



History of Science Teaching in Brazil: From the Colonial Period to Present Days

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Abstract

By means of a literature review, this article aims to present basic aspects of the scientific and educational history of Brazil, from the colonial period to the present day. The major goal is to understand how science education has developed and consolidated as an important component of school curriculum and a formal field of research. Four phases were defined (1549–1800; 1800–1950; 1950–1970; 1970–today) to encompass the pedagogical, methodological, curricular, investigative, and legal processes that took place over these different periods in history. By offering a comprehensive overview of the national events that occurred over time and giving educators and researchers who are interested in the topic a view of the past, the historical perspective chosen aims to contribute to the composition of the memory of science teaching.

Keywords: Science Teaching, History of Science Education, History of Science

História do Ensino de Ciências no Brasil: Do Período Colonial aos Dias Atuais

Resumo

Por meio de uma revisão de literatura, este artigo tem o objetivo de apresentar aspectos basilares da história científica e educacional nacional desde o período colonial até os dias atuais para compreender de que forma o ensino de ciências se desenvolveu e se consolidou no Brasil no âmbito das disciplinas escolares e como campo formal de pesquisa. Foram definidas quatro fases (1549–1800; 1800–1950; 1950–1970; 1970–dias atuais) para abarcar os processos pedagógicos, metodológicos, curriculares, investigativos e legais que atravessaram esses diferentes períodos históricos. A perspectiva histórica adotada busca contribuir na constituição da memória do ensino de ciências pela síntese integrativa dos eventos que ocorreram no país ao longo do tempo, propiciando um panorama para educadores e pesquisadores interessados em conhecê-lo.

Palavras-chave: Ensino de Ciências, História do Ensino de Ciências, História da Ciência

Historia de la Enseñanza de las Ciencias en Brasil: De la Colonia a Nuestros Días

Resumen

Por medio de una revisión bibliográfica, este artículo pretende presentar aspectos básicos de la historia científica y educativa nacional desde el período colonial hasta la actualidad, con el fin de comprender cómo se ha desarrollado y consolidado la enseñanza de las ciencias en Brasil dentro de las asignaturas escolares y como campo formal de investigación. Se definieron cuatro fases (1549–1800; 1800–1950; 1950–1970; 1970–hoy) para abarcar los procesos pedagógicos, metodológicos, curriculares, de investigación y legales que atravesaron estos diferentes periodos históricos. La perspectiva histórica adoptada busca contribuir a la constitución de la memoria de la enseñanza de las ciencias a través de la síntesis integradora de los acontecimientos ocurridos en el país a lo largo del tiempo, proporcionando un panorama para los educadores e investigadores interesados en conocerlo.

Palabras clave: Enseñanza de las Ciencias, Historia de la Enseñanza de las Ciencias, Historia de la Ciencia

Introduction

The present text aims to introduce basic aspects of the scientific and educational national history from colonial period to the present days in order to understand in which ways the teaching of science has developed and consolidated in Brazil in the context of scholar subjects and as a formal field of investigation. This goal takes into consideration two main elements: first the presence of distinct pedagogical ideas which were historically developed in a very particular way in Brazilian context, directing the course of Brazilian education in general (Saviani, 2021) and second the fact that the analysis underlying the history of science teaching in Brazil seems to indicate it is incomplete in relation to the events of this field due to the emptiness left the academic paradigm which has been taking in consideration a diachronic analysis from the 1950s on.

According to Lemgruber (1999)¹, this last element can be explained because the investigations of Krasilchik (1980; 1987), as an important national reference on the subject, led most researchers in the area of science teaching to consider the mid-twentieth century as the beginnings of the area in the country, due to the transition, in this period, from its local concern to a national interest. However, the adoption of this paradigm ended up centralizing the focus of research on educational aspects related to this chronology, neglecting previous events linked to pedagogical, methodological, curricular and legal elements, equally important for the memory of science teaching.

¹ “If for astrophysics, it is the theoretical limitations that impede this previous knowledge, in our case what happened is that a tradition of following the periodization of Krasilchik’s works has been crystallizing. Thus, as she begins her historical accounts in the 1950s, so do most histories of science teaching” (Lemgruber, 1999, p. 34).

In this sense, as we seek to carry out a historical overview of science teaching in the country that contemplates different periods, we hope to contribute to the formation of a memory that allows the understanding of its antecedents in the history of Brazilian education, considering both the axis of didactics and that of research. The memory of a certain field of knowledge is a social construction that is related to the identities and interpretations of the subjects that constituted it, to the local and global conditions and factors that favored its development (Nardi, 2005; 2014), but also to historical events that fostered certain trends through changes in society, whether political, economic, cultural or scientific. Therefore, broadening the look at such events is understanding both the dynamics in which a school subject has been transformed over time, in the case of the natural sciences: from the demands for access to historically produced scientific knowledge, but, mainly, by the schooling process underlying this demand that regulates, selects and organizes school content (Marandino et al., 2009); as the dynamics in its constitution and consolidation as a research area, namely: the academic production on science teaching that originated with the emergence of the first graduate programs in the country.

Methodological Procedure

Due to the problematic and general research objective established, we used a qualitative literature review as a methodological approach. According to Mariano and Rocha (2017, p. 431), a qualitative literature review is “a type of review that synthesizes the findings of qualitative studies. It is a recreation of meta-analyses applied to qualitative data”. Creswell (2007) clarifies that literature reviews contribute to sharing the results of other related studies; relate the study to the dialogue established by the literature on a certain topic, being able to fill in gaps and expand already published studies; in addition to being an indicator to compare the results of different investigations. Furthermore, the literature review can be integrative when researchers seek to summarize broad themes in the literature (Cooper, 1984), as is the case of this study.

The constituting corpus of this type of research can be varied. Creswell (2007) and Gil (2002) elucidate that one or more bibliographic sources, of first or second order, can be used. In relation to this study, some primary sources were used, such as normative documents to establish legal frameworks on science teaching; but, mainly, secondary sources, such as books, scientific articles and postgraduate research focused on describing the history of science teaching and the history of the development of Brazilian science.

These sources were obtained through two processes: I. by identifying them on official websites of the Ministry of Education (in the case of normative documents), national journals and institutional repositories and II. through the selection of works on the subject contained in the references of the analyzed documents. This second process made it possible to verify the main exponents of the scientific literature on the subject, including the authors who constituted the first national research groups in the area, in

addition to enabling the expansion of the corpus with documents not identified by the first method of data collection, such as old studies and difficult to access, always taking care to “consider whether they represent rigorous, serious and systematic research for use in a literature review” (Creswell, 2007, p. 54).

The documents were selected through an exploratory reading in order to verify if the text was of interest to the research problem. In turn, the documents conducive to contemplating the research objectives were treated through analytical reading, characterized by the complete reading of the text together with the identification, hierarchization and synthesis of key ideas of the materials (Gil, 2002). Such procedures were essential for ensuring care when comparing contrasting information between different documents, seeking to minimize the reproduction of erroneous data and broaden discussions with the deepening of the analysis of an interpretative nature.

The analytical and interpretative treatment of the corpus led to the composition of a chronology of the history of science teaching in four phases, whose main criterion was due to the consideration of the different social and cultural transformations that were established over time in the country, as well as the changes that occurred in educational and scientific trends at national and international level. Therefore, the following were defined: a first phase, whose origin dates back to the colonial period, in particular, with the first undertakings of Jesuit pedagogy based on the *ratio studiorum*, extending until the founding of the Seminary of Olinda in 1800 (1549–1800); a second phase, which runs through the 19th century until the mid-20th century, when scientific disciplines in the area of natural sciences began to be inserted and unified in the school curriculum (1800–1950); a third phase, marked by the science teaching renewal movement, which originated institutions dedicated to the production of books, texts and equipment and to the training of science teachers (1950–1970); and, a fourth phase, which begins in the 1970s and extends to the present day. This last phase consolidated the didactics of science as an autonomous scientific field in Brazil and has as its main landmark the academic production on science teaching in the postgraduate context — a fact that contributes even more to the analysis of science education in the school context. It is also the phase that marks the revision of the objectives of science education by different movements and theorists in the field concerned with the social, cultural, environmental, economic, political and ethical implications of Science (1970–present).

It should be noted that the chronology adopted in four phases, although sufficient for the purposes we propose, should not be understood as a definitive delimitation, as it does not ignore the interdependence between different phenomena and events, nor their coexistence at certain moments in history of science education in the country. It cannot be ignored that such a chronology brings together in the same set of events different historical periods that have their specificities of political and social order in a larger background. Therefore, it should be clear that the demarcation of specific phases in this text only served to systematize the periodicity in which the processes in the field of science education took place in the national context.

