V. Microbiology in science and biology textbooks: STS approach and applicability of knowledge. **Revista Brasileira de Ensino de Ciências e Tecnologia**, v.16, p. 1-19, 2023. Available at: https://periodicos.utfpr.edu.br/rbect/article/view/14605/pdf_1. Access on: April 16, 2025.

TORTORA, G. J.; FUNKE, B. R.; CASE, C. L. **Microbiologia**. 12. ed. Porto Alegre: Artmed, 2017. Available at: https://tga.blv.ifmt.edu.br/media/filer_public/6c/09/6c09bd4b-f1ff-405c-8536-79faf088f655/microbiologia-tortora.pdf. Access on: April 10, 2025.

TRUJILLO, J. A. B. **Micologia Médica Básica**. 5ª ed., v. 1, Santa Fe, Mc Graw Hill Education, 2015.

UMBELINO, M.; ZABINI, F. O. A importância da interdisciplinaridade na formação do docente. In: SEMINÁRIO INTERNACIONAL DE EDUCAÇÃO SUPERIOR, 1., 2014, Sorocaba. **Anais [...]**. Sorocaba, 2014. p. 1-8. Available at:

<https://www.feevale.br/hotsites/seminario-internacional-de-educacao/edicoes-antiores/2014>. Access on: April 15, 2025.

VASCONCELOS, S. D.; SOUTO, E. O livro didático de ciências no ensino fundamental - proposta de critérios para análise do conteúdo zoológico. **Ciência & Educação**, v. 9, n. 1, p. 93-104, 2003. Available at: <https://www.scielo.br/j/ciedu/a/GPVrSHkbqs46FYZvkYth9fg/?format=pdf&lang=pt>. Access on: April 15, 2025.

Received: Aug. 14th, 2024.

Approved: Aug. 23rd, 2026.

DOI: 10.3895/rbect.v19n1.18984

How to cite: SANTOS; E. M. O.; OLIVEIRA, J. B.; MONTEIRO-ALVES, R. J.; MARTINS, A. C. C.; MARTINS JUNIOR, A. S. The Kingdom Fungi in Basic Education: an analysis of Mycology content in High School textbooks used in the public school system of Belém, Pará, Brazil. **Brazilian Journal of Science Teaching and Technology**, Ponta Grossa, v.19, p. 1-18, 2026. Available at: <<https://periodicos.utfpr.edu.br/rbect/article/view/18984>>. Access on: XXX.

Mailing address: Esterfane Monique de Oliveira Santos - esterfane.santos@aluno.uepa.br

Copyright: This article is licensed under the terms of the Creative Commons-Atribuição 4.0 Internacional License.

