ALEXANDRIA

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Comparative analysis: the history of science approach in the BNCC skills and in the elementary school natural sciences text book

Análise comparativa: a abordagem da História da Ciência nas habilidades da BNCC e no livro didático de ciências da natureza do ensino fundamental

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Abstract: The study aimed to analyze the History of Science (HC) approaches identified in the thematic units and skills of the National Common Curricular Base (BNCC) of area Natural Sciences (CN) and the possible relationships in Textbooks (TB) CN of the Final Years of Elementary School (AFEF). This is documentary research, carried out with the HC Content Analysis in the CN TBs from the 6th to the 9th AFEF. Among the skills in the EFAF CN area, the BNCC document presents 63 skills, 10 of which are linked to HC, so the HC approach depends on the teacher's interpretation. 132 excerpts from the HC were identified in the TB, of which 82 are unrelated to the BNCC's skills regarding the HC. In the TB excerpts, a linear HC approach was observed, as it did not problematize the construction of human knowledge.

Keywords: History of sciences, Common National Curriculum Base, teacher's manual, basic education.

Resumo: O estudo teve o objetivo de analisar as abordagens da História da Ciência (HC) identificadas nas unidades temáticas e nas habilidades da Base Nacional Comum Curricular (BNCC) da área de Ciências da Natureza (CN) e as relações possíveis nos Livros Didáticos (LD) de CN dos Anos Finais do Ensino Fundamental (AFEF). Trata-se de uma pesquisa documental, realizada com a Análise de Conteúdo da HC nos LD de CN dos 6º ao 9º AFEF. Entre as habilidades da área de CN do EFAF, o documento da BNCC apresenta 63 habilidades, sendo 10 que se articulam com a HC, assim a abordagem da HC depende da interpretação do professor. Foram identificados 132 excertos da HC nos LD, destes, 82 não tem relação com as habilidades da BNCC acerca da HC. Nos excertos dos LD constatou-se

uma abordagem da HC linear, pois não possuía a problematização da construção do conhecimento humano.

Palavras-chave: História das ciências, Base Nacional Comum Curricular, manual do professor, educação Básica.

Introduction

In this study we understand the potentialities of History of Science (HC) in Teaching Sciences (TC) as an instrument for the humanization of Sciences, meaning of the concept, exploration of the difficulties, as well as its interdisciplinarity, criticism and breaking of dogmas (Matthews, 1995; Martins, 2005; Martins, 2007; Guarnieri et al., 2021). For this purpose, Matthews (1995); Chassot (2003); Martins (2007); Forato, Pietrocola & Martins (2011); López, Gómez & Moreno (2018); Gomes, Lorenzetti & Aires (2022); Santiago, Leite & Hermel (2024) understand HC as a study of all knowledge built and in (re)construction in the history of humanity, as a nonlinear process, in all areas of knowledge.

However, obstacles to HC approach are also known, such as: deficiency in the initial and continuing training of teachers; lack of specific knowledge; fragmented teaching and bureaucracies (curriculum structure, school) (Chassot, 2003; Martins, 2005; Guarnieri et al., 2021; Gomes, Lorenzetti & Aires, 2022; Santiago, Leite & Hermel, 2024). There is a deadlock for the use of HC in scientific education, as “there are still related difficulties in how to bring this approach into the classroom” (Gomes, Lorenzetti & Aires, 2022, p. 438).

Some research indicates that the students of Basic Education (BE) did not have access to the knowledge in terms of scientific work, the conception of scientific research was prescribed structurally by numerous means, among them: those reproduced by the media (Reis & Galvão, 2006; Reznik, 2014). The HC present in the BE curriculum is marked: “[...] by the Eurocentric history of science presented in the Didactic Books (LDs), which erased and hid the history of other people who worked with the construction of scientific knowledge” (Gomes, Lorenzetti & Aires, 2022, p. From this, it is understood that there may be limiting aspects in the HC presented in the Didactic Book (DB) and in the school curricula.

In the HC research present in the Common National Curricular Base (BNCC) (Brasil, 2018a) developed by Guarnieri et al. (2021) was found in the introductory text and in the general competences of this document inadequacy in the understanding of HC, in which sometimes this was presented as a product, that is, linear, and in others as a nonlinear process constructed historically. We understand,

like the authors, that this conceptual duality can imply that HC is linear, while it surrounds knowledge as a product, emphasizes names, dates, locations, in a continuous “supposed discovery, creation” that is not linked to a process of (re)construction of humanity’s history. Thus, this research proposes an analysis of BNCC (Brasil, 2018a) and its abilities, in order to identify HC present in this document that guides BE and its implications in HC present in TB.

The final years TB of the 6th to 9th years of elementary education (EFAF) were distributed in the year 2020, through selection in the National Program of Books and Teaching Materials (PNLD). The evaluation was conducted in accordance with edital 01/2018, which had as one of the eliminatory selection criteria to relate the content of the TB to the skills, general competencies and specific competencies of BNCC (Brasil, 2018a). Considering these aspects, the analysis of HC approaches in BNCC and the relationship with HC in TB becomes necessary, as having HC in BNCC directly implies TB according to the edital (Brasil, 2018b).

From this, the TB is understood as a written curriculum (Lopes, 2007), in the understanding of Goodson (1995) this is able to publicly express aspirations, intentions, standards and guiding criteria of public evaluation of schooling. TB is understood as a “curricular text that reinterprets meanings and meanings from multiple contexts and that constitutes a cultural production to be effected in the different readings carried out in the school space” (Lopes, 2007, p. 215).

There are previous studies discussing TB and EC (Fracalanza, 2006; Megid Neto & Fracalanza, 2006; Emmel, 2015; Azevedo & Alle, 2022). TB is a resource that is characterized as a facilitator of the teaching process and even contributes to the improvement of teaching practice (Geraldi, 1994). However, the problem lies in the TB often command the pedagogical process and/or constitute its own, since this constitutes a basic instrument and reference of the teacher's work (Geraldi, 1994), and has aroused interest from many researchers in recent decades, analyzed from various perspectives, the educational aspects and their role in the current school configuration are highlighted (Bizzo, 1998; Fracalanza, 2006; Lopes, 2007; Emmel, 2015; Thomas et al., 2015).