First Phase (1549–1800): The Entry of Science Into the National Context

The historiography of Brazilian Science shows that the implementation of scientific activities in the country was neither linear nor continuous, but deeply marked by nuances that made Science advance in a very gradual and late way in the country, if we compare the scientific development already consolidated in European countries during the sixteenth century (Azevedo, 1944; Filgueiras, 1990; Schwartzman, 2012; 2015). It is unequivocal that the delay in the development of Brazilian Science in the colonial period is linked to factors of different orders at the time, in particular, political, economic, social and cultural factors that made formal scientific establishment difficult. Schwartzman (2012) clarifies in this regard that:

Unlike nations such as France, Holland and England, which transferred some form of ‘colonial science’ to the territories and nations they occupied, the same could not be expected from Portugal, which had not developed its own scientific tradition. Portuguese colonialism was predatory and exploitative, without the intention of creating a complex society in the New World, with institutions to produce and transmit knowledge. Some technological procedures were developed for gold mining and sugar production, the main economic activities during the four centuries of colonial occupation in Brazil, and little else (Schwartzman, 2012, p. 157).

In turn, Azevedo (1944) points out that Portugal’s political and ideological position in relation to other countries in the world at the time was an impediment, with a clear “vanguard position, in defense of the Church, against the Reformation and the modern spirit” (Azevedo, 1944, p. 297). The author also emphasizes the humanistic assertion of the Portuguese and their effort to seek to form literate and erudite people, disregarding the scientific commitment that was already being established in other parts of Europe and the world:

The attachment to dogma and authority, the scholastic and literary tradition, the almost total lack of interest in science and the repugnance for technical and artistic activities had to characterize, in Colonia, all the education modeled on that of the Metropolis, which remained closed and irreducible to the critical and analytical spirit, to research and experimentation and, therefore, to this ‘audacious mentality that blossomed in the 16th century to take hold in the 17th century: a century of light for the rest of Europe and a century of darkness for Portugal’ (Sérgio, 1929, p. 22). Not that the old scholastic mentality had deserted from ‘the rest of Europe’ beyond the Pyrenees, — the same one that prevailed, without contrast, in the peninsula; but with it, and in open struggle, this revolutionary mentality already coexisted, which sprouted from the critical spirit, freedom of investigation and experimental methods and vigorously tore the path between the still living forces of tradition (Azevedo, 1944, p. 297) .

Azevedo (1944) emphasizes that:

[...] free examination, the spirit of analysis and criticism, the passion for research and the taste for intellectual adventure, which only dawned in Europe, would undoubtedly have broadened our mental horizon and enriched, in the philosophical field, our culture that was without thought and without substance, almost exclusively limited to letters (Azevedo, 1944, p. 298).

These excerpts help to briefly glimpse the project of society in force in the country during the colonial period, as well as the relationship between the existence of an agrarian-slavery economic system and its consequent implications for the rudimentary techniques employed here. In any case, if this whole configuration of colonial science must be properly associated with the secondary status of Brazil in relation to the Portuguese metropolis when considering the country's colonization status, it must also be considered along with other aspects directly linked to production, sharing and the dissemination of national scientific knowledge, such as the absence of universities in Brazil. This last element is extremely relevant, since other colonies, such as Spain, already had institutional systems of universities established since their first century of colonization (Filgueiras, 1990). Once again, the direct influence of the Portuguese Crown is pointed out here in the absence of universities, as well as in the national press, due to the fear “that some Brazilian institute could rival the Portuguese ones” (Schwartzman, 2012, p. 158)² — a strong indication of the isolation policy established by Portugal that led it to deprive the colony “of all communication and commerce with the nations of Europe” (Azevedo, 1944, p. 208)³.

Like these limited scientific endeavors during the colonial period, the treatment of Science in the field of education did not occur differently. In addition to the factors already mentioned, it can be said that the incipience of scientific content to be taught in the few educational institutions in the colony was also due to the inconsistency of an educational system linked to the agrarian, landlord and slave-owning regime; for the control and mediation of Brazilian educational institutions to the Portuguese metropolis; by the primacy of humanistic knowledge to the detriment of scientific content by the Jesuit tradition; and by the models of education being copied from European institutions that, for the most part, did not adapt to the conditions and context of the country with its sociocultural and geographic specificities (Sociedade Brasileira de Física, 1987; Alfonso-Goldfarb & Ferraz, 2002; Zotti, 2004; 2005). It is for this reason that Schwartzman (2012) states that “until the second half of the nineteenth century, Brazilian scientific and educational institutions could not be compared with those of Hispanic America” (p. 159).

2 When referring to the relations of the Catholic religion with the Brazilian State, Schwartzman (2015) states that “the Portuguese never created universities in Brazil like those that Spain installed in its American colonies [because it was already]: too late for Catholic universities, in the traditional sense, and too early for modern universities” (p. 99).

3 The association between the press and the dissemination of scientific knowledge became clearer after the installation of the Royal Press with the arrival of the royal family in 1808. According to Alfonso-Goldfarb and Ferraz (2002), “the Royal Printing was fundamental in first years of installation of higher education courses in Brazil, as it gave the public a good part of the books recommended for teaching medicine and engineering” (p. 7).

It should be remembered that the first national educational project was developed by the Society of Jesus and, even though it was subordinated to the Portuguese colonization project, it had a certain autonomy, supporting the new social and educational structure of the Brazilian colony (Shigunov Neto & Maciel, 2008). According to Correia (2004), during the first educational experiences with the institution of Jesuit colleges and schools, the fundamentals of science in education were minimal, consisting only of meager mathematical notions and rudiments of Aristotelian physics. This curriculum followed the requirements of the *ratio studiorum* (1599) which was basically composed of three levels of knowledge: humanities; philosophy and science; and theology and sacred sciences (Franca, 1952).

According to Azevedo (1944), the philosophy and science course was divided into three years and had as its purpose “the training of the philosopher, through studies of logic, general metaphysics, elementary and higher mathematics, ethics, theodicy and the physical and natural sciences, taken by scholasticism and still studied at that time as ‘sciences definitively constituted by Aristotelian speculations’” (Azevedo, 1944, p. 299). Still in the words of the author: “in Aristotle, according to the scholastics, there was everything: nothing to investigate or discuss; just had to comment. Thus, all intellectual life, ‘in terms of the study of the external world, writes Antônio Sérgio, was reduced to comments. Comment on the books of antiquity; comment, subtly, comment’” (Azevedo, 1944, p. 299).

An addendum regarding the Jesuit scientific contents is made by Almeida Junior (1979) when he cites as part of the Jesuit curriculum the observation and collection of meteorological data carried out by teachers together with their students when studying the contents of this theme in the books proposed by the *ratio studiorum*. However, this author makes it clear that this practice, although it could be classified in the list of scientific contents, was insufficient for scientific training and could not even be considered as part of the experimental sciences due to its methodological superficiality based on the pure verification of the “opinions of the ancients” (Franca, 1952, p. 161).

In general, it is consensual for virtually all scholars of the subject that, throughout the colonial period, since the arrival of the Jesuits in 1549 in Brazilian lands, there was no incentive in the curriculum proposals for science studies. For Buss (2016):

An attempt to preamble science teaching in our country took place in 1637, during the Dutch invasion. A squadron of the Dutch West India Company led by João Maurício de Nassau, the Count of Nassau, landed in Brazil with the objective of conquering territory and riches in the Northeast region. [Nassau] decided to transform the city of Recife into a modern capital by building canals, dikes, bridges, the Palace of Friburgo and the Palace of Boa Vista, a botanical garden, a zoo, a natural museum and an astronomical observatory. As an admirer of the sciences and the arts, he brought to Brazil a group of scholars, painters, landscapers, cartographers, artisans, glaziers, carvers, writers, theologians and architects (Buss, 2016, p. 93)⁴.

4 Azevedo (1944) refers to the work *Historia Naturalis Brasiliae* (1648), written by Guilherme Piso, J. Bontius and J. Marckgraf, who were part of the Dutch mission, as “the most notable work on medicine, flora and fauna in the country in colonial times” (p. 206).

During the Dutch occupation, Recife became “the greatest center of intellectual differentiation in the colony, which the Catholic effort towards integration sought to keep alien to the new sciences and new languages” (Freyre, 1936, p. 272). Even so, “the spirit of integration in the Catholic and Portuguese sense would end up dissolving differences, drawing the populations of Pernambuco back into the orbit of Iberian influence” (Azevedo, 1944, p. 207). Almeida Junior (1979) complements these facts by highlighting that, after the expulsion of the Dutch from the country:

The Metropolis continued to suffocate any manifestation of living culture, any penetration of the critical spirit and any diffusion of the study of sciences in the Colony, which remained alien, as well as that one, to the scientific revolution that was being processed in the Old World. As Rui Barbosa pondered: ‘scientific instruction did not exist in Brazil, in Portugal and throughout the Peninsula’ (Almeida Junior, 1979, pp. 47–48).

