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Analysis of the circulation of the topic of biofuels in natural sciences and technology textbooks for high school

ABSTRACT

Given the depletion of fossil fuels and the associated environmental problems, there is a growing need to seek new energy sources, such as biofuels, and to develop technologies to harness renewable and less polluting energy. The current situation calls for a shift in attitudes toward the environment, which requires the formation of critical citizens, and the school is a crucial environment for this. Education can promote more responsible behavior among students in society, and one way to introduce relevant topics for sustainable development is through textbooks. This research aimed to analyze how the topic of biofuels is addressed in seven collections of Natural Sciences and Technology textbooks selected by the 2021 National Textbook and Teaching Material Program for High School in Brazilian public schools, following the recommendations of the National Common Curricular Base. The analysis was based on Bardin's (2011) framework. It was observed that the approach to the topic varied among the collections, with some books addressing the subject in more depth and others more superficially. Additionally, the research identified the use of different didactic resources, such as images and diagrams. The articulation of the topic with the competencies of the National Common Curricular Base showed that the focus was more on specific content about biofuels, revealing some limitations in the practical application of this knowledge and in the critical-citizen education of students.

KEYWORDS: Biofuels; Textbooks; Science Education.

Análise da circulação do tema biocombustíveis em livros didáticos de ciências da natureza e suas tecnologias para o ensino médio

RESUMO

Diante do esgotamento dos combustíveis fósseis e dos problemas ambientais associados, surge a necessidade de buscar novas fontes de energia, como os biocombustíveis, e desenvolver tecnologias para explorar energias renováveis e menos poluidoras. A atual situação exige uma mudança de postura em relação ao meio ambiente, o que demanda a formação de cidadãos críticos, e a escola é um ambiente crucial para isso. A educação pode promover uma atuação mais responsável dos alunos na sociedade, e uma forma de inserir temas relevantes para o desenvolvimento sustentável é através dos livros didáticos. Esta pesquisa teve como objetivo analisar como o tema dos biocombustíveis é abordado em sete coleções de livros didáticos de Ciências da Natureza e suas Tecnologias, selecionadas pelo Programa Nacional do Livro e do Material Didático de 2021 para o Ensino Médio das escolas públicas brasileiras, conforme as recomendações da Base Nacional Comum Curricular. A análise foi realizada com base nos pressupostos de Bardin (2011). Observou-se que a abordagem do tema variou entre as coleções, com alguns livros tratando o assunto de forma mais aprofundada e outros de maneira superficial. Além disso, a pesquisa identificou a utilização de diferentes recursos didáticos, como imagens e esquemas. As articulações do tema com as competências da Base Nacional Comum Curricular mostraram que o foco estava mais nos conteúdos específicos sobre biocombustíveis, revelando algumas limitações na aplicação prática desses conhecimentos e na formação crítico-cidadã dos alunos.

PALAVRAS-CHAVE: Biocombustíveis; Livros didáticos; Ensino de Ciências.

INTRODUCTION

Science/Chemistry Education is essential for fostering a sense of citizenship in students that leads to conscious action in various contexts. We believe that Natural Science Education, particularly Chemistry, can help students develop their way of thinking about the world around them, enabling them to build arguments to explain the natural and scientific phenomena they observe, as well as apply their scientific knowledge in everyday situations.

Therefore, for chemistry education to contribute significantly to the development of a broad understanding of knowledge and the critical-citizen development of students, it must include socially relevant topics in the classroom, relating them to chemical processes and concepts, in order to build scientific knowledge that can be applied to everyday situations and contexts linked to the environment, technology, the economy, and society.

The crucial importance of caring for the environment is constantly mentioned in the mass media and in textbooks about sustainable development, with the aim of raising awareness of society's attitudes toward the environment. When it comes to sustainability, it is essential to consider the composition of the global energy matrix and the possibility of replacing non-renewable energy sources with renewable ones, which can reduce the damage caused to the environment. In this regard, one of the specific skills (EM13CNT309) outlined by the National Common Curricular Base is:

> Analyze socio-environmental, political, and economic issues related to the world's current dependence on non-renewable resources and discuss the need to introduce alternative and new energy and material technologies, comparing different types of engines and processes for producing new materials. (Brasil, 2018, p. 560).

In this context, addressing the topic of biofuels in the classroom and their inclusion in the energy matrix as a replacement for fossil fuels is important because it enables students' individual and collective decisions and actions to aim at minimizing socio-environmental impacts, which can improve living conditions at the local, regional, and global levels and promote sustainable development.

In addition to the conceptual chemical content related to the topic of biofuels, schools can address issues related to environmental education and sustainability, enabling students to explore and understand the natural resources that can be used in the energy matrix in a way that reduces harm to nature and maintains a healthy balance between society and the environment. According to Pinto (2016), developing the topic of biofuels as a theme in education is important because:

> [...] society has little knowledge regarding environmental issues. Therefore, it is necessary to include these subjects in the school context because it is in this environment that they are effectively discussed, allowing for the understanding of environmental themes and the development of an active stance of participation, leading toward sustainable development." (p. 14).

Further on this topic, it is worth highlighting the discussion developed by Angeli and Carvalho (2020), who draw attention "to the fact that the injustices generated by the capitalist production model go beyond socio-economic

inequalities, also affecting access to environmental resources and exposure to environmental degradation." (p. 2).

Introducing the topic of biofuels into the school context enables children and adolescents to be aware, from the beginning of their social formation, of the importance of caring for the environment and adopting sustainability-based attitudes.

One way to introduce this topic to students is by addressing it in textbooks, pedagogical materials focused on teaching and presenting disciplinary content and concepts, which, in addition to serving as tools to support teaching practices, also provide a basis for students to acquire knowledge and information.

Therefore, based on the relevance of addressing the topic of biofuels in the classroom to promote argumentative and autonomous thinking as well as students' sustainable awareness regarding environmental issues, this article aims to analyze how this topic circulates in Natural Sciences and Technology textbooks for High School selected by the 2021 PNLD.

BRIEF HISTORY OF TEXTBOOKS

The history of textbooks (LDs) in Brazil dates back to the 1830s, when, under the influence of French liberalism, the Pedro II School was established in Rio de Janeiro, serving only privileged classes. In this context, drawing on European education as a reference, schools used instructional manuals in French or translated into Portuguese that were imported to Brazil (Silva, 2012).

Following the Francisco Campos Reform of 1931, textbooks underwent some changes. The main modification concerned the presentation of the books, with most becoming serialized textbooks based on the official program of the Reform. In 1942, the Capanema Reform introduced changes to the content of certain topics. These books were published, maintaining the inclusion of exercises and questionnaires at the end of the chapters (Mortimer, 1988).

Enacted in 1961, the Law of Guidelines and Bases of National Education (LDB) remained in effect until 1970, a period characterized by heterogeneity in textbooks due to the absence of legislation and guidelines to organize the programs for each subject (Mortimer, 1988). In response to numerous criticisms of the textbook distribution processes, the National Textbook Program (PNLD) was created in 1985 through Decree No. 91.542 of 08/19/85 (Schirmer & Sauerwein, 2017). Since then, a call for submissions has been issued every three years, inviting publishers to submit collections for evaluation by Ministry of Education committees.