There are also investigations on HC contained in the TB of the area of Natural Sciences (CN) (Batista, Mohr & Ferrari, 2011; Hipólito, Fioresi & Cunha, 2015; Murça et al. 2016; Thomas et al. 2015). HC in TB is addressed in small texts that focus on scientific curiosities, or “anecdotes that show the inventions of the past of some scientists” (Reis, Silva & Buza, 2012, p. 5). TB play a role in this misconstruction of students as well as teachers, while they support dogmatic arguments, often reducing

the contents of disciplines to “numerical formulas and expressions without proper contextualizations” (Kosminsky & Giordan, 2002, p. 10).

According to Torres Santomé (2013) external evaluations reinforce the imposition of a standardized (inter)national curriculum, this is being replicated in the TB. Some large publishers exercise power under the government and reinforcing privatization policies, and so do the business world’s millionaires by promoting and supposedly “investing” in knowledge and research, which give economic return to them, and focus on mass formation for the workforce (Idem). That is, the curricular reorientations replicated in the TB, disguise and broaden the stratospheric difference of access to basic means for a decent life, or admission of students from less favoured classes to university for life change, which should be the main educational goal (Torres Santomé, 2013; Lino, 2017).

According to Lopes (2007), TB are simultaneous to the construction of a serialized secular education and affirm themselves with mass education, with their economic importance being expanded, but also their cultural importance. “The textbooks are part of the collective memory, cross with the emotional memories of the school and configure conceptions of knowledge, values, identities, world views” (Lopes, 2007, p. 208). The same author highlights how these cultural conceptions are not crystallized in their pages, but are constantly produced by the multiple readings performed.

Considering the BNCC document (Brasil, 2018a), this study proposes to analyze HC in the skills of the CN area and in the TB of AFEFs. When analyzing these aspects, the problem of the research involves the following question: “What HC approaches are identified in the thematic units and skills of BNCC in the area of CN and the possible relationships in the AFEF Sciences TBs?” Thus, the research aimed to: - Analyze the approaches of HC identified in the thematic units and skills of BNCC in the area of Natural Sciences and the possible relationships in the Science textbooks of the Final Years of Elementary Education.

Methodology

This study has a mixed approach, being qualitative and quantitative (Lüdke & André, 2001) of the bibliographic type, as searches were developed in secondary sources, these corresponding to the junction of publications (Lakatos & Marconi, 2003) and documentary (Gil, 2024). Based on the identification, reading, analysis of HC content presented in the skills of BNCC (Brasil, 2018a) in the EFAF CN area and

in eight BE CN TBs, belonging to the PNLD 2020 from the 6th to 9th years of the EFAF.

The delimitation of these two collections (Araribá More - Sciences and Teláris Sciences: Basic education, final years) were given, as they were produced and selected according to the guidelines of BNCC, and are among the collections with the largest quantity of copies acquired by PNLD (2020). By selecting TB with high drawing and distribution in national territory, we hope that the results will have greater representativity within the educational landscape of the country. Still in the regional scenario, the distribution of these TBs in schools of the state and municipal public education network is identified.

Collections were organized in simultaneous documents, in Microsoft Word (prints) and in Microsoft Excel program spreadsheets, so that if we needed to consult the excerpt we would have this again in full and quickly as it is arranged in the TB. For the data collection in these documents, each work was identified (author, year, title, target audience, content, BNCC thematic unit, HC skills, HC presentation in text (T), activity (A) or figure (F), HC excerpt with page and induced curricular approach). In a second reading we developed the analysis to identify what were the approaches of HC, aiming to understand how it is disposed, the links in relation to the concepts, problems, difficulties, contexts and, therefore, curricula (identities) presented in the *corpus* analyzed composed of TB of CN, intended for students from 6th to 9th years of EFAF, indicated by the PNLD (2020).

Thus, the sample for analysis was constituted by HC extracted from the eight volume books of two different authors, which are presented in Table 1.

Table 1

Corpus of analysis in the textbook of the Graduate Primary Education (AFEF)

Collections	Author/Year	Editora	Didactic Book*			
Araribá more: Sciences: teacher's manual (6th to 9th year)	Andy de Santis/2018	Moderna	LD 1	LD 2	LD 3	LD 4
Teláris Sciences: elementary education, final years – Teacher's Manual (6th to 9th year)	Gewandsznajder , F.; Pacca, H. /2018	Ática	LD 5	LD 6	LD 7	LD 8

Note: *Didactic Book Code in ascending order by year of AFEF. Source: The authors, 2024.

After reading and organizing the material, we performed the Content Analysis (CA) proposed by Bardin (2011) following the steps: pre-analysis, exploration of the material and treatment of the results, interference and interpretation. With the interpretation of HC present in the abilities of BNCC and in a comparison with the HC excretions of BE CN TB. Thus, we extracted fragments from the skills of BNCC

(Brasil, 2018a) that contains HC, as well as from the texts about HC present in the analyzed TB, step developed manually in the document of BNCC and the TB, that is, sheet by sheet, since there was no way to search using a search term in the Microsoft® Excel program filtering tool.