Even after the rupture generated by the Pombaline reform in 1759, which resulted in the Jesuit expulsion from Brazilian territory, the educational system barely changed the current legacy, both in terms of content and form, because the introduction of royal classes designed to make up for the lack of Jesuit schools left the curriculum completely unstructured — even though it made room for modernizing teaching that until then had been centered on the classical and humanist tradition (Zotti, 2005).

In Portugal, in the second half of the 18th century, proposals for a scientific education were much more striking than those in the Brazilian context. Among them, we can mention the foundation of the first secondary school (Collegio dos Nobres), in 1761, whose novelty was the creation of a Physics Cabinet and the inclusion of scientific subjects in its curriculum (Carvalho, 1986). In any case, this introduction happened very briefly, because shortly afterwards disciplines such as physics would be extinguished as a result of “the high standard of demand for unprepared students” (Sampaio, 2004, p. 18). There was also the introduction of teaching physical and natural sciences during the profound transformation the University of Coimbra underwent between 1768 and 1772 (Azevedo, 1944). According to Schwartzman (1979), the reform of the University of Coimbra, by Marquês de Pombal, resulted in the creation of a Physics Office, a Chemistry laboratory, a Botanical Garden, an Anatomy laboratory and a pharmaceutical dispensary. Commenting on this reform, Azevedo (1944) states that, for the first time, “its dignity in teaching could be recognized for science” (Azevedo, 1944, p. 209).

In the Brazilian case, the only landmark in this sense, but little connected to the specific context of teaching, was the creation of the Scientific Academy in Rio de Janeiro (1772–1779), with an ephemeral duration due to the lack of organized scientific activity and regular scientists in Brazil (Almeida Junior, 1979; Silva, 1988; Filgueiras, 1990; Schwartzman, 2012).

Only at the beginning of the 19th century, in particular, with the arrival of the royal family, is it possible to verify the appearance of different enterprises that, decisively, contributed to the introduction of a scientific thought in the national context, such as

the foundation of several scientific institutions, colleges and schools, whose curricula began to include the natural sciences (Schwartzman, 2012). Marques (2009) elucidates that:

[...] The transfer of the Portuguese court to Rio de Janeiro in 1808 led to the formation of important scientific institutions in our needy country, such as: the Naval Academy of Rio de Janeiro and the Surgical School of Salvador (1808), the Academia Militar of Rio de Janeiro (1810), the Medical Surgical Academy of Rio de Janeiro (1813), the Botanical Garden (1818) and the Imperial Museum (1818). Also, even though they are not institutions of science, we have the Royal Press (1808) and Bank of Brazil (1808), which later had its history interrupted and resumed. After the proclamation of Brazilian Independence, we will still have the Imperial Astronomical Observatory (1827), the Medical Society (1829), the IHGB (1838), which are some of the milestones of science in the first Empire (Marques, 2009, p. 12).

At that moment, more than in previous centuries that had made the country a field of natural exploration for the recognition of its natural resources (see Alfonso-Goldfarb & Ferraz, 2002), Brazil began to receive dozens of foreign travelers who sought knowledge about the lands and peoples of the New World. This is the case of the expedition carried out by fifteen European scientists in the so-called “Austrian Mission”, which lasted three years (1817–1820). This mission, originated from the arrival of the Austrian Archduchess Leopoldina, aimed to explore and study the national nature, resulting in the publication of a series of books, such as: “Synopsis Filicum Brasiliensium” (1819), “Agrostografia brasiliensis” (1823), “Plantarum Brasiliensium Nova Geneva” (1825), “Flora Brasiliensis” (1840) and the famous work “Viagem ao Brasil”, published in 1823 (Azevedo, 1944).

In this context, Dom Pedro II’s interest in Science also stands out, which led him to seek the company of scientists and participate in most of the country’s cultural and scientific events (Schwartzman, 2012). Even so, there were some caveats regarding scientific questions addressed to the general population because, although in full cultural effervescence and in an atmosphere of great establishments of Science, “mainly military engineering was taught and there was no interest in encouraging research” (Correia, 2004, p. 03). In other words:

[...] the academies of D. João VI were not interested in scientific research, experimental practice or the training of future scientists. What we had was precisely a utilitarian application of a few scientific concepts to military strategies and practices and to medical techniques, especially surgical ones (Buss, 2016, p. 98).

On this topic, Azevedo (1944, p. 222) states:

The truth is that a taste for facts, a critical and investigative spirit, and an enthusiasm for the experimental method could develop among us as elsewhere; and the main cause of the Brazilians' lack of interest in the sciences, far from residing in a natural ineptitude, [was] rather, the almost exclusively literary, bookish and rhetorical type of teaching that was implemented in Brazil, from the Colony until the end of the Portuguese Empire.

All the elements described so far allow us to conclude the following data: although several scientific activities have been undertaken in the country since the arrival of the Portuguese in 1500, with “exploratory journeys, records of the local flora and fauna; studies on indigenous culture and languages; astronomical observations by Jesuits based here, among others” (Dantes, 2005, p. 26), it is not possible to affirm a regular and organized activity of scientific activity in the Brazilian territory, since its institutionalization could only effectively take place from the arrival of the royal family in 1808, with the implementation of different scientific institutions constituted through state subsidies (Filgueiras, 1990). The same can be said of science education due to the predominance of the humanist tradition in teaching. Therefore, in this first phase of the development of Science in Brazil (1549–1800), there was a shortage of both scientific research and science teaching, specifically, which would only begin to increase with the creation of the first secondary education institutions, inspired by European schools, mainly the French and German ones, and with the establishment of higher education institutions at the end of the 19th century, giving rise to “the first traditions of scientific research work in Brazil, in the areas of physical and biological sciences” (Schwartzman, 2012, p. 165).

Second Phase (1800–1950): The Configuration of the Natural Sciences in the Imperial and Republican School Curriculum

Due to this variety of factors during the colonial period that limited the implementation of Science in the country in educational terms, it was only in the beginning of the 19th century that we can identify the inclusion of scientific content in the curriculum in a more present way, more specifically, in the year 1800s with the development of the subjects of Physics, Chemistry, Mineralogy and Botany, at the Seminary of Olinda (Buss, 2016) and the subjects of Zoology, Mineralogy, Botany, Chemistry, Physics and Astronomy at College Pedro II, with the systematization of teaching secondary in the imperial context (Decree s/n, 1837). Azevedo (1944) comments that, unlike the Jesuit colleges with their excessively rhetorical, literary and religious teaching, the Seminary of Olinda represented a break with the Jesuit tradition of the colonial period by introducing courses in natural sciences aimed at training priest-explorers.

For Gilberto Freyre (1936), the Seminary of Olinda:

[...] began to teach the useful sciences that would make the boy more able to respond to the needs of the Brazilian environment, whose transition from agrarian patriarchy to a more urban and more industrial type of life required mentors, well-educated technicians, and not only black and mulatto mechanics and craftsmen. [...], [in addition to] the study of economic problems created by mining, industrialization, the decline of an economy based simply on monoculture or monopoly (Freyre, 1936, p. 105).

In relation to College Pedro II, former Seminary of São Joaquim, in addition to the disciplines implemented in its foundation, subjects such as Geology were incorporated into Mineralogy studies, in order to deepen geological studies, accompanied by the addition of Philosophical Zoology, a unique subject of this institution, “which brought to light the debates of the most renowned German and French scientists on embryonic development” (Lorenz & Vechia, 2011, p. 125; cf. Lorenz, 2007). The inclusion of these two disciplines served to tune school studies with scientific ideas on the rise in Europe. Furthermore, the Statutes of College Pedro II provided for the existence of a Physics Office, a Chemistry Laboratory and a collection of products derived from the mineral, vegetable and animal kingdoms (Lorenz & Vechia, 2011). In any case, in pedagogical and methodological terms, it is quite likely that most educational institutions of the period followed a traditionalist and encyclopedic pedagogy pedagogy with purely expository and propaedeutic teaching (Sampaio, 2004; Bueno et al., 2012, pp. 441–442). In this regard, Agassiz’s comment, in 1865, on the Central School (transformed in 1874 into the Polytechnic School) stands out:

Courses in mathematics, chemistry, physics, natural sciences are widely and seriously taken; but even in this establishment I was impressed by the meanness of the means of practical and experimental demonstrations; teachers do not seem to have sufficiently understood that the physical sciences are not taught solely and mainly through textbooks (Agassiz, 1938, p. 593 cited in Alfonso-Goldfarb & Ferraz, 2002, p. 9).