Currently, the PNLD 2021 call for the new High School curriculum is in effect, dividing the program into different categories (object). The first object features works involving Life Projects and Integrative Projects, while the second object includes works organized by knowledge areas rather than subjects, based on the organization of the National Common Curricular Base (BNCC): Mathematics and its Technologies, Human and Social Sciences, Natural Sciences and its Technologies, and Languages and their Technologies, with six volumes for each area (Brasil, 2021).

The tumultuous history of the construction of the BNCC involved numerous episodes in which legitimacy was sought through mechanisms such as formal consultations with segments of the educational field. However, it is important to consider that each school has its own particularities, and it is subjective to think of competencies and a common curriculum for all schools across the country. Furthermore, it is crucial to emphasize that the construction of this Base should be ongoing, and it is up to education researchers to critically question and debate the processes of producing and implementing the document (Franco & Munford, 2018; Silva, 2018).

The BNCC in the area of Natural Sciences and its Technologies addresses environmental aspects that can be worked on in the classroom to encourage individual and collective actions that minimize socio-environmental impacts at local, regional, and global levels. In this way, the topic of biofuels is a relevant theme, capable of helping students understand some of the natural and renewable resources that can be used as energy sources in the energy matrix to reduce environmental damage.

BIOFUELS FROM AN ENVIRONMENTAL PERSPECTIVE

The inclusion of biofuels in the global energy matrix is of utmost importance, as is its approach in the school context. Some studies in the literature have developed this theme in different contexts from an environmental perspective.

Melo, Bara, Fernandes, Vieira, and Freitas-Reis (2021) propose a didactic sequence involving the sugarcane cycle for third-year high school students to improve their understanding of the chemistry behind sugar production and ethanol. As a result, the authors observed both the importance of addressing chemical concepts in a contextualized manner, bringing students closer to their everyday lives, and the need to use different methodologies and strategies that spark students' interest.

From the development of the project “Biogas – Renewable Energy for the Future,” an investigation was carried out in which students recognized biogas as a viable energy source from economic, social, and environmental perspectives. They also grasped conceptual and procedural scientific content and the importance of experimentation in scientific activities (Souza & Martins, 2011).

Pereira, Marciniuk, Pricinotto, Crespan, and Soares (2021), through the Science, Technology, Society, and Environment (CTSA) perspective, developed a didactic proposal using the three pedagogical moments (initial problematization, knowledge organization, and knowledge application) and addressed problem-solving situations about biodiesel for third-grade high school students, encouraging them to reflect and solve problems critically, as citizens in a democratic society.

Martins, Auth, Epoglou, Tavares, and Silva (2015) investigated the use of different interdisciplinary didactic activities based on a problem-solving situation centered on the theme “fossil fuel vs. biofuel.” Among the didactic activities used were discussions, questionnaires, reports, and a simulated jury, which allowed students to establish a connection between scientific knowledge and cultural and socio-economic aspects.

Bizerra, Queiroz, and Coutinho (2018) conducted an activity with high school students by dividing the class into two groups: one responsible for researching fossil fuels and the other for researching biofuels. Later, a debate was held, and the research findings were presented. Through this activity, students were able to research and develop their own conceptions about the theme "The environmental impact of fossil fuels and biofuels."

Based on this brief account, we can conclude that there are different approaches, strategies, and methodologies available for addressing the topic of biofuels in the school context. Moreover, in most of the studies, activities related to the theme piqued students' interest and contextualized chemical concepts, bringing them closer to everyday situations, fostering critical thinking, and empowering them to act as citizens. We also observed that none of these studies investigated the topic in textbooks, thus highlighting the relevance of the present research.

METHODOLOGY

This research is qualitative and documentary in nature, as it involves the analysis of textbooks. Our sample consisted of seven collections of high school textbooks in Natural Sciences and its Technologies, which were approved by PNLD 2021: Ser Protagonista (LD1), Moderna Plus (LD2), Matéria Energia e Vida (LD3), Diálogo (LD4), Multiversos (LD5), Conexões (LD6), and Ciências da Natureza Lopes & Rosso (LD7).

To understand how the theme of biofuels circulates in the Natural Sciences and its Technologies textbooks from PNLD 2021, we used the Content Analysis (CA) method based on the principles of Bardin (2011). According to the author, CA is defined as:

> A set of communication analysis techniques aimed at obtaining, through systematic and objective procedures for describing message content, indicators (whether quantitative or not) that allow the inference of knowledge related to the conditions of production/reception (inferred variables) of these messages. (Bardin, 2011, p. 46).

Bardin's (2011) organization of CA involves three stages: 1) pre-analysis; 2) material exploration; and 3) treatment of results, inference, and interpretation. Based on this methodology, it is possible to collect data from an investigative question about a particular material and then analyze what was collected, not only regarding what is explicitly stated but also concerning what is implicitly communicated in the message.

It is important to note that in this study, we established *a priori* category: Competencies and Skills of the BNCC. After reading the *corpus*, during material exploration, we defined certain chapters of the textbooks as context units and identified two additional categories of analysis: Form of Thematic Approach and Didactic Resources Used. Furthermore, subcategories emerged following the exploration of the textbooks. Table 1 presents a systematization of these ideas.

Table 1

Categories and Subcategories of Analysis

Categories	Subcategories	Units of Analysis
	Subcategory 1.1 – Biodiesel: A renewable alternative to the use of fossil fuels	14
	Subcategory 1.2 – Production and use of ethanol biofuel in Brazil	10
Category 1 – Form of Thematic Approach	Subcategory 1.3 – Biogas: An alternative to fossil fuels: conditions of production and advantages	5
	Subcategory 1.4 – Biofuels: Biomass as an energy source from a general perspective	12
	Subcategory 2.1 – Schemes and images	12
	Subcategory 2.2 – Activities and research questions	12
Category 2 – Didactic Resources	Subcategory 2.3 – Use of scientific dissemination texts	3
	Subcategory 3.1 – Analysis of the competencies and skills of the BNCC in LD2	5
Category 3 – Competencies and Skills of the BNCC	Subcategory 3.2 – Analysis of the competencies and skills of the BNCC in LD7	6

Source: The authors (2022).

In Category 3, LD2 and LD7 were selected for analysis because, during the research, we observed that these books offered the most comprehensive approach to biofuels. Additionally, this selection is justified by the detailed analysis that this category required, allowing for a deeper discussion of the data. Therefore, this category consists of two subcategories of analysis, one for each book.

RESULTS AND DISCUSSIONS

ANALYSIS OF CATEGORY 1: FORM OF THEMATIC APPROACH

Category 1 focuses on the thematic approach involving the content on biofuels found in the Natural Sciences and its Technologies textbooks, and all the textbooks analyzed fall into this category. As previously described, this category consists of four subcategories of analysis, which we will discuss below, presenting some examples of the units of analysis found in the textbooks.

Subcategory 1.1 – Biodiesel: A Renewable Alternative to Fossil Fuels

In this subcategory, we found aspects related to biodiesel in four textbooks, totaling 14 units of analysis: (LD1=2, LD2=2, LD4=6, LD7=4).