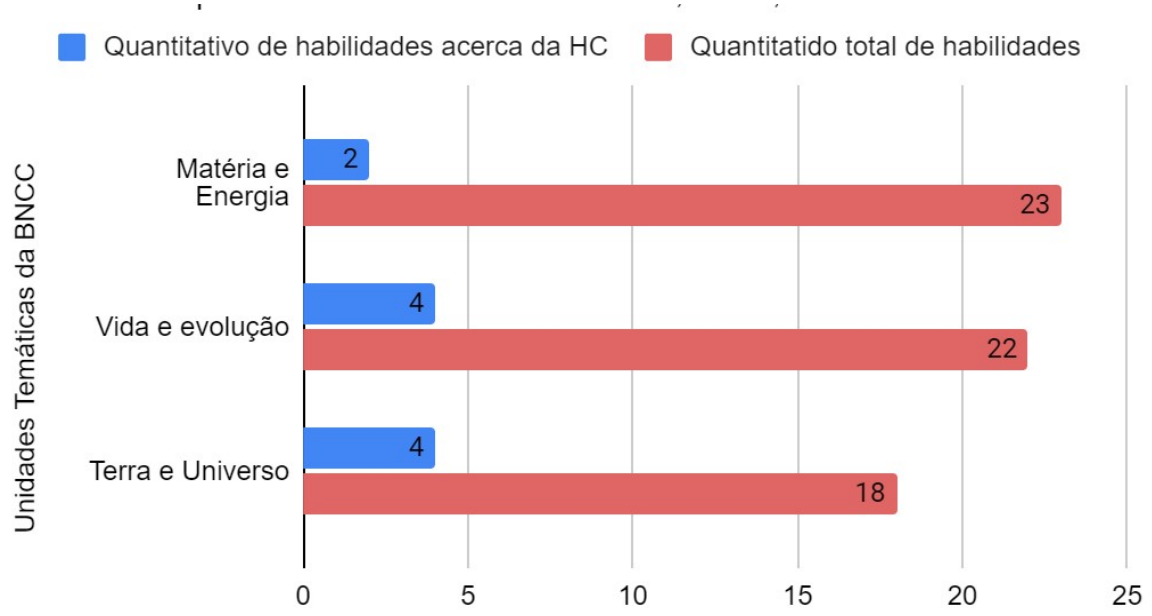
The next step for achieving the CA was the analysis of the extracts from the HC approaches that were extracted from the skills of BNCC (Brasil, 2018a) and the TB, which considered the HC problematizations relevant to the analysis of the research results, linked to theoretical fundamentation (Bardin, 2011).

Analysis and Discussions

Through the reading and interpretation of the data tables were developed in the Excel program, enabling the use of the filtering tool to gather and organize the thematic units, the skills of BNCC on HC (Brasil, 2018a) and the extracts contained in the TB about HC approaches. It is highlighted a summary from Figure 1 that brings the quantitative skills about HC in Natural Sciences (CN) at BNCC (Brasil, 2018a).

Figure 1

Distribution of BNCC's quantitative skills related to the History of Science in relation to the total skills in Natural Sciences in AFEF, Brazil, 2024.



Note. [Image description] Image of a bar chart. It has a rectangular shape with a white background. There is the bar design, in the blue and red colors, which represent the distribution of the quantitative skills of BNCC related to HC in relation to the total skills of the CN area in AFEF. On the left side of the drawing is written BNCC Thematic Units, in major letters and black color. [End of description]. Source: The authors (2024).

From Figure 1 we observe that there is a disparity in total skills and skills linked directly or indirectly with HC. From the reading of the thematic units and skills

from the 6th to 9th year of the AF, present in the CN area of BNCC (Brasil, 2018a), it was found that of the total of 63 skills, only 10 have direct or indirect articulation with the approaches of HC being linear, or non-linear.

Corroborating the topic, among the ten general competencies of the BNCC document (Brasil, 2018a) the first one refers to the valuation of historically built knowledge:

> Value and use historically built knowledge about the physical, social, cultural and digital world to understand and explain reality, continue learning and collaborate to build a just, democratic and inclusive society (Brasil, 2018a, p. 9).

This competence was investigated by Guarnieri et al. (2021) that found in the same document of BNCC (Brasil, 2018a) the inadequacy in relation to the understanding of HC, of Science as a product, erroneous disseminations of Science, the HC linked to everyday life, the lack of cultural, social, economic context of knowledge construction, etc. (Guarnieri et al., 2021). In this sense, there is a confusion, in which at times the HC is brought in a traditional way, giving the teacher an understanding, that this is more a concept to be worked out and at other times brings the HC as an approach, it is necessary clarity and a reference that anchors the HC that is desired in this document (Guarnieri et al., 2021).

Based on a definition of HC presented at BNCC, it is believed that it would allow to improve the quality of HC in TB, since there would be theoretical assumptions that underpin this approach. On the other hand, indefinity leaves room for a gap of interpretations that leads to the understanding that any HC approach serves. Looking at HC as the study of the process of building historical knowledge that emerges from human necessity (Matthews, 1995; Martins, 2005), the issue is addressed in the above general competence, so in theory, even having skills that do not deal with human knowledge in construction, the general competence 1 presents a non-linear perspective.

It is known that from the TB evaluation and selection edital (Brasil, 2018b) there needs to be an articulation between the general competence, the specific competence and the skills of BNCC (Brasil, 2018b). It is highlighted that this edital contains as one of the specific eliminatory criteria of the inscribed works:

> The works should ensure, in particular, the presence and approach of the objects of knowledge aligned with the skills of each curricular component present there. The thematic units, constituted in the BNCC, should not necessarily serve as a criterion for the elaboration of the work.

> The criteria for evaluating the disciplinary works intended for the final years of elementary education are:
> a. Consistency and coherence between the contents and activities proposed and the objects of knowledge and skills constituted at BNCC; b. Contemplation of all objects of knowledge and skills constants in BNCC. Works that do not contribute adequately to the development of all the general competencies specific competencies of the areas of knowledge, constituted at BNCC will be excluded. (Brasil, 2018b, p. 42).

Thus, it is evident, from the excerpt of the edital, that containing a specific ability in the document about HC directly implies the use of this in the works inscribed in this type of edital, since it is an eliminatory criterion of the work to compete. It should be noted that this edital does not specifically bring selection criteria for CN discipline to be evaluated, instead it is presented as examples of literary works, some historical aspects to be considered in the works of the EFAF.

When we look at the 01/2018 edital, in general, it contains grids of forms in which the evaluator must mark with a code whether or not the criteria are considered (identification of the work, scratches, pageing, conforming to the BNCC and obeying the legal precepts, etc.). It is identified that in these there is no need and concern to define what is the HC approach that is contained in the TB.