It is important to be clear that the concern to expand the scientific content in the school curriculum at the beginning of the 19th century stems from the fact that, after the proclamation of Brazil’s independence from Portugal, there was a whole process of reorientation of educational policy, mainly in relation to the development of the scientific spirit driven by the ideals of the French Revolution (Almeida Junior, 1979) and also by changes in the organization of Brazilian education, also by French inspiration, which contributed to the reform of the current classical tradition (Zotti, 2005). Zotti (2005) clarifies that it is “from the imperial period that the conflict between the humanist curriculum and the scientific curriculum will be the subject of reasonable discussion” (p. 31), denoting the curricular concern in relation to the ideals of modernization of the Portuguese Empire. Undoubtedly, secondary education represented a new phase of

Brazilian education, designating a new level of the educational process that contributed to the implementation of all these changes. College Pedro II marked the beginning of the central government's action in the systematic organization of this level of education in opposition to the isolated classes inherited from the colony, destined to make up for the absence of Jesuit schools after the Pombaline reform, starting to be considered the standard teaching establishment to be followed by other institutions in the country (Zotti, 2005).

However, it cannot be neglected that, during this same period, in addition to College Pedro II, other forms of secondary education were being instituted with their respective curricula, including knowledge in the area of natural sciences. As an example, one can cite the Lyceum⁵. According to Mendonça et al. (2013), the main difference between lyceum and colleges was related to their social objectives, "(...) related to their social objectives, as well as to the degree of organicity in its institutional character".

In passing, Paraense Lyceum is cited, which, according to Barros and Alves (2015), represented a significant contribution to the advancement of modernization in the educational institution of Pará. According to the authors:

The Paraense Lyceum was created in 1841 with the aim of providing secondary education. Its creation changed the panorama of previous secondary education. He introduced serial classes, which before were exclusively isolated, and scientific knowledge, which had not yet been introduced in schools in Pará. This happened ten years after its creation, that is, in 1851, when the curriculum provided for the subject called "Elements of Physics, Chemistry and General Principles of Botany". The insertion of this chair was pointed out by the president of the province Fausto D'aguilar as a point of "program development" because it would be important and practical useful (Barros & Alves, 2015, p. 4).

However, Barros and Alves (2015) also highlight the absence of professors to take over these subjects and the low demand from students. They also point out that, unlike College Pedro II, where scientific disciplines were present since the end of the Portuguese Empire, at Paraense Lyceum there were profound oscillations and even the withdrawal of some of these disciplines from the curriculum due to the non-absolute incorporation of the values of modernity. Gonçalves Dias, in charge of integrating the public education inspection commission in the northern and northeastern provinces, testified that, if any high school, at the time, sought to introduce natural sciences into the school curriculum, it soon found itself at the forefront of fruitless efforts:

5 According to Massunaga (1989) and Sampaio (2004), the first provincial lyceums emerged thanks to the gathering of isolated chairs existing in the capitals of the provinces. They are: the Lyceum of Pernambuco (1826), the Athenaeum of Rio Grande do Norte, in 1835, and the Lyceums of Bahia and Paraíba in 1836.

Our Lyceums are preparatory schools for the Academies, and bad schools; because in addition to not requiring a Bachelor of Arts degree to start scientific careers, the preparatory exams at the Academies are carried out in such a way that most Academics, at the end of the second or third year, have completely forgotten, or only retain superficial notions of that they learned in secondary schools [...] If any of them has wanted to introduce into the framework of secondary education notions of natural and exact sciences such as pure mathematics, chemistry, physics, botany, agriculture, surveying, they see these studies languish, because they are not required for any literary degree. The two chairs of chemistry and physics and botany in Bahia have only one student (Gonçalves Dias, 1852 cited in Haidar, 1972, p. 22).

Zotti (2005) also points out two central points that can be highlighted regarding the failure of scientific disciplines during the time in these different institutions, but, mainly, in College Pedro II: the preparatory function for higher education courses that surpassed the formative function of teaching itself and, on the other hand, the European import of a conception of education that did not fit the molds of national particularities. On this second point, the successive reforms of primary and secondary education led to the inconsistency of systematic planning linked to national concern. For the most part, they were linked to the European educational model, including the virtually integral reproduction of educational programs: “for example, the geology program included the careful study of Parisian soil and ignored the particularities of Brazilian soil” (Zotti, 2005, p. 38). Attesting to this data, Lorenz and Barra (1986) state that the textbooks used by College Pedro II “presented examples and focused on matters directly related to the interests of European schools to the detriment of what was important to Brazilian students” (p. 1971). Even with this neglect of cultural and geographical scope, the authors claim that the didactic materials used in the institutions of that period reflected the best of European thinking for science teaching.

As for curriculum issues, from the foundation of College Pedro II⁶ from 1837 to 1900, there were at least 13 curricular reformulations, instituted by different decrees (Lorenz, 2002; Lorenz & Vechia, 2011). In the first plan of College Pedro II (1838), the teaching of science occupied only 9% of the 207 hours of classes planned, compared to 62% dedicated to classical-humanistic studies. With the changes made in 1841, by Antônio Carlos de Andrade e Silva, 5% of the total class hours was allocated to each area related to science disciplines. This plan remained unchanged until the mid-1850s (Lorenz & Vechia, 2011).

From 1838 to the beginning of 1850, the science curriculum at College Pedro II was basically composed of the disciplines of Zoology, Botany, Mineralogy, Chemistry, Physics, Astronomy and Geology (included in the 1841 plan). With the institution of the reform of primary and secondary education in the Municipality of Corte (Reforma Couto

⁶ The focus that we dedicate here to the analysis of the curricular transformations of College Pedro II is due to the fact that this institution was created to serve as a model for isolated classes and other secondary education establishments in the provinces. Therefore, the modification carried out in their curricula was a parameter for the curricular modification of other educational institutions of the period.

Ferraz) in the year 1854, the disciplines of natural sciences began to be defined based on two subjects “one of which was natural history with the first notions of zoology, botany, mineralogy and geology, and another of elements of physics and chemistry, comprising only the general principles and those most applicable to the uses of life” (Decree nº 1.331-A, 1854, art. 79). As explained by the document itself, the subjects were quite generic, in addition to being restricted to the last years of secondary education, with a predominant emphasis on humanities subjects (Decree nº 1.331-A, 1854).

A significant but provisional alteration was the enactment of the regulations of College Dom Pedro II in 1855, by Minister Couto Ferraz, who divided secondary education into two cycles and transferred scientific studies to the first years, relegating studies classics to the last series (Decree nº 1.556, 1855). According to Zotti (2005):

“First-class studies” lasting 4 years and of a more scientific nature, were intended for those who did not go on to higher education, qualifying them for vocational schools or “second-class studies”. The curriculum matrix had a concentration of more than a third in the areas of science and mathematics. “Second-class studies” lasting 3 years enabled the student to obtain a bachelor’s degree in letters and enabled immediate entry into higher education. The curriculum was essentially humanistic and literary, as access to higher education practically did not require scientific preparation (Zotti, 2005, p. 37).

Lorenz (2002) describes two French reforms that contributed to this new model, namely: Narcisse Salvandy’s reform (1847), which aimed to offer technical-scientific teaching and classical teaching in secondary schools, and Hippolite Fortoul’s reform (1852), who “also advocated this double function for high schools, but through the bifurcation of the curriculum, that is, the creation of two study plans, distinct but interconnected, which resulted in the conferring of the title of Bachelor of Science or Bachelor of Arts” (Lorenz, 2002, p. 5). Almeida Junior (1979) adds that this change was also due to the influence of scientific schools (*realschulen*) in Germany, which had been developing secondary education that was more scientific than literary, which led Brazilian education to appropriate methodologies involving experiments and practical demonstrations, especially in physics teaching, however, without the direct participation of the student. However, according to the author, this attempt to incorporate scientific studies based on German schools did not last long in the Brazilian context due to the lack of adequate teaching materials, the unpreparedness of teachers and the Brazilian economic structure itself, fundamentally agricultural at the time.

In 1857, with the assumption of the imperial ministry by the Marquês de Olinda, the College Pedro II study plan underwent further changes, extending the “first class studies” established by the previous reform from four to five years. In the case of scientific disciplines, Lorenz and Vechia (2011) point out that, with the new reformulation in 1857, the total number of hours devoted to teaching science was reduced from 13% to 10%, in addition to being restricted to the intermediate and finals, which nullified the previous reform’s objective of providing a science foundation for all students,

including those who would choose to proceed to second-grade studies and, in most cases, to higher education. Such an event could still be found in the following years, as in 1862, mainly due to the fact that “scientific studies (physics, chemistry and natural sciences) [were] reduced to general notions in the 5th and 7th grade” (Zotti, 2005, p. 38). In addition, the new reform of 1862, which lasted until 1870, ended up abolishing the system of bifurcating studies into two courses (technical and classical) and instituting a single seven-year course centered exclusively on humanistic studies to direct students to courses superiors. The class hours of science studies remained at 10% in relation to other disciplines (Lorenz & Vechia, 2011).