As we can see, not all textbooks addressed biodiesel, which we consider a drawback since biodiesel is widely discussed and disseminated in mass media today. It is an extremely important biofuel due to its environmental and economic advantages. Currently, a 10% biodiesel blend with diesel is mandatory in the fuel sold in the country (Brasil, 2021).

Some of the analysis units found in the textbooks present biodiesel as an alternative to fossil fuels due to environmental concerns:

> Biodiesel has become an alternative to petroleum diesel in recent decades. It has similar properties to diesel, but it is biodegradable and sulfur-free. These characteristics make this fuel highly relevant for pollution control. (LD1, p. 152).

> According to studies, the use of biodiesel reduces carbon dioxide emissions by up to approximately 78% compared to diesel. This occurs because during its production, the oil-producing plants capture and consume the CO_2 emitted by the combustion of this fuel, reducing the accumulation of this gas in the atmosphere. Thus, the use of organic biomass does not alter the carbon cycle, as observed with the use of fossil fuels. (LD4, p. 99).

As mentioned earlier, biodiesel is a fuel derived from biomass, renewable and biodegradable. Since it is obtained from renewable sources, it has a neutral carbon cycle, reducing carbon dioxide (CO_2) emissions, which is the main cause of the greenhouse effect. This is because all the CO_2 released into the atmosphere from burning this biofuel is reabsorbed during photosynthesis by the plants used as raw materials. This important fact about biodiesel should be addressed in textbooks, as it helps students understand why biodiesel emits fewer pollutants compared to diesel. However, only LD4 referred to this neutral carbon cycle.

Moreover, there are other aspects related to biodiesel and petroleum diesel that could be explored but were not found in the analyzed textbooks, such as the structural differences between them. Biodiesel is a mixture of fatty acid esters with short-chain monohydric alcohols, while diesel oil consists of hydrocarbons with chains of up to 28 carbon atoms, containing low concentrations of sulfur, oxygen, and nitrogen atoms. Furthermore, only LD7 highlighted the mandatory addition of a percentage of biodiesel to commercial diesel oil.

Some of the analysis units also address biodiesel production:

> While Brazilian bioethanol is based on a single raw material, sugarcane, biodiesel uses various oilseeds for its production: palm oil in Pará, castor beans in the semi-arid Northeast, and soybeans in the Midwest and South. Other alternatives include cotton, babassu, sunflower, peanuts, canola, palm, and jatropha, as well as animal fats (beef, pork, and poultry). (LD2, p. 141).

> Transesterification is the reaction between an ester and an alcohol, leading to the formation of a new ester and a new alcohol. In the case of biodiesel synthesis, a vegetable oil is treated with a short-chain alcohol, usually methanol or ethanol. The resulting products are methyl or ethyl esters of the fatty acids present in the original material, along with glycerol (glycerin). (LD7, pp. 106-107).

Regarding biodiesel production, some textbooks discuss the transesterification reactions of fatty acids for biodiesel synthesis in a very superficial way. However, LD7 explains this process in more detail than the other textbooks and also presents the advantages of using biodiesel in diesel engines, which is relevant since simply mentioning the transesterification reaction without

explaining how it works and its benefits may confuse students. This is particularly important considering that, depending on the year of high school in which the topic is discussed, organic reactions may not yet have been covered. We also highlight that LD7 mentions the possibility of producing biodiesel from residual materials. According to Oliveira, Mota, Oliveira, and Sampaio (2017):

> Many alternative energy sources are wasted, such as cooking oil, which is discarded and pollutes the environment. Each liter of oil dumped into urban sewage has the potential to pollute about a million liters of water, which is approximately the amount a person consumes over 14 years of life. (2017, p. 914).

Thus, by learning about the possibility of producing biodiesel from residual oil, students can understand one of the pillars of Sustainability, the reuse, a process that reduces the environmental impacts caused by improper disposal of cooking oils and allows for cost reduction. Two of the analyzed textbooks also contain excerpts on the historical aspects of biodiesel use:

> Another fuel that can be obtained from biomass is biodiesel. The history of biodiesel began with the creation of diesel engines in the late 19th century, designed by the German Rudolf Diesel (1858-1913) to run on vegetable or animal oils. (LD2, p. 141).

> In 1900, in France, during the Universal Exposition in Paris, an event created to showcase new technologies, German engineer Rudolf Diesel (1858-1913) presented a prototype engine that ran on peanut oil. He believed this technology could aid agricultural development in countries, and the use of vegetable oils (or animal fat, substances from the triacylglycerol class) could become as important as petroleum. [...] Many scientists developed and tested various methods, but none achieved significant results until the transesterification reaction was employed to produce biodiesel in the mid-1930s. (LD7, p. 106).

Introducing historical context into science teaching is important because historical events can contribute to a better reflection on the construction of scientific knowledge. Generally, science is presented in schools only as content, concepts, and formulas for students to memorize. However, by integrating historical aspects of science into lessons, content can be contextualized and approached in a reflective way, giving meaning to science learning and enabling greater interaction and participation in discussions.

Finally, in analyzing this subcategory, we noticed that among the textbooks where the topic was found, different approaches were identified, with some being more superficial and others more in-depth. However, none of the textbooks referred to the economic and social advantages of using biodiesel. According to Guarieiro, Vasconcellos, and Solci (2011, cited by Pereira et al., 2021, p. 34116), the use of biodiesel blended with diesel can be considered both an economic strategy, as it can reduce diesel imports, and a social one, as it contributes to keeping people in rural areas. The inclusion of this energy matrix can generate employment and income in rural areas, given that the policy used to encourage biodiesel production in Brazil requires that part of its production comes from oilseeds sourced from family farming.

Subcategory 1.2 – Production and Use of Biofuel Ethanol in Brazil Subcategory

In this subcategory, we address aspects related to ethanol that appeared in four textbooks, comprising ten units of analysis: (LD1=3, LD2=2, LD5=1, LD7=4).

Similar to the biodiesel analysis, not all textbooks covered ethanol, which was even more surprising considering the high production and use of this biofuel in Brazil, as some textbooks themselves point out:

> Brazilian bioethanol fuels much of the national fleet of light vehicles and stands out compared to ethanol produced in the rest of the world due to its high productivity and relatively low cost. Brazil's 2018/2019 sugarcane crop of 620.4 million tons, according to the National Supply Company (CONAB), produced 33.14 billion liters of ethanol. (LD2, p. 141).

> Currently, Brazil is the second-largest producer of ethanol in the world. The United States ranks first, where corn is the primary source, yielding a smaller volume of ethanol per cultivated area. (LD7, p. 102).

Several important aspects related to ethanol that could be explored in the classroom were not covered in the textbooks, such as: the historical aspects of ethanol use as a fuel and the implementation of the Proálcool program, considering the importance of integrating the history of science into the school context; the production of second-generation ethanol, which has been the focus of numerous studies and is produced from the controlled fermentation of various sources of plant biomass, including the waste discarded in the first-generation ethanol production process.

