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Geoeducation in brazilian school education: an overview of scientific research[1]

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ABSTRACT

The current environmental crisis calls for geoconservation initiatives. In school settings, geoeducation can contribute to the conservation of geodiversity and foster the development of context-based educational practices. This article presents a state-of-the-art literature review on school geoeducation in Brazil. It is an exploratory bibliographic study that employed the digital tools Zotero and IRaMuTeQ to support the analyses. The following key themes were identified: the growth of research on geoeducation, curricular challenges, teacher training, and the scarcity of instructional materials. The analysis indicates that geoeducation can promote a deeper understanding of environmental issues, encourage interdisciplinary approaches, and support the development of critical thinking.

KEYWORDS: Geoconservation; Basic Education; Geosciences.

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A geoeducação na educação escolar brasileira: um panorama das pesquisas científicas

RESUMO

O contexto da atual crise ambiental demanda ações de geoconservação. A geoeducação nos espaços escolares pode contribuir para a conservação da geodiversidade e potencializar a construção de práticas educativas contextualizadas. Este texto apresenta um estado do conhecimento de pesquisas acerca da geoeducação escolar no Brasil. Trata-se de um estudo exploratório bibliográfico que utilizou como auxílio nas análises as ferramentas digitais Zotero e IRaMuTeQ. Os seguintes temas essenciais foram identificados: crescimento das pesquisas sobre geoeducação, desafios curriculares, formação docente e escassez de material didático. Conclui-se, a partir da análise, que a geoeducação pode favorecer uma compreensão mais aprofundada das questões ambientais, da abordagem interdisciplinar e da formação do pensamento crítico.

PALAVRAS-CHAVE: Geoconservação; Educação Básica; Geociências.

Geoeducación en la educación escolar brasileña: una visión general de la investigación científica

RESUMEN

El contexto de crisis ambiental actual exige acciones de geoconservación. La geoeducación en espacios escolares puede contribuir a la conservación de la geodiversidad y potenciar la construcción de prácticas educativas contextualizadas. Este texto presenta un estado de conocimiento sobre las investigaciones sobre geoeducación escolar en Brasil. Se trata de un estudio bibliográfico exploratorio que utilizó las herramientas digitales Zotero e IRaMuTeQ como ayuda en el análisis. Se identificaron los siguientes temas esenciales: crecimiento de la investigación en geoeducación, desafíos curriculares, formación docente y escasez de material didáctico. Se concluye, del análisis, que la geoeducación puede promover una comprensión más profunda de las cuestiones ambientales, un enfoque interdisciplinario y la formación del pensamiento crítico.

PALABRAS CLAVE: Geoconservación; Educación Básica; Geociencias.

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Introduction

The context of the planet's environmental crisis calls for educational, political, economic, and cultural changes. Global demonstrations, marked by debates, meetings, and conventions on socio-environmental conditions, have become recurrent, reflecting the complex society that emerged after the Industrial Era. A report released by the World Meteorological Organization (WMO) assessed global temperature trends and confirmed that 2024 was the hottest year on record[4].

However, the political ascendance of right-wing forces in several countries (most notably in the United States) has signaled a rollback of the environmental agenda, including cuts to research funding, the weakening of multilateral bodies, and the spread of climate-change denialism across social networks. This dynamic broadly implicates and impacts life on the planet.

In this scenario, fostering environmental awareness has driven the dissemination of a host of new concepts, narratives, and practices. "Biodiversity," for instance, has become a pivotal term in a world marked by crisis and climatic extremes, where the unprecedented pace of species extinctions underscores the ongoing degradation of natural systems (IPBES, 2019). While biodiversity struggles for survival, geodiversity still calls for visibility and recognition of its value.

The 1992 United Nations Conference on Environment and Development, held in Rio de Janeiro (commonly referred to as the Rio-92 Summit) was a watershed moment for acknowledging and promoting the importance of geodiversity. Since then, the ecosystem services provided by geodiversity have come to be recognized as fundamental to maintaining the ecological and systemic balance of the Earth's ecosystems (Brilha *et al.*, 2018; Gray *et al.*, 2024).

[4] https://brasil.un.org/pt-br/287173-onu-confirma-2024-como-o-ano-mais-quente-j%C3%A1-registrado- with-about-155%C2%B0C-above-n%C3%ADABLE.

Understanding environmental issues through the integration of biodiversity and geodiversity is proposed as a way to counter thinking that fragments and isolates, divides reality into separate parts, oversimplifies complex systems, ignores context, and assumes linear cause-and-effect relationships. The conception of nature as an inexhaustible resource legitimizes unsustainable practices such as overexploitation and pollution. Geoeducation is advocated on the basis of complex thinking, which emphasizes the interdependence of society and nature and the wholeness and complexity of systems, while taking into account the context in which phenomena occur (Morin; Díaz, 2016).