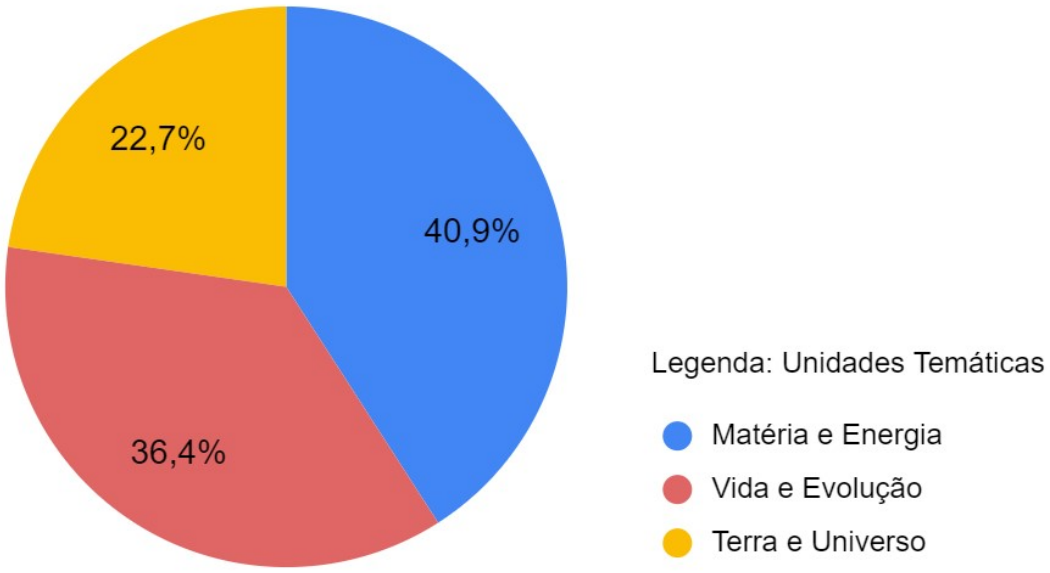
Among the 10 skills that contain the linear or nonlinear HC, there are 4 that have the term “History” and/or “historical” in their description and 6 present the term understood, thus, depends on the teacher’s interpretation. It is understood that this movement to bring the HC approach could help and stimulate its use in the classroom, as as identified in the paper Mapping HC in BE EC there is little initial and continued training on HC (Gasperi & Emmel, 2024).

It is highlighted that HC is not exclusive to the discipline of Sciences, and that the research of Cavalheiro e Fernandes (2021) also identified that in the document of BNCC (Brasil, 2018a) for Higher Education, HC is addressed only in the area of Natural Sciences and its Technologies, which lack methodologies for contextualizing the problems about knowledge in order to stimulate criticism in students. HC spans all areas of knowledge, and should include all levels of education during the formation of the individual at BE, including in the curriculum of the initial and/or continuing training of teachers (Lorenzon et al. 2023), because nonlinear HC contributes to the significance and building of knowledge (Martins, 2005; Vier & Leite, 2019; Ghiggi, Rosa & Vizzotto, 2023). Most teachers have not had access to this type of critical knowledge, as it was not included in the curriculum of their initial and/or continuing education (Martins, 2005; Scheid, 2006; Martins, 2012; Barp, 2017; Faria, 2020; Gomes, Lorenzetti & Aires, 2022).

Figure 2 shows the distribution of the HC approach extracts (linear or nonlinear) according to the thematic units of BNCC, in a first analysis, regardless of whether the skills are linked or not.

Figure 2

Distribution of excerpts from History of Science in separate textbooks by thematic units in the area of Natural Sciences at BNCC, Brazil in 2024.



Note. [Image description] Image of a sector chart. It has a circular shape with a white background. There is the circle drawing, in the colors blue (40.9%), red (36.4%) and yellow (22.7%) that represent the distribution in percentage of the 132 HC excretes extracted from the TB and separated by the thematic units of the CN area at BNCC. On the right side of the drawing is written Legend: Thematic units, in black color. [End of description]. Source: The authors (2024).

In Figure 2, a total of 132 extracts of linear or nonlinear HC were identified in NC TBs from the 6th to 9th year of EF in the two analysed collections. We emphasize that we did not identify HC among the CN skills of the 8th year of EF. The thematic unit that had the highest frequency of excretions in TB about HC was Matter and Energy (54), followed by Life and Evolution (48) and Earth and Universe with the lowest frequency (30). It is highlighted that “Life and Evolution” and “Earth and Universe” had the same quantitative skills (4) each, since the theme “Matter and Energy” has fewer skills linked to HC (2), thus the incidence may be less, as the skills are understood to be HC.

It is identified that Life and Evolution had skills that specifically described HC, emphasizing the discussion of Mendel's theories as Mendel's Law or then the comparison between the evolutionary ideas of Lamarck and Darwin. “Discuss Mendel’s ideas about heredity [...]” and “Comparing the evolutionary ideas of

Lamarck and Darwin presented in scientific and historical texts [...]". (Brasil, 2018a, p. 347). This movement of bringing the scientist was not observed in the other skills contained in the other thematic units.

The HC in Extracts from the TB of Nature Sciences and in the Skills of BNCC

Table 2 demonstrates that the same 132 HC extracts from the TB, although contained in the thematic units, the majority still (82), were not linked to HC skills at BNCC.

Table 2

Number of excerpts identified in textbooks that have no link with the topic of History of Science in BNCC's Natural Sciences skills

Thematic Unit	LD1	LD2	LD3	LD4	LD5	LD6	LD7	LD8	Total of Excerts
Matter and Energy	2	-	8	13	5	1	3	3	35
Life and Evolution	3	7	9	4	5	1	2	1	32
Earth and Universe	3	4	2	2	2	-	2	-	15
Total	8	11	19	19	12	2	7	4	82

Note: *Didactic Book Code (LD) in ascending order by AFEF year. Source: Autors, 2024.

It is identified that the majority of excerpts about HC, has no relation to the above-mentioned BNCC skills, and when it has articulation refers to general competence 1 that discourses about human knowledge construction. Table 2 shows the disparity between the frequencies of excretions: "Matter and Energy" (35); Life and Evolution (32) and Earth and Universe with the lowest frequency (15) that had no link with BNCC's HC skills (Brasil, 2018a). However, when analyzing the excerpts, one realizes that in most cases, the didactic guidelines of each chapter that only the teacher has access to are restricted descriptively and/or in final syntheses in each topic "Thinking Science", "Colletive Sciences" and "Comprehending a Text", as brought in the excerpt:

> Cell discovery
> Currently, we know cells, microorganisms and various other structures invisible to the human eye. Acquiring this knowledge was only possible after the development of equipment that allowed people to see very small structures compared to humans. This began in the 17th century, when the Englishman Robert Hooke (1635-1703) built a microscope and used it to observe fine slices of cork, part of the shell of some trees. This material showed a large number of empty spaces that Hooke called cells. (LD1, p. 156).