The textbooks also did not address the environmental advantages of ethanol considering the differences between its combustion and that of gasoline. Gasoline is a mixture of substances extracted from petroleum, whose combustion produces a range of harmful gases, including carbon dioxide, carbon monoxide, and water vapor. Ethanol, being less complex and composed mainly of ethanol and water, releases only carbon dioxide, a smaller amount of carbon monoxide, and water vapor when burned.

Among the ethanol-related topics covered in the textbooks are aspects concerning its production, such as these excerpts from the analysis units:

> Among the most well-known alcohols is ethanol, used as fuel. In Brazil, ethanol is mainly obtained from the fermentation of sugars present in sugarcane. It can also be derived from corn, beets, potatoes, and other sources. (LD1, p. 153).

> In the industry, sugarcane undergoes washing, crushing, and milling processes to obtain cane juice, which is then filtered to separate it from residues [...] (LD7, p. 102).

Again, similar to the Subcategory 1 analysis, some textbooks present ethanol production in a more general and simplistic manner, while LD7 explains the industrial process more thoroughly. This detailed explanation is important for connecting chemical knowledge to real-life situations experienced by students, helping them understand the relevance of the content learned and its application in different everyday scenarios.

Moreover, a positive point is that two of the textbooks (LD1 and LD7) highlighted the difference between anhydrous ethanol and hydrated ethanol,

another piece of knowledge that can be related to students' daily lives, as it represents the two forms in which ethanol is used as fuel in engines.

1.3 – Biogas: An Alternative to Fossil Fuels – Conditions of Production and Advantages

Regarding Subcategory 1.3, which corresponds to the characteristics of biogas, we identified five units of analysis in two textbooks: (LD2=4, LD5=1). According to Souza and Martins (2011), it is important to cover the topic of biogas because:

> [...] this biofuel is not widely publicized in the media, despite the many favorable points for its use, among which we can highlight: the ease of obtaining raw materials (especially animal manure); the reuse of organic waste; the reduction of greenhouse gas emissions; the production of biofertilizer as a byproduct; and the low-cost generation of thermal and electrical energy. (2011, p. 20-21).

As stated in the excerpt, biogas is not widely publicized in various information channels, which is confirmed by the fact that, among the biofuels analyzed in the previous subcategories, biogas was the least frequently mentioned, appearing in only two of the textbooks.

Biogas is a renewable energy source that offers numerous advantages, including: the generation of electrical and thermal energy; the variety of raw materials that can be used in its production; the potential to create products like fertilizers; its viability as an alternative to fossil fuels, including liquefied petroleum gas (LPG); and its ability to be produced by transforming organic waste into energy, providing new uses for landfills and reducing urban waste-related issues. However, only two units of analysis addressing these issues were found in the textbooks reviewed.

In addition to presenting the advantages of biogas, LD2 also discussed some disadvantages, which is important to provide students with a broader perspective. Understanding both the positive and negative aspects of this biofuel enables students to reflect, analyze, and form critical opinions that can later be used in societal discussions and decision-making:

> There are some drawbacks that need to be considered regarding biogas, including: the risk of explosions in the biodigester; contamination of soil and groundwater in areas where biodigesters are installed due to the disposal of residual water; and the leakage of toxic gases, such as hydrogen sulfide. However, these drawbacks can be managed. (LD2, p. 142).

Both textbooks covered the process of biogas production, as exemplified by the following excerpt:

> Biogas is a gaseous mixture produced by the decomposition of organic matter. Many countries have used biogas for electricity generation due to its energy efficiency and environmental benefits associated with the reuse of organic waste, such as fruit peels and food scraps, and wastewater treatment residues, such as sewage sludge. (LD5, p. 31).

The discussions involving biogas production in the textbooks are coherent and offer opportunities for classroom activities and experiments simulating

biofuel production, considering all the steps involved in the anaerobic digestion process.

Despite the limited presence of biogas in only two textbooks, both effectively explain certain aspects of its production. However, they lack detail regarding the various stages of the process, such as hydrolysis, acidogenesis, acetogenesis, and methanogenesis, which would have clarified the biodigestion process further. An environmental aspect related to biogas use that was not covered in any of the books is the combustion of biogas. While this combustion does contribute to global warming through CO_2 emissions, it also consumes methane gas, which has a much more severe impact on the greenhouse effect. By converting methane into energy, biogas combustion prevents its direct release into the atmosphere during organic matter decomposition. A positive aspect found in LD2 is its correlation of the advantages and disadvantages of biogas usage beyond merely defining and explaining its production.

Subcategory 1.4 – Biofuels: Biomass as an Energy Source from a General Perspective

Subcategory 1.4 refers to the units of analysis in the textbooks (LDs) that focus on biofuels in general rather than on a specific biofuel. In this subcategory, we identified 12 units of analysis across five different textbooks: (LD2=1, LD3=1, LD5=4, LD6=3, LD7=3). Within this subcategory, we found several excerpts addressing the use of biomass as an energy source, as illustrated by the following examples:

> Humans began using biomass as an energy source thousands of years ago with the discovery of fire, a source of heat and light. Biomass consists of organic material, either animal or plant in origin, present in a given area at a specific time. (LD2, p. 141).

> Among the advantages of using biomass as an energy source is the reuse of waste from agricultural activities, such as harvest residues or tree cuttings. Additionally, its use emits fewer polluting gases compared to those emitted by fossil fuels. Another advantage is that it does not depend on climatic conditions. (LD5, p. 23).

Biomass is any organic matter of plant or animal origin that can be used for energy production. Through the process of photosynthesis, plants absorb carbon dioxide and water, using the energy captured from solar radiation, and metabolize them to produce the substances that make up plants. Photosynthesis releases oxygen into the atmosphere, and some of that oxygen is consumed in the respiration process, forming glucose molecules that serve as the basis for organic molecules such as carbohydrates, among other substances present in plants.

One way to harness biomass for human activities and in nature is through its transformation into energy. There are countless raw materials that can be used as biomass for energy production, and numerous biofuels can be derived from it, such as biodiesel, ethanol, biogas, charcoal, synthetic biogas, and bio-oil. Biomass is a renewable and efficient energy source, with its main advantage being its carbon balance. The combustion of biofuels produced from biomass releases the CO_2 that was already in the atmosphere and absorbed by plant sources, while

fossil fuels release CO_2 that has been fossilized for thousands of years. Regarding biofuels derived from biomass that can be used as alternatives to fossil fuels, the textbooks state:

> Biofuels are derived from biomass and used as an alternative to fossil fuels in energy production processes, whether in combustion engines or power plants. According to the International Energy Agency (IEA), global biofuel production in 2018 was 154 million liters, which corresponds to about 1/10 of the world's energy supply. (LD7, p. 101).
>
> When compared to other energy sources, biofuels emit fewer pollutants, in addition to allowing the reuse of their byproducts and increasing job creation in rural areas. (LD6, p. 139).

As we have mentioned, biofuels are advantageous compared to fossil fuels because they emit fewer greenhouse gases and, as noted in LD6, they also allow for the reuse of byproducts and boost job creation in rural areas. However, the global energy matrix is still largely composed of fossil fuels derived from petroleum.

On the other hand, biofuels are expected to gain more ground in the global energy landscape, aiming to improve the environment. Brazil's energy matrix is one of the "cleanest" in the world, with around 45% of the energy and 18% of the fuels consumed in the country coming from renewable sources.