From the 1870s onwards, what was seen to emerge with great intensity was the influence of European debates directly on the reform of secondary education, including the concern with the diversification of the secondary curriculum and the need for technical and scientific training. According to Haidar (1972), during this period, with the strong influence of positivist ideas:

The question of scientific education assumed special importance in the area of secondary studies, which sought to be entrusted with the broader mission of fully training citizens, enabling them not only to enter higher education, but to face, thanks to better basic preparation, the complex and varied needs of social life (Haidar, 1972, p.120).

However, in practice, the changes in relation to scientific studies brought about by the Reform of 1870 were not significant, since in the face of the rush to enter higher education courses, students tended to drop out of school and try to pass exams in installments, which neglected subjects scientific (Zotti, 2005).

Until the following decade, Lorenz and Vechia (2011) list a series of three new reforms (1876, 1878, 1881⁷), that did not contain substantial changes. Only with the different reforms initiated from the 1890s⁸ there was the decline of classical disciplines to the detriment of scientific disciplines due to the increasing influence of positivist thinking in secondary and higher education. In the case of College Pedro II, for example, the emphasis given to humanities studies was reduced from 41% to 36% of the class hours, while the emphasis given to other areas, especially science, was increased from 7% to 18%. In this context, the introduction of disciplines such as Meteorology, Biology, Mechanics and Calculus, in the field of natural and exact sciences, is also verified. All these modifications were carried out by Benjamin Constant following the hierarchical order of human knowledge established by August Comte (Lorenz & Vechia, 2011).

Although this increase was positive during 1890, it is not possible to affirm its maintenance or even the growth of the class hours destined to the scientific disciplines in the years that followed, since their importance continued to decrease until the end of the decade and, even in the first decades of the twentieth century by the different

7 It stands out, in an unprecedented way in this institution, the inclusion of the Hygiene discipline alongside the Natural History discipline, in the year 1881.

8 To check in more detail the different reforms of the College Pedro II study plan during the 1890s (1890, 1894, 1898, 1899), see Lorenz and Barra (2011).

regulations established for the *Gymnasio Nacional*, maintaining an average of 10% of the total class hours of the curriculum. From this perspective, the educational reforms that took place at the end of the 19th century continued to lean towards the hegemony of humanistic studies, which practically prevailed until the 1950s (Ferreira, 2007). Indeed, it is clear from a diachronic comparison of science and humanities studies in the Brazilian secondary curriculum that the increase in emphasis on humanistic studies has implied a respective devaluation, in terms of class hours, of scientific disciplines (Lorenz & Vechia, 1984).

Alongside these nuances in the scientific curriculum, the growth in the appreciation of national Science from the 1870s onwards stands out, but much more as a “fashion”, through the consumption of manuals and books on scientific dissemination, than as a practice and production. According to Schwarcz (1993), “scientistic fashion enters the country through literature and not through science more directly” (p. 26). The author points out that in this period, different theories such as social evolutionism, positivism, naturalism and social-darwinism began to spread, “having as a reference horizon the debate on the foundations of a national culture in opposition to the metropolitan legacies and to the colonial origin” (Schwarcz, 1993, p. 24). This scientific ideology provided, on the part of the country’s intellectual elites, not only a political and social interpretation of the population, but also a confidence in the nation’s progress in the midst of an idea of backwardness resulting from the colonial legacy.

For this reason, despite the devaluation of scientific knowledge in the school curriculum, in the second half of the 19th century it became increasingly evident, both in Brazil and in other parts of the world, the need to expand the educational scope beyond classical teaching, which was no longer appropriate to the new emerging socioeconomic conditions (Lorenz & Vechia, 2011). The Constant reform (1890), inspired by the positivist movement, must be understood as one of the most important educational reforms in relation to science teaching in that period, mainly because it incorporated the scientific concerns that had been taking place in Europe, which favored in the following century the exponential growth of concerns in this area (Lorenz, 1986; 2002).

According to Diogo and Gobara (2008), two points represent a certain advance in the republican period in relation to the colonial and imperial contexts: the inclusion of the content of fundamental sciences according to the logical order of positivism, such as: Mathematics, Astronomy, Physics, Chemistry, Biology and Sociology; and the 1891 Constitution, which determined secular education in public educational establishments. These two points, although they were not fully considered in the following years, were fundamental, especially when defending scientific knowledge, seeking to dispel the classical-humanist tradition of the Church and ensure the secular principles of education through the official removal of religious influence in teaching, which tended to obstruct much of the contemporary knowledge that was emerging.

Despite a certain optimism arising from the positivist logic, Almeida Junior (1980) describes the controversy surrounding the positivist ideas in the curriculum:

All secondary education reforms, in the first republican period, showed great hesitation as well as an absolute lack of continuity in the study and solutions of the fundamental problems of educational organization, when they did not offer excessively rigid guidelines and schematic frameworks that restricted the freedom of schools to organize their laboratories and develop their own methods. The illusory scientific education of Comtean inspiration was far from realizing a legitimate formation of scientists through deep studies of the exact sciences, without detriment of the experimental part, which is the very instrumentalization of these sciences (Almeida Junior, 1980, p. 59).

From what was described above, it is noted that there was no significant change during the Portuguese Empire and the first years of the Brazilian Republic that replaced the predominantly classical education inherited from the Jesuits, precisely because of resistance to modifications of classical-humanistic studies considered as one of the highest knowledge aimed at the development of intellectual capacities and the moral faculties of the students during that time (Almeida Junior, 1979; Lorenz & Vechia, 2011). That is why, only in 1930, through the Francisco Campos Reform⁹, the subject Physical and Natural Sciences could become official in secondary education, with the unification of previously fragmented fields of knowledge (Marandino et al., 2009).

It is possible to identify from Decree nº 18.890, of April 18, 1931, which instituted the Francisco Campos Reform, the prediction of Physical and Natural Sciences, in the first and second series of the five-year fundamental course, and the presence of the disciplines Physics, Chemistry and Natural History in the last three grades of this level of education. In the last two cycles of secondary education, known as the complementary course, there is the presence of the discipline of General Biology, inserted in the first grade for candidates to enroll in the legal course; and the disciplines of Physics, Chemistry, Natural History and Cosmography, included in the first and second series of the complementary course, for those students who opted for later enrollment in higher education courses in Medicine, Pharmacy and Dentistry and in Engineering and Architecture courses (Decree nº 18.890, 1931).

In general, as the national literature had already indicated, science teaching ceased to be treated as a local concern of some educational institutions in the country and began to receive greater attention in the national educational scenario from the mid-twentieth century, influenced by the emerging process of industrialization and by account of international factors related to the post-World War II economic crisis and the fierce scientific dispute over the space race for the launch of the Soviet satellite Sputnik (Barra & Lorenz, 1986; Krasilchik, 1980; 1987). It was as a result of these new political, economic and technological processes that a broad debate on the reform of science education began to spread in countries such as the United States and England, and later moved to Brazil.

⁹ According to Dallabrida (2009), the Francisco Campos Reform sought, at a legal level, to confer “organicity to the school culture of secondary education, perceived by its prescriptions that aimed to overcome the regime of preparatory courses and exams in installments” (Piletti, 1987; Romanelli, 1996 cited in Dallabrida, 2009, p. 186). In addition, it increased the duration of secondary education from five to seven years, divided into two cycles. Such cycles were rearranged by the Organic Law of Secondary Education of 1942 (Capanema Reform) by establishing the junior high school cycle, of four years, and the collegiate cycle, of three years, which lasted until the 1970s.

It is interesting to point out that, since the 1920s, Brazil had already been undergoing a profound policy of educational reconstruction linked to the developmental thinking of the economy and the installation of industrial capitalism (Nagle, 1974; Abrantes & Azevedo, 2010). According to Lorenz and Barra (2001), in the second half of the 19th century, there was already a line of thought on the part of the government that “education should aim at the economic development of the country” (Lorenz & Barra, 2001, p. 127), especially, technical-scientific education. Therefore, the yearnings driven by the enthusiasm for education as an instrument of national development and the pedagogical optimism established at the turn of the century were conducive to stimulating the role of schooling and the acquisition of scientific knowledge in the country’s scientific and technological progress. As Nagle (1974) states, it is in this climate of enthusiasm that the teaching of scientific content was seen as the “richest, most vigorous and current standard of teaching and culture, the only one capable of placing the Nation at the height of the century and laying solid foundations to the desired economic progress of the country” (Nagle, 1974, p. 119).