Aspects of linear HC are evidenced, with the use of terms “discovery”, “acquiring this knowledge”, however, in the nonlinear perspective, knowledge is not acquired, this is (re)constructed from human necessity throughout history. In this sense, it is compacted with Matthews (1995) and Martins (2005) in which the approach of HC in teaching is based on the problem of how the knowledge was developed, considering whether in fact the students were led to explore the knowledge and the context of these, enabling environments for critical thinking about them.

The duality and indefinity of HC can be seen in the document of BNCC (Brasil, 2018a) which has already been studied and pointed out by Guarnieri et al. (2021) and implies HC presented in the TB. As in the excerpt about the didactic orientation, in which one has in the same sentence the linear HC with the terms “creation”, “discovery” and indications of nonlinear HC with “promotes a discussion”, observed in TB2 (p. 16): “Promoting a discussion about the creation of the term cell. Remind students of the discovery of the cell, made by the English researcher Robert Hooke (1635-1703) by observing a piece of tree shell (cork) in a microscope built by him.”

In the excerpt from TB2 when knowledge is expressed as “ready”, there is no room to promote a discussion about the problem surrounding knowledge, as this is already given. The HC presented in this excerpt is an example of the simplification of Science, exposed as a product, a truth by being named, facts and dates (Matthews, 1995; Allchin, 2004; Martins, 2005; Megid Neto & Fracalanza, 2006; Santiago, Leite & Hermel, 2024), and there is omission of the historical building process of knowledge (Matthews, 1995; Allchin, 2004; Martins, 2005, Martins, 2006; Martins, 2007).

This HC approach is based on a reproduction of the scientist’s name “without any contextualization of where they lived or in which institutions they developed their studies, or even without working on the historical construction process of the scientific concept” (Santiago, Leite & Hermel, 2024, p. 398). The process of building knowledge, in its entirety, is also not developed at BNCC, instead the end product of Science and its application in the everyday life of students is highlighted (Guarnieri et al. 2021). The finding contradicts nonlinear HC, and ends up triggering a utilitarist view and contributing to distortions of misconceptions of Science (Kosminsky & Giordan, 2002, Allchin, 2004, Reis & Galvão, 2006).

The linear HC does not contribute to the teaching and learning processes, as it propagates a dogmatic, stereotyped Science that restricts and enhances access to

scientific knowledge to certain peoples and social classes, making students not identify as subjects capable of building knowledge.

It is also noticed in some excerpts that there is an articulation of any skill with the general competence 1 that deals with historically constructed human knowledge, a little explored movement in the TB, which would provide at least a perspective of human construction of knowledge, though linear. As proposed in TB7 that addresses the history of electricity:

> After the discovery of Tales of Miletus in ancient Greece, other philosophers and physicians sought to understand what made ambar and other materials electrified. The first to apply this knowledge in the construction of a machine capable of electricizing a body was the Dutch physicist Otto von Guericke (1602-1686). He also realized that a body could be electrified by induction. In 1775, the Italian Alessandro Volta (1745-1827) developed a type of pile, from which many machines were later developed. In 1831, the Englishman Michael Faraday (1791-1867), using the knowledge of electricity and magnetism of the time, managed to develop a device capable of generating electric current. He is considered one of the greatest physicists of the 19th century. In 1879, the American Thomas Edison (1847-1931) presented the first economically viable electric lamp, causing a revolution in the use of electricity. (LD7, p. 180).

It should be noted that even if the knowledge of electricity is articulated to general competence 1, yet aspects of the terminology of linear HC prevail, such as the term “discovery” or as a knowledge that has only evolved throughout history, where the scientist, the year and its contribution are quoted. Thus, it is understood that the way HC is presented makes it impossible to problematize the context of the knowledge-building process and its implications in society.

For Hipólito, Fioresi & Cunha (2015) and Guarnieri et al. (2021) when developing the non-linear HC approach, it is fundamental to consider the context and the problems of the time of the construction of said knowledge, because the knowledge is not neutral to the context and thus would humanize the EC, bringing students closer to scientific knowledge (Matthews, 1995). The contextualization of knowledge was not identified in the TB7 excerpt, instead a list of scientists and their “discovery” was presented.

Thus, the HC present at BNCC (Brasil, 2018a) and the TB does not contribute to instigating critical thinking, which aims to involve students in issues surrounding the construction of human knowledge (Forato, Pietrocola & Martins, 2011). The nonlinear HC approach favors the development of critical teaching and learning processes, while its use seeks to work with the deconstruction and reconstruction of knowledge, and understanding the context of knowledge creation, fundamental for teaching and citizen training (Matthews, 1999; Martins, 2005).

In another excerpt that deals with the concept of the laws of chemical reactions in TB8 is presented a description of an experiment with silver chloride (AgCl) in a container with water and evidencing that the AgCl ends up depositing in the bottom of the glass. The following identifies the excerpt with the historiography around the conservation of the mass: “This is a law of chemistry known as the law of mass conservation or Lavoisier’s law. It was formulated by the French chemist Antoine Laurent de Lavoisier (1743-1794), considered the founder of modern chemistry” (LD8, p. 155). Again, the TB emphasizes the names, facts and dates instead of working with the problem of this knowledge.

From this, it is observed that, when the TB identify punctual errors, such as grammar errors or in illustrations, even in the long run, these are easier to be corrected, however “the same cannot be said of erroneous conceptions overdue, partial, mistaken, mythified about Science, Environment, Health, Technology” (Megid Neto & Fracalanza, 2006, p. 160). On this, the authors highlight:

> Despite all the efforts undertaken so far, the treatment given to the content present in the book that mistakenly configures scientific knowledge as a finished product, elaborated by privileged minds, devoid of political-economic and ideological interests, that is, that presents knowledge always as absolute truth, unlinked from the historical and sociocultural context, has not changed. In fact, usually school books use almost exclusively the timeless present (present of the indicative) to convey the contents. (Megid Neto & Fracalanza, 2006, p. 160).