In addition to the numerous and significant advantages of biofuels over fossil fuels, two of the textbooks (LD6 and LD7) also discuss some disadvantages, which is relevant for students to develop critical thinking and argumentative skills by understanding different perspectives:

> However, their use also presents disadvantages: for example, the processing of sugarcane generates waste that can harm the environment if dumped into rivers. There is also the issue, mentioned earlier in this volume, of replacing areas that would naturally be occupied by complex biological communities with monocultures. In the case of biodiesel, planting different species for its production can deplete the soil and raise the price of food products. (LD6, p. 139).

Overall, the textbooks provide an adequate approach to biofuels and biomass as their raw material, as well as to the advantages and disadvantages of their use. However, it is worth noting that the textbooks show a lack of information about the use of biohydrogen and hydrogen as fuels. The former is produced from biological processes in organic waste, and the latter through the electrolysis of water—a cheap and easily obtainable raw material—where its combustion produces water again. Additionally, hydrogen is a non-polluting, renewable, and inexhaustible source, and it is considered by some scientists as the "fuel of the future" (Santos & Mól, 2016).

ANALYSIS OF CATEGORY 2: EDUCATIONAL RESOURCES

Category 2 refers to the educational resources used in Natural Sciences and their Technologies textbooks (LDs) to address the topic of biofuels. This category is divided into three subcategories, all of which emerged after analyzing the

material. Below, we discuss each of them, with examples of units of analysis taken from the textbooks.

Subcategory 2.1 – Schemes and Images

In this subcategory, we found schemes and images in the research conducted on six textbooks, totaling 12 units of analysis: (LD1=1, LD3=1, LD4=1, LD5=2, LD6=1, LD7=6). Among these units of analysis, two are tables, five are figures, three are graphs or infographics, as well as one structural formula and one reaction scheme. Below are some examples of images that constitute the analysis units of this subcategory.

Figure 1

Comparison between gasoline and etanol

COMPARISON BETWEEN GASOLINE AND ETHANOL					
Fuel		**Calorific Value (kcal/kg)**	**Complete Combustion Reaction (ideal and simplified)**	**Fuel/Air Mixture[1]**	**Average Efficiency Compared[2]**
Gasoline	non-renewable	10,400	$C_8H_{18}+12.5O_2 \rightarrow 8CO_2+9H_2O$	15	1
Ethanol	renewable	6,750	$C_2H_6O+3O_2 \rightarrow 2CO_2+3H_2O$	9	0,7

(1) Considering the stoichiometric proportion of the oxygen + nitrogen mixture.

(2) Considering gasoline as a parameter, there are sources that indicate the average efficiency of ethanol as slightly higher than 0.7.

Source: LD1 (2020, p. 153).

We emphasize that all the images presented in the analyzed textbooks are relevant and can contribute to the teaching and learning process. The first unit of analysis (Figure 1), for example, consists of a table comparing the calorific value of gasoline and ethanol. The calorific value corresponds to the amount of energy released by the complete combustion of a unit of mass of a given fuel, under constant pressure and temperature. Knowing the calorific value of different fuels is of utmost importance, as it brings students closer to real and tangible situations from their daily lives, making it easier to connect chemical concepts with everyday life. Furthermore, analyzing calorific value provides an understanding of both the energy potential and the economic viability of using certain fuels on a large scale.

The use of images in education, whether they are illustrations, tables, diagrams, infographics, photographs, charts, graphs, or cartoons, is fundamental because it helps students in the process of making sense of the content learned and formulating scientific ideas by bridging and associating verbal and visual reading through visualization. Additionally, images, schemes, or visual representations, in general, are effective educational resources to stimulate students' interest in the content.

According to Marandino (2014, as cited in Zama, 2018, p. 18), the use of images that require interpretation, such as graphs and other illustrations, aims to assist in the understanding of scientific concepts, ideas, and processes. Therefore, we also find that, in addition to the positive aspects mentioned, the use of these visual resources has the potential to promote students' practice of interpreting and understanding phenomena.

Subcategory 2.2 – Activities and Research Questions

Subcategory 2.2 corresponds to the presence of activities and exercises in the analyzed textbooks that address the topic of biofuels or involve research-related questions. In this subcategory, we identified 12 units of analysis (LD1=2, LD2=2, LD3=2, LD4=2, LD5=1, LD6=2, LD7=1), as exemplified in Figures 2 and 3.

Figure 2

ENEM Activity

5. (Enem) Federal Law no. 11,097/2005 establishes the introduction of biodiesel into the Brazilian energy matrix and sets at 5%, by volume, the mandatory minimum percentage to be added to diesel oil sold to consumers. According to this law, biodiesel is "derived from renewable biomass to be used in internal combustion engines with compression ignition or, as regulated, for the generation of another type of energy, which may partially or fully replace fossil fuel-based fuels."
The introduction of biofuels into the Brazilian energy matrix
a) contributes to reducing the effects of global environmental degradation caused by the use of fossil fuels, such as petroleum derivatives.
b) causes a 5% reduction in the quantity of carbon dioxide emitted by motor vehicles, helping to control deforestation.
c) encourages the Brazilian economic sector to adapt to the use of a renewable energy source derived from renewable biomass.
d) points to the possibility of expanding the use of biofuels, fixed at 5%, in the consumption of petroleum derivatives.
e) diversifies the use of alternative energy sources that reduce the impacts of ethanol production from sugarcane monoculture.

Source: LD2 (2020, p. 142).

Figure 3

Research activity on renewable energy sources

Get together with three classmates and conduct research on other renewable energy sources used in Brazil. Identify the advantages and disadvantages of using this alternative compared to fossil fuel sources. Based on this research, produce a podcast to be shared with other classes at school, as well as with your family and friends.

Source: LD4 (2020, p. 99).

The units found under Subcategory 2.2 generally encompass different types of activities, ranging from exam or ENEM questions to case studies, practical activities, or research projects with subsequent presentations, discussions, or podcast production. Among the units of analysis presented as examples in this section, Figure 2 is an activity at the end of a chapter in LD2, serving as a review exercise. It features an ENEM question about the introduction of biofuels into Brazil's energy matrix. Figure 3 shows a group research activity on renewable energy sources used in Brazil, as well as the advantages and disadvantages of their use compared to fossil fuels. This activity proposes the creation of a podcast to present the research findings, with the goal of being used as a scientific outreach tool for the school, family, and friends.

In addition to these two activities, other textbooks also include activities involving scientific research, which is very positive, considering that research in the classroom is a great ally in the teaching and learning process. It contributes to

the development of investigative skills, as well as the ability to inquire, reflect, and argue, fostering students' critical awareness.

We observe that research encourages students to participate in discussions within the school environment, which can be about social, scientific, environmental, or economic issues. Moreover, research enables students to solve problems and transform their reality through curiosity, reflection, reasoning, and the knowledge acquired in the classroom. All these aspects contribute to the critical-citizen formation of students and the construction of the idea of science as something in constant development, which takes place within social, historical, political, and economic contexts, highlighting the importance and necessity of scientific knowledge.