Third Phase (1950-1970): The Renewal of Science Teaching

Without a doubt, we can say that the curricular reforms of science teaching in countries like the United States and England, in response to the launch of the Russian artificial satellite in 1957, provided the necessary impetus for the development and consolidation of science education in Brazil. It was precisely in the context of foreign reforms that Brazilian scientific education, which previously had a merely local character, came to be considered a national problem. The movement for curriculum renewal in science teaching that spread to Brazil at the end of the 1950s began to have as its goal “the transformation of a sector of the curriculum: the teaching of Science at school (then of first grade) and of Biology, Physics, Chemistry and Mathematics at school (second grade)” (Krasilchik, 1980, p. 167)¹⁰.

In addition, from the end of the first half of the 20th century, a series of important transformations in the scientific and educational field that were already being established throughout the country, could take effect, such as the creation of several scientific societies, such as the Brazilian Society for the Progress of Science, in 1948 (Abrantes & Azevedo, 2010; Nardi, 2014), the foundation of the National Council for Scientific and Technological Development (CNPq) and the Coordination for the Improvement of Higher Education Personnel (CAPES) in 1951. These last two entities were fundamental for the implementation of several educational actions that followed, such as encouraging exchanges between national and foreign institutions, granting scholarships, supporting scientific events, among others (Nardi, 2014).

According to Nardi (2014), one of the first actions of these two entities was the institutionalization of the Brazilian Institute of Education, Science and Culture (IBECC) in 1952. The foundation of the IBECC, in 1946, derived from a project by the National

¹⁰ We remember the teaching of Geosciences inserted as part of the natural sciences (Amaral, 1998) and its importance in the American and English curriculum projects of the time (Earth Science Curriculum Project and Geology and Earth Science Sourcebook).

Commission of the United Nations Educational, Scientific and Cultural Organization (UNESCO) with the aim of disseminating in Brazil the projects that UNESCO had been carrying out in the international field. Its establishment in the national territory was a milestone for the emergence of groups, projects and events, bringing together researchers and teachers of basic education, aiming at improving scientific teaching, but specifically, with the adoption of the experimental method (Lorenz & Barra, 1986; Nardi, 2014). This entity was essential for the production of equipment and teaching materials in Brazil from 1950 to 1980 with the aid of foreign funding. In this respect, we highlight the support of Brazilian events by UNESCO and the subsidies for curriculum projects, teaching materials and teacher training in the area of science teaching by the Rockefeller Foundation, the Ford Foundation, the United States Agency for International Development (USAID) and by the Pan American Union (Nardi, 2014; Krasilchik, 2000).

During the 1950s, the main activity of the IBCEC was the production of textbooks, equipment and support materials for practical activities in the laboratory, which began to be distributed to different schools in the country and sold to the general public¹¹. These experimentation kits, as they came to be known, were intended to “enable students, even outside the school environment, to carry out experiments and learn to solve problems by themselves” (Lorenz & Barra, 1986, p. 1972). Such actions were based on the assumption that the teaching of experimental science could train people with a scientific mindset and attitudes, in addition to encouraging them to pursue careers in the field of natural sciences (Krasilchik, 2000).

However, with the outbreak of the science teaching renewal movement, around 1959, the IBCEC turned its focus to curriculum projects, which began to be implemented in western countries. The elaboration of curriculum projects by this institution went through two distinct moments: a first moment, which corresponded to the translation and adaptation of teaching materials produced in the United States and England in the 1950s, designed with the aim of reducing the distance between Western countries and the Soviet Union; and a second moment, characterized by the production of teaching materials designed to meet the specificities of Brazilian schools, due to the limits that were being identified in the transfer process of foreign projects and a perception of external imposition on national rationality (Lorenz & Barra, 1986; Nardi, 2005).

Among the main American and English curriculum materials published during this period, the following stand out: Biological Science Curriculum Study (BSCS), Physical Science Curriculum Study (PSSC), Chemical Bond Approach (CBA), Chemical Educational Material Study (CHEMS), Introductory Physical Science (IPS), Project Harvard Physics, Earth Science Curriculum Project (ESCP), Geology and Earth Science Sourcebook and the Nuffield Biology (Lorenz & Barra, 1986; Amaral, 1998; Marandino et al., 2009; Nardi, 2014). According to Lorenz and Barra (1986, p. 1974):

¹¹ The return of emphasis on experimentation kits years later was due to the creation of FUNBEC, in 1967, which, in collaboration with IBCEC, began to industrialize textbooks and scientific equipment for schools. According to Lorenz and Barra (1986), by 1965 more than 25,000 kits had already been produced.

With the financial support of the Ford Foundation and the guarantee of the United States Agency for International Development (USAID), the IBECC, between 1961 and 1964, translated and adapted the American materials. Subsequently, the green version of the BSCS and the texts from CBA and PSSC were presented in Brazil, thus encompassing studies in biology, chemistry and physics. Later, the BSCS (blue version) was also presented, in 1966; the ‘Chem Study’, in 1966; the IPS, in 1967, in 1967; the ‘Geology and earth science sourcebook’, in 1967, and the English project ‘Nuffield Biology’.

With regard to production, there are more than 400,000 copies of the four volumes of the PSSC published between 1964 and 1971 in Brazil. Regarding the BSCS, a total of 209,000 copies of volume I, blue version and 115,000 copies of volume II were published from 1965 to 1972 (Lorenz & Barra, 1986). This extensive production is related to the grants directed to the institute by the Ford Foundation in 1961, in the amount of 125 thousand dollars, which aimed at “the distribution of kits through state agencies and sale to the public, training of science teachers and the distribution of science teaching materials developed in the United States” (Lorenz & Barra, 1986, p. 1973). It is estimated that, between 1961 and 1964, around 1,800 teachers were trained in courses sponsored by the IBECC with a view to using the BSCS and PSSC (Lorenz & Barra, 1986).

The IBECC also “was responsible for the important task of training leaders and administrators to work in the newly created centers” for the teaching, research and dissemination of Science (Lorenz & Barra, 1986, p. 1975). These Science Centers (CECIs) were created in 1965 by the Ministry of Education, during the dictatorial period that started to promote the technical model in education (Saviani, 2021). Altogether, six centers were founded in different Brazilian capitals with the objective of training teachers, producing and distributing textbooks and materials for laboratories in different schools: the Centro de Ciências do Nordeste (CECINE), the first to be implemented, and the others, founded subsequently — CECIRS in Porto Alegre, CECIMIG in Belo Horizonte, CECIGUA in Rio de Janeiro, CECISP in São Paulo and CECIBA in Salvador (Lorenz & Barra, 1986; Nardi, 2014). Abrantes and Azevedo (2010) point out that such centers were linked to both universities and local education departments and relied on resources from the Ministry of Education (MEC) to international agencies, such as the Ford Foundation, which, in 1966, granted 86 thousand dollars for the training of leaders who would work in these centers.

This first phase, related to the introduction of foreign curriculum materials in the Brazilian educational environment, can be seen from two different points of view: on the one hand, “the lack of resources in schools, combined with the unpreparedness of teachers, made it difficult to use, on a large scale, of the new teaching materials produced” (Lorenz & Barra, 1986, p. 1982); for another,

[...] had, in a way, a positive effect. They showed, through their organization, the importance of experimental teaching in science and, even more, the role that good curriculum materials can play, allowing students to experience the scientific

research process. They also showed the good results that can be achieved when scientists, teachers and technicians participate together in the preparation of scientific materials for science teaching (Lorenz & Barra, 1986, p. 1982).

The second phase of this process, on the other hand, can be seen from a national and technical point of view: national, since it was sustained by internal factors anchored in the specific demands of the Brazilian reality, which foreign projects were no longer able to cope with; technician because it transformed educators into mere technicians and executors of ready-made projects applied on a large scale. According to Lorenz and Barra (1986):

[...] although much has been done in terms of translating and disseminating the new materials, as well as training teachers in their use, specifically with regard to improving learning, the results show that, in general, they fell short of expectations. [...] the lack of resources in schools, combined with the unpreparedness of teachers, made it difficult to use new teaching materials on a large scale (Lorenz & Barra, 1986, p. 1982).