As evidenced by the authors in research from another decade, the linear HC approach, which presents scientific knowledge as a product, propagates scientific stereotypes, a neutral science, a truth and outside the sociocultural context, is reverberated in EFAF's CN TBs. And in this research, it is identified in the above excerpts that the results corroborate with the study, while it was identified, throughout the analysis, the presentation and terms of the HC approach that lead to the concept of linear HC.

Thus, it is highlighted that these excerpts generally do not match the content taught in the chapter, and when they approach it is something succinct, a list of scientists, a curiosity, even a text outside the content and/or context. Based on the analysis of the excretions, it is understood that the approach of HC in TB presents an emphasis on the scientist and his “supposed discovery” and not the problem around that complex process of building human and historical knowledge. Corroborating with the studies of Reis, Silva & Buza (2012), Thomas et al. (2015) which state that HC in the TB, when addressed, is identified in small texts that focus on scientific curiosities and often without context.

Table 3 presents TB excretions that have articulation with HC abilities.

Table 3

Quantitative extracts in each textbook that relate to BNCC's skills on the History of Science (HC)

Thematic Unit	AFEF CN skills over HC at BNCC	LD 1	LD 2	LD 3	LD 4	LD 5	LD 6	LD 7	LD8	Total
Life and Evolution	(EF07CI10) Argue about the importance of vaccination for public health, based on information about how the vaccine acts in the body and the historical role of vaccination for the maintenance of individual and collective health and for the eradication of diseases.	-	3	-	-	-	5	-	-	8
	(EF07CI11) Historically analyze the use of technology, including digital, in the different dimensions of human life, considering environmental and quality of life indicators.	-	2	-	-	-	3	-	-	5
	(EF09CI09) Discuss Mendel's ideas about heredity (hereditary factors, segregation, gametes, fertilization), considering them to solve problems involving the transmission of hereditary characteristics in different organisms.	-	-	-	1	-	-	-	2	3
	(EF09CI10) Compare the evolutionist ideas of Lamarck and Darwin presented in scientific and historical texts, identifying similarities and differences between these ideas and their importance to explain biological diversity.	-	-	-	2	-	-	-	1	3

Matter and Energy	(EF07CI05) Discuss the use of different types of fuel and thermal machines over time, to evaluate advances, economic issues and socio-environmental problems caused by the production and use of these materials and machines.	-	6	-	-	-	6	-	-	12
	(EF09CI03) Identify models that describe the structure of matter (atom composition and composition of simple molecules) and recognize its historical evolution.	-	-	-	2	-	-	-	2	4
	EF06CI12) Identify different types of rock, relating the formation of fossils to sedimentary rocks in different geological periods.	2	-	-	-	3	-	-	-	5
	(EF06CI13) Select arguments and evidence that demonstrate the sphericity of the Earth.	2	-	-	-	2	-	-	-	4
Earth and Universe	(EF07CI16) To justify the shape of the Brazilian and African coasts based on the theory of continental drift.	-	1	-	-	-	1	-	-	2
	EF09CI15) Relate different heaven readings and explanations about the origin of the Earth, the Sun or the Solar System to the needs of different cultures (agriculture, hunting, myth, space and temporal orientation, etc.).	-	-	-	2	-	-	-	2	4
Total	10	4	12	-	7	5	15	-	7	50

Note: *Didactic Book Code (LD) in ascending order by AFEF year. Source: Autoras, 2024.

When we analyze Table 3, we realize that the greater the number of skills that the HC contains, the greater the frequency with which the excretions are presented in the TB. This is identified in TBs of the 7th years (TB2 and TB6), as they were those who possessed the majority of HC excretions (27), with 4 of 10 abilities over HC. Therefore, the same happens with the 9th-year-old TB (TB4 and TB8) (14) who also have 4 of 10 skills.

In these TB, the linear HC approach compared with the nonlinear HC approach was outstanding. Just like Martins (2005) and Santiago, Leite & Hermel (2024) one understands that HC goes far beyond dates, names, curiosity and random portraits to the content, as being linear, on the contrary the approach of HC is linked to the nonlinear process that means, instigates and problematizes the concept built throughout human history.

It is highlighted that no skills linked to HC were found in the 8th Year of EFAF in the BNCC document (Brasil, 2018a). Evidence of a possible fragility of HC presented in the 8th Year TB, when compared with the other Years (6th, 7th and 9th Years), while in Table 2, the 8th Years TB were those who had the highest frequency of excretions unlinked with HC in the LD (26:82).

Thus, at different times, TB “is the only material that the teacher has at his disposal and, often, becomes not a supporting tool, but rather the limiting guide for what will, or will not, be addressed in the classroom” (Azevedo & Alle, 2022, p. 2). For this reason, one understands the need for a definition of HC in the document of BNCC (Brasil, 2018a), as it would bring the theoretical assumptions that define HC that will guide the teaching of CN.

The analysis of an excerpt that briefly addresses the contribution of “[...] ideas of Greek philosophers were taken back by the English chemist and physicist John Dalton (1766-1844). In 1808, he proposed a theory to explain the constitution of matter. For Dalton, matter would be made up of substances [...]” (LD4, 2018, p. 38). The excerpt presents basic data for identification, is linked to content and ability (EF09CI03), but does not present context that surrounds knowledge, thus, it partially contained the chronology of HC, while we addressed the “evolution” of perceptions with different peoples and scientists throughout human history.

In the skill (EF09CI03) that deals with the structure composition of matter, traces of a linear HC are identified, in the excerpt “recognize its historical evolution”. Thus, this could justify what is found in the 9th Year TB (TB4 and TB8), because the term “evolution” is contained in the ability, that is, a knowledge that has only evolved,

while there have been no crises and (re)constructions throughout human history about the knowledge of the constitution of the concept of atom.