Subcategory 2.3 – Use of Popular Science Texts

Regarding Subcategory 2.3, we selected units of analysis related to the use of popular science texts (PST) as a teaching resource in the textbooks, totaling three units of analysis: (LD1=2, LD4=1). In Figure 4, we present an example of an analysis unit from this subcategory.

Figure 4

Electric car: its history is as old as the automobile itself

Carro elétrico: sua história é tão velha quanto o próprio automóvel

É difícil precisar quando o carro elétrico foi inventado. [...]

Sabe-se, contudo, que, já no século XIX, inventores na Hungria, Países Baixos e Estados Unidos trabalhavam em projetos do tipo, independentemente.

A ideia delee era criar um veículo movido a bateria. E, nessa mesma época, ainda estava em desenvolvimento o próprio carro movido a combustão, como o conhecemos hoje.

Flocken Elektrowagen, de 1888: o carro elétrico existe desde o século XIX. Foto de 2011.

O carro a combustão e o elétrico

[...]

[...] por volta de 1890, já havia uma frota de táxis elétricos rodando em Nova York. E os automóveis, em geral, foram se tornando mais acessíveis e se popularizando.

No início do século XX, as lojas ofereciam carros elétricos, a combustão, ou a vapor. Este último sendo a tecnologia mais antiga entre as três e, basicamente, movido a água.

[...]

Nessa época, o carro elétrico tinha tudo para vencer a disputa de mercado, por ser o mais silencioso, prático e limpo. Só que, aí, a indústria petroleira passou na frente.

O petróleo matou o carro elétrico?

Quando a categoria dos elétricos tinha tudo para ser a mais vendida, o automóvel ainda era um bem oneroso.

E os movidos a bateria eram ainda mais caros, custando cerca de US$ 1 750, em comparação aos movidos a gasolina, vendidos por em torno de US$ 650, segundo o Departamento de Energia dos Estados Unidos.

Essa era a realidade em 1912, e o carro elétrico pouco avançou nos anos subsequentes. Na década de 1920, [o] petróleo foi encontrado em larga escala nos Estados Unidos, barateando a gasolina.

Logo, um lobby se formou ao redor da matéria-prima. Sua exploração levou, inclusive, ao massacre de comunidades indígenas detentoras dos direitos sobre as terras que a ofereciam.

Com isso, a gasolina se tornou a fonte de energia mais facilmente disponível, tornando o carro elétrico ainda menos atrativo em comparação ao movido a combustão.

Por fim, a expansão das estradas pavimentadas terminou de sepultar os carros a bateria. Com a maior possibilidade de locomoção, a disponibilidade de combustível se tornou um diferencial.

A volta dos elétricos

Hoje, o carro elétrico está voltando à disputa. Com a ameaça do aquecimento global e legislações ambientais exigentes ao redor do mundo, a tecnologia está no alvo das fabricantes automotivas.

[...]

Isso não quer dizer que [os elétricos] sejam desnecessários – afinal, carros a combustão são igualmente atrasados, apesar da vantagem econômica –, mas significa que precisam evoluir, para seu bem e [para] o nosso, também.

Carro elétrico: sua história é tão velha quanto o próprio automóvel. Autopapo, 27 mar. 2020. Disponível em: https://autopapo.uol.com.br/noticia/carro-eletrico-historia/. Acesso em: 13 jul. 2020.

Source: LD1 (2020, p. 154).

The analysis unit presented (Figure 4) corresponds to a text taken from the UOL website found in LD1. This text narrates the history of the emergence of the electric car and makes comparisons between combustion-powered and electric cars. The article highlights that the large-scale emergence of oil in the United States in the 1920s made gasoline cheaper and the electric car less attractive for a period of time, emphasizing that today, electric cars are making a comeback. In summary, this text relates historical aspects of the use of electric and combustion-powered cars, bringing relevant information and curiosities on the

topic and the subjects studied, which contribute to the students' learning process.

We consider it a negative aspect that only a few TDCs related to the topic in question are found in the Natural Sciences textbooks (only three), as the use of these texts in the school context guarantees students access to relevant information, the development of discussions on current issues in the classroom, and the possibility of contextualizing the concepts and content studied. According to Silva, Ferreira, Silva, and Queiroz (2020, p. 246), "pointed out as a good device when it is desired to extend content teaching to the preparation of students for citizenship, the use of TDCs is configured as a strategy that aligns the discourse of scientific dissemination with the promotion of reading habits in students." We consider that, in addition to being a means of information, the presence of TDCs in textbooks or in the classroom, in general, helps develop reading and argumentation skills, as well as learning concepts and familiarizing students with scientific terms.

ANALYSIS OF CATEGORY 3: BNCC COMPETENCIES AND SKILLS

In Category 3, we analyzed whether the BNCC competencies and skills that the LDs mention as being present in topics related to biofuels are consistent with the content, approaches, and teaching resources they present. Subsequently, we discuss the two subcategories, relating them to the BNCC competencies and skills that were configured as analysis units in this category.

Subcategory 3.1 – Analysis of BNCC Competencies and Skills in LD2 Subcategory

When exploring the specific guidelines presented in LD2, we found that the skills related to the topic "Biomass Energy" in Chapter 11 – Energy Today and Tomorrow were EM13CNT101, EM13CNT307, EM13CNT310, EM13LGG303, and EM13LGG304, constituting five analysis units, some of which are discussed below. Skill EM13CNT101 corresponds to:

> Analyze and represent, with or without the use of devices and specific digital applications, transformations and conservations in systems involving the quantity of matter, energy, and motion to make predictions about their behavior in everyday situations and in productive processes that prioritize *sustainable development, the conscious use of natural resources, and the preservation of life* in all its forms. (Brasil, 2018, p. 555).

We consider that LD2 adequately addressed Skill EM13CNT101 by representing and demonstrating the possible natural resources that can be used in energy transformation processes. In this case, biomass was presented as a source for producing bioethanol, biodiesel, and biogas, considering that its use as an alternative to fossil fuels is linked to sustainable development. Thus, through this approach, students can analyze aspects related to the use of biomass and these energy transformation processes, prioritizing sustainable choices in everyday situations.

The authors indicate that Skills EM13LGG303 and EM13LGG304 were developed in the group activity on page 141, which consists of research on the

contributions of Brazilian science to current technological advances aimed at reducing the use of non-renewable energy and increasing the utilization of alternative sources. The skills cited, respectively, address:

> Debate controversial issues of social relevance, analyzing different arguments and opinions, to formulate, negotiate, and sustain positions in light of the analysis of different perspectives. (Brasil, 2018, p. 493).
>
> Formulate proposals, intervene, and make decisions that take into account the common good and Human Rights, socio-environmental awareness, and responsible consumption at local, regional, and global levels. (Brasil, 2018, p. 493).

We consider that these skills are partially favored according to the research activity already mentioned. Although it presents a socially relevant issue related to socio-environmental awareness, it merely proposes that students conduct the research and then communicate their results, without encouraging them to debate, formulate arguments, make proposals, and intervene by making decisions. Thus, we believe that the statement could be reformulated to make the possibilities of argumentation and debate explicit.