Challenging the dichotomous view requires movements that promote the recognition and appreciation of geodiversity and its conservation through geoconservation actions. Geoconservation, conceived both as a social practice and a theoretical framework, aims to manage and safeguard elements of geodiversity that embody intrinsic, cultural, economic, and educational values (Brilha *et al.*, 2018).

Among the initiatives endorsed by geoconservation, geoeducation stands out as a geoconservation strategy and pedagogical practice, a specific branch of Environmental Education developed in both formal and non-formal educational settings (Moura-Fé; Nascimento; Soares, 2017; Silva; Costa, 2023). Under the same rationale that supports movements for biodiversity conservation, which is embedded in the terrestrial environment and forms a key component of the ecosystem services promoted and safeguarded by Environmental Education, there is also a call for the recognition, appreciation, and conservation of geodiversity. Geoeducation is therefore proposed as grounded in the principles of critical Environmental Education (Sato, 2001; Willms *et al.*, 2024; Costa; Loureiro, 2024) and in the paradigm of complexity (Morin, 2016). These perspectives make it possible to understand geoeducation as a historical, social, and cultural construct and as an epistemic and political conception that challenges the traditional naturalist and conservationist bias.

Geoeducation can be implemented in a variety of ways and across different socio-educational and cultural contexts. As an educational approach within critical Environmental Education, it faces the challenge of operating in diverse settings shaped by different levels of governance, curricular regulations, projects, and bodies of knowledge.

It also has strong interdisciplinary potential, making it possible to connect multiple areas of knowledge, particularly the disciplines of Science and Geography and the field of geosciences within primary and secondary school curricula.

Considering the above, this study presents the results of an exploratory bibliographic investigation and the construction of a state-of-the-art review from the perspective of Morosini, Kohls-Santos, and Bittencourt (2021, p. 23). This approach "is characterized by a process of identification and categorization, aiming at synthesis and reflection on a specific topic within the scientific production." In this case, it examines the procedures used to understand the overview of research on geoeducation in Brazilian basic education settings.

Methodologic Procedures

The study initially conducted a literature review, focusing on research and scientific publications addressing the incorporation of geoeducation into school education. Scientific outputs, including dissertations, theses, and peer-reviewed articles, were selected through searches in digital platforms for scientific dissemination and institutional repositories of theses and dissertations.

Data were collected from March 2023 to October 2024 through the digital platforms Scielo, the CAPES (Brazilian Federal Agency for Support and Evaluation of Graduate Education) Journal Portal, the CAPES Theses & Dissertations Catalog, and the Brazilian Digital Library

of Theses and Dissertations. The searches were not limited by date, as geoeducation is a concept that has evolved in recent years. No publications prior to 2009 were identified.

The inclusion criterion consisted of publications addressing geoconservation within the context of school education. Platform searches were guided by the keywords geoconservação (geoconservation), educação (education), and geoeducação (geoeducation), combined using the Boolean operators (geoeducação OR geoconservação) AND educação AND escol*. Identified publications were imported into Zotero[5], which allows duplicate items to be identified and removed, and organizes publications into dissertations, theses, and peer-reviewed scientific articles.

A total of 94 theses and dissertations and 54 scientific articles were identified. Based on thematic relevance, 4 theses, 13 dissertations, and 29 articles were selected for analysis, including only publications describing geoeducation or geoconservation actions in school settings. This constituted a textual documentary corpus of 46 scientific outputs, which were examined individually with the purpose of identifying, interpreting, and reflecting on the subject matter (Lima; Mioto, 2007). The reading process was carried out in two stages. First, an exploratory reading was conducted to determine whether the selected data aligned with the objectives of the study. Subsequently, following the selective reading, a more refined choice of materials that met the research objectives was carried out.

As Mattar and Ramos (2021) note, a systematic review involves the process of selecting and critically evaluating studies that fulfill the inclusion criteria defined in the protocol. Applying these criteria, only studies addressing geoeducation within school education were retained, while initiatives implemented in non-school educational contexts were excluded.

[5] Zotero is an open-source reference management software designed to manage bibliographic data and research materials. Its main features allow integration with web browsers, online synchronization, in-text citation and bibliography generation, as well as integration with word processors.

In the third stage, the selected publications were imported into Zotero as PDF files, processed, and transferred to an Excel spreadsheet using the same tool. During this phase, publications were categorized according to publication type and the data summarized in Table 1. The selected works encompassed a range of research designs, including case studies, exploratory descriptive studies, action research, collaborative action research, analyses of pedagogical practice, and bibliographic studies. It should be noted that, given the emergent and socially dynamic nature of this field, many studies emphasize theoretical and methodological discussions.