When one has a skill that magnifies a scientist, such as the EF09CI09 which aims to promote the discussion of Mendel's "ideas about heredity", one perceives a greater attention to the contributions and a detailed description of the theories of the scientist, even if limited only to his knowledge. Like the passage:

> The work of Mendel
> Due to scientific advances in the field of genetics, we have understood for some time that genes are responsible for hereditary characteristics, that is, those transmitted from parents to children. But the similarity between parents and children has been explained in various ways throughout history. Until the mid-18th century, some scientists believed in the theory of pre-formation, according to which each sperm would contain a miniature, fully formed individual. For other scientists, it was body fluids, like blood, that contained the transmitted characteristics. Another idea present throughout history is that the elements that determined the paternal and maternal characteristics were mixed in the children. This idea became known as mixed inheritance theory. According to this theory, once mixed together, these elements would no longer separate. Ideas like these have prevailed for almost the entire 19th century. About the same time, the Austrian monk Gregor Mendel (1822–1884) conducted research on heredity, from 1858 to 1866, the year of publication of the result of his research. He used the peas of the species Pisum sativum as study objects and his experiments were made in the garden of a monastery in the city of Brünn, Austria. (LD8, p. 13).

In addition, when you have the ability at BNCC about the HC (Brasil, 2018a), there is a greater concern about bringing more than a summary with a text at the end of the content approach. Is more HC synonymous with better HC? In the studies of Allchin (2004), Rosa & Silva (2010) was developed this reflection whether by bringing more HC in the TB will result in a better quality of the presented "will 'more' effectively imply 'better'?" (Rosa; Silva, 2010, p.76) or then will only be loose information without any contextualization of the historical episodes of knowledge.

HC needs to be approached in a different way in CN teaching and not the same HC (Allchin, 2004). This approach requires problematization of the process of building human knowledge and not to be "transmitted" in the classroom, as is mostly the case, replicating and simplifying scientific knowledge to a product (Allchin, 2004). In the activities involving HC with the representation in illustrations:

> 1. What is the difference between homozigoto and heterozigoto? 2. Mendel also studied the texture of the seeds, observing that there were plants with smooth seeds and plants with rough seeds. The allele for smooth seed is dominant over the allele for rugged seed. • Develop a scheme representing the intersection between a "pure" plant of smooth seed and a rugged seed plant. Indicate the alleles of the mother plants and their possible offspring. Also show the gametes that can be formed by mother plants (LD4, p. 142).

> 1. By crossing mutant drosophiles with trace wings, a researcher realized that this feature is transmitted to the offspring and is recessive relative to the normal wing. Assuming that this inheritance occurs in a similar way to what we observe in the inheritance of the color of Mendel's peas, determine the expected proportion in the intersection represented in the figure. (LD8, p. 33).

In these extracts, which deal with Mendel, there is a greater presence of HC, even though it is still a HC presented in its majority as linear. It is noted that the use of terms such as “discovery”, in addition to not containing details of studies prior to Mendel, and about the contributions of these scientists. The ideas that “from Mendel’s work, such as the discovery that the genes are contained in the chromosomes located in the nucleus of the cells and the description of the chemical structure of DNA, from which the genes are formed” (LD8, p. 31).

Thus, this excerpt does not portray nonlinear HC, but represents a duality, which at times brings aspects that would be of linear HC and in others of nonlinear HC. Movement also evidenced in the BNCC document (Brasil, 2018a) in the study of Guarnieri et al. (2021), where for moments HC is brought in a traditional, linear way, and in others as a process of building human knowledge. In this sense, it is corroborated with the authors that a better theoretical foundation is needed about HC as an approach in the document, in order to avoid even greater difficulties for teachers in using the HC approach (Guarnieri et al., 2021).

The presented HC still needs to promote critical thinking, but there are no indications that enable the problematization of knowledge, the debate in the classroom. The approach of HC provides a critical view of the Nature of Science (NdC), breaking with dogmatic perceptions (Gil Pérez, 2001 & Allchin, 2004), by mediating moments, practices that lead to the understanding of Science as a process (re)construction of human knowledge throughout history (Chassot, 2003).

A greater care is observed with the detailing of the process of building knowledge, as in the excerpt that deals with the ability of the 6th year to provide evidence and arguments that demonstrate the sphericity of the Earth.

> About 2,200 years ago, the Greek scholar Eratosthenes (276 B.C.-194 B.C.) conducted a simple experiment that reinforced the idea that the Earth is spherical and that it allowed to calculate, with relative accuracy, the size of our planet. [...] Eratosthenes knew that, in a certain Egyptian city, at noon of every June 21, the Sun was exactly above the observer’s head. This was known because in it there was a well whose bottom was lit only once a year, exactly at that date and time. At that moment, the sun's rays only illuminated the water at the bottom, not the sides of the well as on other days, indicating that the Sun was directly above the well. The same did not happen in Alexandria, where Eratosthenes lived. At that same date and time, a stick raised vertically on the ground in Alexandria projected a small shadow. If the Earth were flat, as was believed at the time, this difference between the two cities should not exist. Eratosthenes then deduced that the Earth was spherical. Knowing

> the distance between the two cities and using knowledge available at the time, Eratosthenes calculated the measurement of the circumference of the Earth. Even without sophisticated equipment, the value obtained was very close to the value we currently consider. (LD1, p. 47).

The excerpt brings significant evidence that can be problematized in the classroom with students, thus, the fragment can be a non-linear HC potentiator, by showing the process of building knowledge of the measurement of the earth's circumference that demonstrated its sphericity. However, there is still a duality, for in the following excerpt: “Eratosthenes knew that in a certain Egyptian city, at noon every 21 June, the Sun was exactly above the head of the observer,” it is expressed that he already possessed this knowledge, as something ready and finished, but there were studies prior to his, which led his knowledge at the time.

From the way it is in TB it is assumed that knowledge is “produced”, when, in fact, it was obtained through empiricism which “consists in the collection of data through careful observation and experiments and the subsequent derivation of laws and theories from these data by some kind of logical procedure” (Chalmers, 1993, p. 13). Eratosthenes built elements based on observation, as when the term “deduced” appears, and with the contributions of other scientists to the elaboration of this knowledge.