In this way, we conclude that LD2 presents pertinent approaches and teaching resources, being partially adequate to the BNCC skills, given the gaps mentioned.

3.2 – Analysis of BNCC Competencies and Skills in LD7

According to the specific guidelines by unit presented at the beginning of LD7 for Theme 2 – Renewable, Recyclable, and Biodegradable Materials of Unit 2, we found that the competencies presented are mostly aimed at teachers conducting research activities and discussions on the topics covered in this Unit. Therefore, we lack data to discuss the adequacy of these competencies, as they involve open-ended activities to be developed at the teacher's discretion. Thus, this subcategory only considers Skills EM13CNT101, EM13CNT104, EM13CNT203, EM13CNT301, EM13CNT307, and EM13CNT309, totaling six analysis units. For example, Skill EM13CNT104 and Skill EM13CNT203 address, respectively:

> Evaluate the benefits and risks to health and the environment, considering the composition, toxicity, and reactivity of different materials and products, as well as the level of exposure to them, critically positioning oneself and proposing individual and/or collective solutions for their responsible use and disposal. (Brasil, 2018, p. 555).
>
> Evaluate and predict the effects of interventions in ecosystems, and their impacts on living beings and the human body, based on life maintenance mechanisms, matter cycles, and energy transformations and transfers, using representations and simulations of such factors, with or without the use of devices and digital applications (such as simulation software and virtual reality, among others). (Brasil, 2018, p. 557).

Regarding these two skills, the authors highlight that their promotion was addressed in the book by focusing on the reactions involved in obtaining biofuels, relating their properties, applications, and possible environmental impacts with their structures and intermolecular interactions, and comparing the macroscopic

aspects of these materials with their structural models, physicochemical properties, and reactivity. Both the reactions for obtaining biofuels and the applications, structural characteristics, properties, and reactivity of these compounds were identified in the book, but no connection was made between these aspects and environmental impacts. Moreover, the book does not discuss the impacts of fossil fuels compared to biofuels, which could enhance students' ability to evaluate and compare, seeking individual and/or collective solutions to these impacts, consciously intervening in ecosystems.

Skill EM13CNT301 involves:

> Constructing questions, formulating hypotheses, predictions, and estimates, using measurement instruments, and representing and interpreting explanatory models, data, and/or experimental results to build, evaluate, and justify conclusions in addressing problem situations from a scientific perspective. (Brasil, 2018, p. 559).

In the specific guidelines by unit, the authors mention that this skill aligns with Skill EM13CNT307 (cited in the previous subcategory), as both aim to relate the properties of materials and their submicroscopic explanation to evaluate and justify their use as sustainable energy sources. Although the book explores these explanatory models, it does not encourage students to construct questions and formulate hypotheses with a scientific perspective aimed at solving problem situations. To support these skills, it would be ideal for LD7 to propose educational resources that encourage scientific research and the formulation of hypotheses and arguments to solve problem situations related to environmental, social, and economic contexts in students' daily lives.

In light of this, we observed that LD7 broadly presents chemical content related to biofuels, as well as the processes for their production, providing diagrams and images to represent these processes. However, to further strengthen the connection between this content and the BNCC skills, it lacks more educational resources for research or scientific dissemination linked to environmental, economic, and social contexts, in a way that fosters the critical thinking and agency that the BNCC for High School strongly recommends. In this regard, Silva (2018, p. 12) argues that:

> The notion of competencies, incorporated as a device capable of producing changes in the curricular organization of high school education with a view to overcoming the limits of excessive disciplinarity and based on the accumulation of information, proves limited by its pragmatic and ahistorical nature. It reproduces, on different grounds, the limits imposed by the disciplinary and sequential curriculum, as it does not allow the necessary inversion, that is, it does not permit learning and the exercise of reflection with the depth that cultural formation requires. (2018, p. 12).

Thus, we observe that in the analyzed units, the main focus of the skills is on content, with limited application of this knowledge in everyday life.

FINAL CONSIDERATIONS

From the analysis conducted in this study, we were able to understand how the topic of biofuels is addressed in the Natural Sciences and Technologies

textbooks selected by the PNLD 2021, as well as identify which concepts are related to this topic in the books. In general, the seven textbook collections present different approaches, with some being more comprehensive and others having certain limitations. Additionally, the textbooks relate the biofuel topic to different content areas.

LD7 and LD2 were the books that provided the most comprehensive approach to biofuels, though they used different content to address the topic. While LD2 discusses biofuels in a chapter on energy sources, LD7 addresses the topic in connection with Organic Chemistry content, structural properties, intermolecular interactions, bonding models, and reactivity.

LD1 and LD4 also presented appropriate approaches, both associating the biofuel topic with thermochemistry content; however, LD4 only covered biodiesel, without addressing other biofuels. LD5 and LD6 developed the topic more briefly and from an environmental perspective, in chapters related to renewable energy sources and environmental impacts. LD3 was the book where the biofuel topic was least present, being superficially mentioned in a chapter on green chemistry.

This research also revealed that various educational resources are used to address the biofuel topic in the textbooks, with diagrams, images, and research activities and questions being the most employed. On the other hand, the use of scientific dissemination texts, as well as suggestions for websites, films, and books, was absent in most textbooks.

Regarding the alignment between the BNCC competencies and skills and the approaches involving the biofuel topic in the analyzed textbooks (LD2 and LD7), although they presented an adequate approach to the biofuel topic, they only partially fulfilled the BNCC skills. While many of these competencies and skills were observed in these two books, we also identified some limitations and gaps in the practical development of this knowledge, in its relation to the students' daily lives, and in fostering their critical and civic formation. It is worth noting that the BNCC emphasizes the goal of directing Brazilian education towards comprehensive human development and the construction of a just, democratic, and inclusive society—issues that were not effectively encouraged in the analyzed textbooks.

REFERENCES

Angeli, T., & Carvalho, L. M. (2020). Significados e sentidos de justiça ambiental nas teses e dissertações brasileiras em educação ambiental. *ACTIO: Docência em Ciências, 5*(2) 1-21.

Bardin, L. (2011). *Análise de conteúdo.* (L. A. Reto, & A. Pinheiro, Trad.). São Paulo: Edições 70.

Bizerra, A. M. C., Queiroz, J. L. A., & Coutinho, D. A. M. (2018.). O impacto ambiental dos combustíveis fósseis e dos biocombustíveis: as concepções de estudantes do ensino médio sobre o tema. *Revista Brasileira de Educação Ambiental (RevBEA), 13*(3), 299-315.

Brasil. Ministério da Educação. (2018). *Base Nacional Comum Curricular.* Brasília, DF.

Brasil. Ministério da Educação. (2021). *Guia Digital PNLD 2021*. Brasília, DF.

Franco, L. G., & Munford, D. (2018). Reflexões sobre a base nacional comum curricular: um olhar da área de ciências da natureza. *Horizontes, 36*(1), 158-171.

Martins, R. A., Auth, M. A., Epoglou, A., Tavares, F. M., & Silva, A. A. (2015). O ensino-aprendizagem em ciências com base no tema gerador combustível fóssil x biocombustível. In *Anais do Encontro Nacional de Pesquisa em Educação em Ciências – ENPEC, X*, Águas de Lindóia, SP.