Pioneering national projects came mainly from institutions linked to the Ministry of Education and Culture, such as IBECC/FUNBEC, and the Teaching Expansion and Improvement Program (PREMEN), which financed projects linked to universities and science centers, based on the National Project for the Improvement of Science Teaching. By IBECC/FUNBEC, national projects for first grade are listed, such as “Iniciação à Ciência” (1960); the “Mirim” collection (1966), with 30 kits; the “Cientistas do Amanhã” collection (1965), with 21 kits; the project “Ciências para o Curso Primário” (1968), with four textbooks for students and four guides for teachers, among others (cf. Lorenz & Barra, 1986, pp. 1977–1978). Among those that emerged together with the universities, one can point out the various projects in the field of physics teaching developed since the beginning of the 1970s, among them: the Physics Teaching Project (PEF), the Self-Instructive Physics (FAI) and the Brazilian Project for Teaching Physics (PBEF) by the Institute of Physics of the University of São Paulo (Lorenz & Barra; Nardi, 2014), in addition to those linked to science centers: the National Project for Secondary Chemistry Teaching, linked to CECINE (1972), the Science Teaching Project (PEC), linked to CECIRS, among others (cf. Lorenz & Barra, 1986, pp. 1980–1981). From 1972 to 1980, a further twelve projects were sponsored by PREMEN and carried out jointly with other agencies, colleges and science teaching centers, such as CENAFOR and FUNBEC, all of them with an emphasis on experimental teaching. The same happened with IBECC/FUNBEC with the launch of twelve projects aimed at first and second grades, in addition to adult education. However, in the early 1980s, the actions of these institutions were gradually reformulated, focusing on training science teachers (Lorenz & Barra, 1986).

Despite the criticisms regarding the “cultural distance” of the American and English projects of the first phase indicated, the comment of Isaías Raw, former general secretary of the IBECC, is highlighted¹²:

12 As historical data about the moment experienced by researchers in the area during the dictatorial period in Brazil, we mention the persecution and arrest of Isaías Raw on charges of subversion. Available at: <http://www.hu.usp.br/wp-content/uploads/sites/59/2015/07/Isa%C3%ADas-Raw.pdf>

The importance of the São Paulo IBECC program in innovation in science teaching has been widely recognized outside Brazil. I would say, without modesty, that the IBECC initiatives triggered the priority given by UNESCO and the Pan American Union to the importance of science teaching as a development factor (Raw, 2005, p. 25 cited in Abrantes & Azevedo, 2010, p. 485).

Some data legitimize this argument from the point of view of the impact of the programs instituted by the IBECC:

In the period from 1954 to 1963, around 15,000 kits were produced, sold to around 3,000 secondary schools, which corresponded to almost 80% of the school network, to which were added another 20,000 kits sold in 1965, and more 30 thousand, in 1968. In the line of books, in 1965, there were 400 thousand textbooks, with the support of a team of 60 professionals (Raw, 1965, p. 8; 1970, p. 43 and 107 quoted in Abrantes & Azevedo, 2010, p. 485).

These initiatives resulted, as previously stated, not only in the strengthening of new foundations for science education, which resulted in the development of 42 curricular projects by IBECC/FUNBEC and PREMEN, in collaboration with universities and science teaching centers at the end of the decade from the 1950s to the beginning of the 1980s (Lorenz & Barra, 1986), but even in the very social appreciation of Science in the country.

Alongside all these events, other elements were significant for the appreciation of science teaching: from a legal point of view, mention is made of the enactment of the Law of Guidelines and Bases of National Education (Lei de Diretrizes e Bases da Educação Nacional, LDBEN), n. 4,024, of December 21, 1961, essential for expanding the participation of science in the school curriculum, both in the first years of the junior high school course and in the increase in the class hours of subjects such as Physics, Chemistry and Biology in the high school course¹³ (Law n° 4.024, 1961; Krasilchik, 2000). In addition to expanding the scope of scientific disciplines, the 1961 LDBEN also allowed for a certain decentralization of curricular decisions, which required the adoption of official programs, making it possible to make the choice of content to be taught more flexible. Teixeira (2008), based on Reznik (1995), points out that:

The LDB/61 instituted the discipline Sciences, indicated to be present in the curriculum due to its “universal character, formative value and practical utility”. In the first and second grades of junior high school it should be given in the form of “Initiation to Science” and in the high school cycle called Physical and Biological Sciences, which can be divided into Biology, Physics and Chemistry (Reznik, 1995, p. 83). According to the author, the mentioned law assumed a conception of criticism of traditional, theoretical, bookish and memoristic teaching, which induced passivity on the part of students. On the contrary, he

13 The LDBEN of 1961 (Law 4.024/61) configured secondary education in two cycles: Junior High School with 4 years duration (current Elementary School Final Years) and Institute with 3 years duration (current High School).

advocated a more up-to-date teaching, in tune with the advances in Science and Technology itself, with the use of an active methodology, inspired by the new school, with a preponderance of practical classes in which students could “learn by doing”, incorporating the research process science in the formation of the citizen (Teixeira, 2008, p. 33).

For Teixeira (2008), “the LDB/61 helped to open the way for the renewal process in science teaching” (p. 33). This openness had to do with the function of disciplines in the area of Science in preparing citizens to “think logically and critically and thus [be] able to make decisions based on information and data” (Krasilchik, 2000, p. 86). On the other hand, the enactment of the following LDBEN, n. 5692/71, represented two different perspectives: on the one hand, it favored scientific teaching in pre-university education, but, on the other hand, it harmed pedagogical practice due to the lack of didactic and human resources necessary for the implementation of the law (Law n° 5.692, 1971; Taglieber, 1984; Lorenz & Barra, 1986). With this same understanding, Krasilchik (2000) points out that one of the prominent characteristics of this regulation was its professional character, through “disciplines supposedly preparatory to work” (Krasilchik, 2000, p. 87). According to the author:

In the 1970s, the national project of the military dictatorship in power was to modernize and develop the country. Science teaching was considered an important component for preparing a qualified body of workers, as stipulated in the Law of Guidelines and Bases for Education, enacted in 1971. This period was characterized by a series of contradictory factors, since, at the same time, where the legal text [LDBEN/71] valued the scientific disciplines, in practice they were deeply harmed by the cluttering of the curriculum by disciplines that intended to connect the student to the world of work (such as zootechnics, agriculture, laboratory technique), without students had the basis to take advantage of them. Basic training was damaged without a corresponding benefit for professionalization (Krasilchik, 2008, p. 16).

Taglieber (1984) points out that, after the approval of this law, “student’s scientific knowledge proved to be eminently factual, typically memorized contents not necessarily understood”. Radhakrishna (1979, p. 143 quoted in Taglieber, 1984, p. 93), in the same direction, adds that such a scientific education system “led to the alienation of national problems and objectives because of the lack of links between what is taught in the school and what is experienced on a daily basis”.

In this sense, it is possible to understand that, even after the innovations that occurred in science teaching and the curricular flexibility promoted legally, the framework of science education did not change substantially, nor the practice of teachers in this field, nor the science curricula of Brazilian schools, since the teaching and learning objectives fell short of the training needs of Brazilian students. As explained, many of these obstacles are due to the implementation of technical and interventionist educational policies

throughout the dictatorial period, predominantly aimed at technical and scientific training of Brazilian students for the job market. In addition, the very methodology aimed at training young scientists by the reform promoted by the movement to renovate science teaching proved to be inefficient in dealing with the pedagogical particularities of scientific learning, becoming the subject of national and international debate. Due to this rupture generated in the late 1970s from the questioning of the objectives of science education and the elaboration of new problems for the area, we consider the emergence of a fourth phase responsible for the emergence of new models of science education designed for the Information Society.

Fourth Phase (1970–present): New Emerging Models in Science Education

The model of a scientific education based on the repetition of the “scientific method” by students, which prevailed throughout the period of implementation of foreign curriculum projects, began to enter into crisis due to the emergence of political, economic, social and, mainly, environmental factors in the late 1970s in Brazil and worldwide. According to Amaral (1998), it became increasingly visible at the end of the 20th century the fact that there was little evidence that “experimental teaching put into practice had provided better results than traditional teaching in terms of training the desired logical and scientific thinking in students (Amaral, 1998, p. 218).

The experimental method, taken as the fundamental axis of science education projects by the reform movement, was based on the model of rediscovery of scientific knowledge, with the support of New School educational ideas (Lorenz & Barra, 1986; Amaral, 1998). In the words of Amaral (1998, p. 215):

Such guidance proved to be appropriate for a new science teaching, in which one of the central objectives was to lead the student to experience the scientific method, with a view to making him intimately familiar with it and preparing the little scientist through an investigative and experimental methodological proposal. However, the (neo)positivist traditions were still very strong in the thinking of science educators at the time for them to give up the conceptual rigor that should surround all scientific knowledge, even in a teaching-learning situation. This is where the didactic method of rediscovery appears, a kind of simulation of the experimental investigative method typical of the physical and natural sciences: through an empirical and inductive process, the student would be led to rediscover the scientific concepts.