TB5 also presented some linear HC records with name and dates (Santiago, Leite & Hermel, 2024): “The oldest historical records that speak of the Earth being round date back to around 600 BC and were written by the Greeks. Pythagoras (sec. Plato (427-347 BC) believed that the planet was spherical” (LD5, p. 87). In this TB, none of the contributions to the process of building this knowledge were detailed, instead, he stopped by bringing the evidence of empirical observation, which were at the time very relevant for scientific knowledge, of navigators in the horizon and shadow of the Earth on the Moon:

> Aristotle (384-322 BC) argued that travelers who followed south saw different stars appear on the horizon, and that this could only happen if they were on a curved surface. He also saw that the shadow of the Earth on the Moon during the lunar eclipse had a circular edge and pointed to this as evidence of the sphericity of the Earth. [...] Strabon (64 BC-24 AD) was another Greek thinker who defended the idea of the spherical shape of the Earth. He quotes the observations of sailors who, as they approached the coast, first saw lights and higher regions from the horizon. (LD5, pp. 87- 88).

When analyzing this excerpt about the sphericity of the earth, we present a linear HC approach. However, in a non-linear perspective, it is believed that empirical knowledge could be explored, through the development of research, where students

could explore this problem from the observation of the sunset, the sky and the horizon line in a takeoff, for example, so that the student is led to experience the process and the problem of building knowledge through empiricism (Chalmers, 1993).

Thus, the HC approach when linked to a BNCC skill (Brasil, 2018a) usually presents some activity, in addition to the texts and/or complementary readings (curiosities) that bring a brief story about the scientist, dates and the alleged contribution (Santiago, Leite & Hermel, 2024). Examples are the skill (EF07CI10) on the importance of vaccination, and its historical role for the maintenance of population health and the eradication of diseases, in which TB2 addresses the case of varicella around the world in a succinct manner, and some methods prior to vaccination, such as in China with the use of wound scratches for the prevention of this disease, and may demonstrate a non-linear principle of approach to HC, but that does not deepen the problematization of the study. The excerpt has an activity to problematize with the class about the importance of vaccination for the maintenance of collective health (LD2).

For the ability (EF07CI05) to discuss the use of different types of fuel and thermal machines over time, as well as to assess socio-environmental problems arising from these materials and machinery. TB6 shows the history of simple machines with records in 5,000 BC (a.C.) with the Egyptians and the construction of rudimentary balances for the balance of weights, later with leverages and ramps to move blocks of rocks. “In the construction of the pyramids, it is assumed that the Egyptians drew immense blocks of rock supported in trunks that could roll on sloping ramps” (LD6, p. 184).

Still in this excerpt, is presented a complementary text on simple machines, some images that illustrate the examples of machines an indication of the film - "Modern Times of Charlie Chaplin of 1936" - to relate to this content and at the end has activities withtemplating the approach of HC.

> Due to the enormous size of the Egyptian pyramids and the weight of the blocks that form these structures, many people doubt that they may have been built by humans. What simple machines may have been used by the Egyptians to move the blocks and build the pyramids? If the pyramids were a current project, would it make sense to use the resources used by the Egyptians to execute it? Talk to a colleague.
> “Give me a point of support and I will move the Earth.” This phrase is attributed to Archimedes. What kind of machines was he referring to and what did he mean with that phrase?
> Choose an instrument (different from those presented in this chapter) that works like a simple machine. Research the function of this instrument and how it used to be. Over time has this instrument been improved (material replacement, addition of other parts, etc.)? Is it still used today? (LD6, pp. 188-189).

The above activities bring the HC approach to CN teaching, enables students to understand that machines can be developed, as well as realize that there have been improvements of utensils throughout human history, identifying the process of building this knowledge. Thus, one realizes that the approach of historical aspects is limited in the elaboration of the TB (Thomas et al., 2015). Thus, it predominated in the extracts of the TB to linear HC, and partially the nonlinear HC, because in part they did not bring a contextualization of Science or even a chronology of HC with the history of construction, problems, theories, hypotheses, experiments (Batista, Mohr & Ferrari, 2011) of how this knowledge was reached. In addition, it was realized that the HC portrayed does not aim to develop critical thinking, through indications that problematize the process of building knowledge.

Final Considerations

In this study, we investigated the relationship between the BNCC, the thematic units of the area of Nature Sciences (CN) and specifically the skills that contemplate the History of Science (HC) in the document, with the found in the textbooks (LD) of CN from the 6th to 9th years of elementary education (EF). Thus, a total of 10 of the 63 BNCC skills that contemplate HC in the document were identified, of which 37.9% were identified in a total of 132 extracts identified about the topic in the TB.

In the intersection of HC excretions in the TB and the BNCC thematic units, a higher frequency (77.3%) of excretions in “Life and Evolution” and “Matter and Energy” was obtained compared to “Earth and Universe” (22.7%). The extracts that do not possess a link with the skills of BNCC (62%), contained syntheses of informative texts, curiosities, most often without contextualization of the process of building human knowledge.

By the analysis it was possible to identify that the extracts that had a respective ability in the document (37.9%) presented a higher quantity of activities, texts and even images related to the ability, but this did not mean having a higher quality about HC in the extracts. Thus, the non-linear HC needs to consider the process, context and problem of knowledge construction so that CN teaching is humanized.

This research made it possible to observe that HC is in TB in an expressive quantity. However, when analyzing CN TB excretions, in general, most of these present a linear HC approach. In addition, the analysis of BNCC’s skills revealed an

indefinite concept of HC approach in this document. In view of this, it is understood the need to explain the theoretical assumptions in the guiding document of the BE, which underpin this approach of HC.

Thus, the analysis of the data showed that bringing the definition of HC approach in the document, implies the presentation of this in the TB, because in the TB evaluation edital brings in one of the eliminatory selection criteria for the PNLD the link with the skills of the document, it is believed that this movement implies in the excerpts of the TB about HC.

Therefore, HC that is present in the TB, may be a consequence of this conceptual indefinition in BNCC. The HC excretions in the TB of CN rarely problematize the process of building human knowledge, since this is presented as an absolute truth, a reproduction without meaning. There were few activities that explore the text, so they need to at least circumvent the concept problematized in the chapter, but this was not always addressed. In general, HC evidenced in TB does not seek to promote the development of criticism and autonomy in students in relation to the knowledge built throughout human history.

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