Melo, P. H., Bara, A. C. C., Fernandes, K. G., Vieira, F. A. C., & Freitas-Reis, I. (2021). Ciclo açucareiro: da fabricação de açúcar à produção de etanol. *Química Nova na Escola, 43*(3), 261-269.

Mortimer, E. (1988). A evolução dos livros didáticos de química destinados ao ensino secundário. *Em aberto, 7*(40)

Oliveira, J. C. C., Mota, P. R. S., Oliveira, A. C., & Sampaio, I. S. (2017). Biodiesel: uma temática para o ensino de química. *Crítica Educativa, 3*(2), 913-923.

Pereira, E. D., Marciniuk, L. L., Pricinotto, G., Crespan, E. R., & Soares, S. S. (2021). Biodiesel: uma proposta reflexiva no ensino de química sob a perspectiva CTSA. *Brazilian Journal of Development, 7*(4), 34113-34128.

Pinto, W. F. (2016) *Biodiesel na escola: uma ferramenta para o ensino de química.* (Trabalho de Conclusão de Curso) Licenciatura em Química, Universidade Federal do Ceará, Fortaleza.

Santos, W. L. P., & Mól, G. S. (Coords.). (2016). *Química Cidadã – Vol. 2,* 3a. Ed., Editora AJS Ltda., São Paulo.

Schirmer, S. B., & Sauerwein, I. P. S. (2017). Livros didáticos em publicações na área de ensino: contribuições para análise e escolha. *Investigações em ensino de ciências, 22*(1), 23-41.

Silva, G. B., Ferreira, L. N. A., Silva, O. B., & Queiroz, L. S. (2020). Abordagem do tema biocombustíveis no ensino médio: textos de divulgação científica em foco. *Química nova na escola, 43*(3), 246-255.

Silva, M. A. (2012). A fetichização do livro didático no Brasil. *Educação & Realidade,* 37(3), 803-821.

Silva, M. R. (2018). A BNCC da reforma do ensino médio: o resgate de um empoeirado discurso. *Educação em revista, 34*, e214130. DOI: http://dx.doi.org/10.1590/0102-4698214130

Souza, F. L., & Martins, P. (2011). Ciência e tecnologia na escola: desenvolvendo cidadania por meio do projeto "biogás – energia renovável para o futuro". *Química nova na escola, 33*(1), 19-24.

Zama, M. Y. (2018) *Imagens no ensino de ciências: análise da taxonomia de imagens presentes no material didático "caderno do aluno" do estado de São Paulo*. (Dissertação) Programa de Pós-graduação em Ensino de Ciências e Educação Matemática (PECEM) – Universidade Estadual de Londrina, PR.

REFERENCES OF THE ANALYZED WORKS

Amabis, J. M., Martho, G. R., Ferraro, N. G., Penteado, P. C. M., Torres, C. M. A., Soares, J., Canto, E. L., & Leite, L. C. C. (2020). *Moderna Plus – Ciências da Natureza e suas Tecnologias – Matéria e Energia*. 1a. ed. São Paulo: Moderna.

Fukui, A., Molina, M., & Oliveira, V. S. (2020). *Ser Protagonista, Ciências da Natureza e suas Tecnologias – Energia e Transformações*. 1a. ed. São Paulo: SM Educação.

Godoy, L., Dell'Agnolo, R. M., & Melo, W. C. (2020). *Multiversos, Ciências da Natureza – Eletricidade na Sociedade e na Vida.* 1a. ed. São Paulo: Editora FTD.

Lopes, S., & Rosso, S. (2020). *Ciências da Natureza Lopes & Rosso – Energia e Consumo Sustentável.* 1a. ed. São Paulo: Moderna.

Mortimer, E., Horta, A., Mateus, A., Panzera, A., Garcia, E., Pimenta, M., Munford, D., Franco, L., & Matos, S. (2020*). Matéria, Energia e Vida – Uma abordagem interdisciplinar – Materiais e Energia: Transformações e Conservação*. 1a. ed. São Paulo: Editora Scipione.

Santos, K. C. (Ed.). (2020). *Diálogo – Ciências da Natureza e suas Tecnologias*. 1a. ed. São Paulo: Moderna.

Thompson, M., Rios, E. P., Spinelli, W., Reis, H., Sant'Anna, B., Novais, V. L. D., & Antunes, M. T. (2020). *Conexões, Ciências da Natureza e suas Tecnologias – Energia e Ambiente*. 1a. ed. São Paulo: Moderna.

PA Publishing Training. (n.d.). *Home* [YouTube channel]. Retrieved February 20, 2020, from https://www.youtube.com/user/PsycINFO/

American Psychological Association. (2020). *Publication manual of the American Psychological Association* (7th ed.). https://doi.org/10.1037/0000165-000

Allmond, S., & Makar, K. (2018, July). Scaffolding data conversations in a primary classroom. In M. A. Sorto, A. White, & L. Guyot (Eds.), *Looking back, looking forward. Proceedings of the Tenth International Conference on Teaching Statistics*, Kyoto, Japan. https://iase-web.org/icots/10/proceedings/pdfs/ICOTS10_4B3.pdf

Chiste, P. de S. (2016). Pesquisa-Ação em mestrados profissionais: análise de pesquisas de um programa de pós-graduação em ensino de ciências e de matemática. *Ciência & Educação***,** 22(3), 789-808. https://doi.org/10.1590/1516-731320160030015

Coelho, J. C. (2010). *Processos Formativos na Direção da Educação Transformadora*: temas-dobradiça como contribuição para abordagem temática. (Tese de Doutorado em Educação Científica e Tecnológica), Universidade Federal de Santa Catarina, Florianópolis.

Cunha, L. L. da; Leite, R. L.; Santos, F. D. G. dos; & Pinto, M. F. (2023). Como os medicamentos e a automedicação são abordados nos livros didáticos de biologia?. *ACTIO*, 8(2), 1-24. https://doi.org/10.3895/actio.v8n2.15333

Freire, P. (2007). *Educação como prática da liberdade*. 30. ed. Rio de Janeiro, RJ: Paz e Terra.

Hussein, A. (2009). The use of Triangulation in Social Sciences Research: Can qualitative and quantitative methods be combined?. *Journal of Comparative Social Work*, 4(1), 106–117. https://doi.org/10.31265/jcsw.v4i1.48

Lopes, C., Antunes, M. L., & Sanches, T. (2019). Writing with ethics: Strategies to quoting and referring. In T. Sanches, M. L. Antunes, & C. Lopes (Eds.), *Improving the academic writing experience in higher education* (pp. 109-153). Nova Science Publishers.

Novo, A., Nobre, A., Simão, J., & Pereira, P. (Coords.). (2020). *Plágio e integridade académica na sociedade da informação*. Universidade Aberta. https://doi.org/10.34627/ftpm-hq41

Silva, A. F. G. da. (2004). *A Construção do Currículo na Perspectiva Popular Crítica: das falas significativas às práticas contextualizadas*. (Tese de Doutorado em Educação), Pontifícia Universidade Católica de São Paulo, São Paulo.

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