The aforementioned author points out the failure of this model due to its “excessively specialized approach to knowledge and the fragmentation of reality” (Amaral, 1998, p. 217). The identification of these limits was essential for reflecting on the objectives of a scientific education that would meet the demands of the emerging Information Society, more concerned with the different implications of Science in

society (Castells et al., 1999). Of great importance in this change of objectives were the movements “Science, Technology and Society” (STS) and “Education in Science for Citizenship” in the 1970s and 80s, allied to the trends of democratization of scientific teaching, such as the movement of “Scientific Literacy” (Krasilchik, 1992). In addition, such movements were essential to replace the false image of a neutral, dogmatic and infallible Science prevailing until then and to enable its representation as a cultural and socio-historical construction. This new vision reverberated in the Brazilian curriculum proposals that redefined the guidelines of the national curricula after the consolidation of the last LDBEN/1996, starting with the National Curriculum Parameters, which conceived a scientific education based on the “political and social implications of the production and application of scientific knowledge and technological, both in the social sphere and in the classroom” (Ministério da Educação, 1997, p. 20).

Although the renewal movement of the previous decades had a posture focused on the process of scientific investigation in practice, the philosophy of science intrinsic to this movement linked the understanding of Science as an activity that could be repeated through trial and error, as if the students could by themselves arrive at the same conclusions that scientists during centuries of theoretical elaboration reached (Amaral, 1998). However, it gradually became more evident that the scientific methodology did not mean the same as the science teaching methodology, since “simple experimenting did not guarantee the acquisition of scientific knowledge” (Ministério da Educação, 1997, p. 20).

This epistemic turn, linked to subsidies from different pedagogical and philosophical currents, was crucial for the methodological redefinition of scientific teaching after the 1970s in Brazil, insofar as it deepened the understanding that scientific content alone was insufficient for scientific literacy (Shamos, 1995). The prerequisite of such literacy, on the other hand, should be focused on understanding the nature of science¹⁴ and in the methodological redefinition of how to think about scientific content (Gil-Pérez, 1986). Therefore, it should involve the contents and conceptions of students and teachers linked to a historical and philosophical approach to Science. The international literature, with great influence in the national context, began to emphasize this methodological turn by identifying that traditional scientific teaching for a long time was based much more on the “what” of Science than on the “how”, that is, much more learning the products of science, rather than the process of building scientific knowledge (Gallagher, 1991; Bentley & Garrison, 1991; Duschl, 1994; Matthews, 1995; McComas et al., 1998; McComas, 2002). In this sense, students’ understanding of the Nature of Science has become one of the greatest goals of science education, as opposed to the rigid repetition of the scientific method (Alters, 1997).

Amaral (1998) also points out that a new paradigm in science teaching has emerged when considering characteristics such as:

[...] curriculum flexibility; interdisciplinarity; development of a systemic view of

14 McComas et al. (1998) point to the 1960s as the beginning of the reflections and actions of philosophers and science educators in including the Nature of Science in school education.

the environment; awareness of the need to preserve nature and the rational use of natural resources; formation of an image of science as a historically determined human activity; articulation between common sense and scientific knowledge; respect for the student's prior knowledge and cognitive structures; correlation between psychogenesis and history of science; incorporation of everyday life into the teaching-learning process; construction of knowledge by the student (Amaral, 1998, p. 220).

Today it is clear that all this transformation in the scientific paradigm in the field of education had to do with the rescue of fundamental objectives, not only of science teaching, but of education in general, such as the development of critical thinking, the need for instrumental appropriation knowledge produced by human beings and, mainly, training for citizenship. Indeed, the influence of educators such as Paulo Freire dates back to this period in the reformulation of a more critical and transformative science education by different research groups (see Delizoicov, 2008).

Finally, mention should be made of the process of development and consolidation of research in science teaching from 1972 onwards in the field of postgraduate studies. According to Teixeira and Megid Neto (2006), nine pioneering studies in the area were defended in 1972. These studies had as their main themes the investigation of methodologies aimed at solving the problems of mass education (Nardi, 2005). Currently, there are several thematic focuses on which studies on science teaching focus (Cachapuz, 2001; Teixeira, 2021).

The formalization of research in science teaching in the country led to the formation of new research groups, graduate programs, scientific societies, organizations, events, scientific journals, in addition to financial support from different entities to educational projects. As an example, it is essential to mention the creation of different scientific societies¹⁵ who committed themselves to improving science teaching in the country, such as: the Brazilian Society of Physics (Sociedade Brasileira de Física — SBF), founded in 1966; the Brazilian Society of Chemistry (Sociedade Brasileira de Química — SBQ), founded in 1977; the Brazilian Society for Teaching Biology (Sociedade Brasileira de Ensino de Biologia — SBEnBio), created in 1997; and one of the most important scientific entities in the field of science education: the Brazilian Association for Research in Science Education (Associação Brasileira de Pesquisa em Educação em Ciências — Abrapec), created in 1997 with the aim of bringing together researchers from different areas of the natural sciences. As a consequence, various events and periodical publications were started (Feres, 2010; Megid Neto, 2014; Nardi, 2014).

Other outstanding factors in this period were the financing made by CAPES, between the 1980s and 1990s, for the Subprogram of Education for Science in the Public Notice of the Support Program for Scientific and Technological Development (PADCT/SPEC), aimed at supporting projects to improve the teaching of science and mathematics

15 Among the scientific societies mentioned, we add the Sociedade Brasileira de Geologia founded in 1946, which has among its missions: "to support, encourage and promote education in geosciences in basic education and for society in general, stimulating knowledge in order to conserve and strengthen empathy about our planet and its history".

and more recently the support of CAPES together with the National Secretariat for Teaching and Technology of the Ministry of Education for the Support Program for the Improvement of High School Teachers in Mathematics and Science, also known as Pro-Science (1996–2000). Finally, there is the definitive consolidation of the Science and Mathematics Teaching area (Area 46 — current Teaching area) by the CAPES Area Committee in the 2000s (Moreira, 2002).

In general terms, it appears that the changes that took place after the 1970s, as a result of different social, philosophical and educational movements, led to a move away from a closed, neutral and standardized perspective of the scientific conception in education, approaching of a more critical understanding on the part of the student and other school subjects of their reality, be it natural or social, “from the limits of their daily life to the totality of the terrestrial environment” (Amaral, 1998, p. 6). At the same time, teaching and learning processes have become more diversified according to the objectives, themes and pedagogical conditions of the Information Society, incorporating different aspects considered by contemporary pedagogy, such as the search for a more dialogical learning and the consideration of the subjects’ action against the construction of scientific knowledge from the duality between objective and subjective reality (Aubert, 2018).

Perhaps it is possible to characterize the current moment by the intense interest in reviewing and critically analyzing the different aspects of science teaching in order to seek ways for its continuous improvement.

Final Considerations

By analyzing science teaching from a historical perspective, it was possible to verify the different interweavings between teaching and research that contributed to the development of this area in the country. Factors of different orders gradually advanced national scientific education, although this has been relegated to a secondary position in much of the history of Brazilian education.

We found that the origin of science in Brazilian education was superficial due to the predominantly humanist character of the colonial curriculum. During the Portuguese Empire, this picture changed little, since the hegemony of the classic and erudite legacy of the Jesuits remained present even after the establishment of the Republic in Brazil. The most effective change in curriculum terms only occurred with the unification of different disciplines of the natural sciences in the 1930s through the Francisco Campos Reform and, later, with the outbreak of the scientific renewal movement, already in the mid-twentieth century, which culminated in the redefinition of objectives and problems in science teaching after the 1970s.

Within the scope of the research, dissertations and theses on science teaching from 1972 onwards are identified. The constitution of research in this area followed the trend of other countries in the consolidation of science didactics (Cachapuz, 2001). The different factors that impacted research in science teaching, such as the increase in

postgraduate programs and the creation of new research groups, expanded the national debate on the area, mainly due to the search for improvement in teaching and learning processes of natural sciences and the advancement of the state of knowledge of research in the field (Salém, 2012; Megid Neto, 1999; 2014; Teixeira, 2008; 2021; Fernandes, 2009; Gonçalves, 2022; Santos, 2022). Currently, research in science teaching continues to expand, especially due to the emergence of new problems and research topics (Teixeira, 2021; Santos, 2022).

Although there are many gaps to be filled and a series of important issues to be problematized given the extent and complexity of the problem addressed here, we hope, with this work, to be able to contribute to Brazilian researchers and educators reflecting on the trajectory of science education in the country to make it advance in the present time and in the future. In fact, the historical analysis of a given field of knowledge, such as science teaching, makes it possible to understand the different processes, advances and ruptures that led to its didactic and investigative constitution. Certainly, this panorama, although limited in several aspects, can favor an understanding of the different pedagogical, methodological, curricular, investigative and legal processes that crossed the different historical periods, but remain dispersed and, many times, veiled by the vast literature on the subject.

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No potential conflict of interest was reported by the authors.

Compliance with Ethical Standards

The authors declare this study was conducted following ethical principles