TABLE 1: Quantity of productions.

Publications	Quantity	Period of publication	Fields of knowledge
Theses	4	2014–2022	Geography and Geosciences
Dissertations	13	2016–2024	Geoscience Education, Environmental Sciences, Geosciences, and Geography
PROFCIAMB	29	2009–2024	Geology, Geography and Geosciences Education

Source: organized by the authors from the data collected on the SciELO platforms, Portal of Journals Capes, Catalogue of Theses & Dissertations Capes and Brazilian Digital Library of Theses and Dissertations.

Finally, the analysis phase was conducted, during which the ideas and data presented in the publications were interrelated and interpreted. This aimed to understand and examine the context of school-based geoeducation in Brazilian education through an integrative review (Lima; Mioto, 2007; Mattar; Ramos, 2021).

The software IRaMuTeQ was used as a tool to support the qualitative analysis process. IRaMuTeQ is an open-source program offering a range of tools for data presentation, visualization, and processing in textual analysis (Martins *et al.*, 2022). The software provides the following functionalities: classical text statistics, research on

group specificities, Descending Hierarchical Classification (DHC), similarity analyses, and word clouds. In this study, the last three functionalities were used. Each abstract was entered into the program as an individual text. Using the program's functions, text segments were classified based on the vocabulary they contained.

The QR Code below (Figure 1) links to the web page containing all the publications from the textual corpus analyzed in this project using IRaMuTeQ.

FIGURE 1: QR Code providing access to the analyzed corpus.

Source: organized by the authors from the data collected on the SciELO platforms, Portal of Journals Capes, Catalogue of Theses & Dissertations Capes and Brazilian Digital Library of Theses and Dissertations.

Based on these data, the software identified and counted the vocabulary items from the predetermined grammatical classes, forming clusters according to the frequency of the targeted words and using statistical calculations that consider both the frequency and the position of words in the sentences. These results supported the qualitative analysis of the texts, allowing the identification of categories relevant to school-based geoeducation within the analyzed corpus (Batista; Brandalise, 2023).

The examination of aspects related to school education guided the construction of the following analytical categories: general overview of research on school geoeducation in Brazil; teacher training; basic education curriculum; teaching practice; and instructional materials.

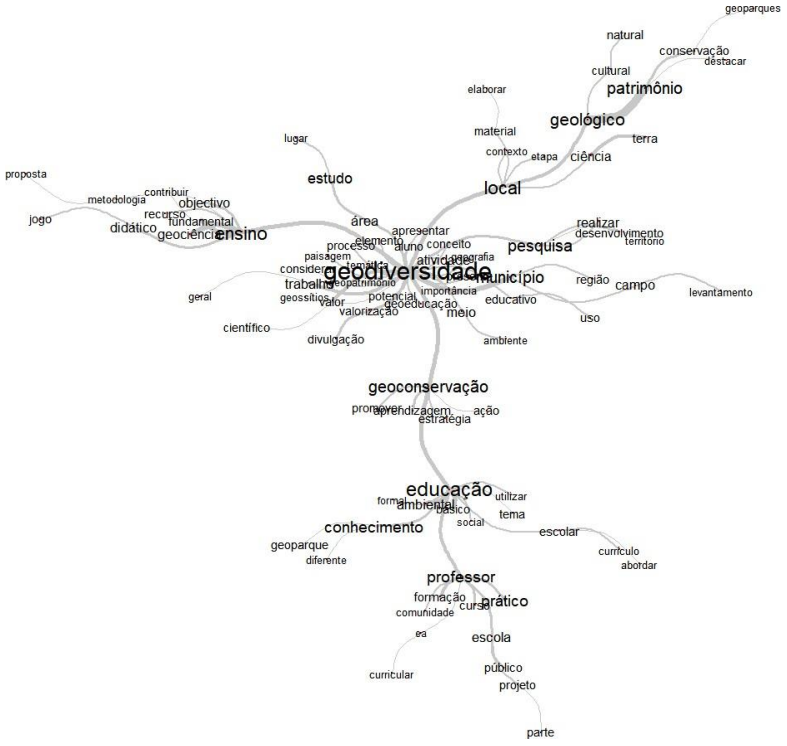
This mixed-methods study sought to deepen the understanding of the works by highlighting different perspectives and approaches within a

qualitative analysis. According to Jacomini *et al*. (2023), research aimed at conducting a systematic literature review contribute to the organization and analysis required to define a field of knowledge, identifying the foundations for building theory and pedagogical practice, pointing out limitations and gaps, and highlighting how research can foster innovations and alternative solutions to problems in pedagogical practice.

Geoeducation in Brazilian School Education

Geoeducation, broadly understood as a field that integrates multiple disciplines and bridges different educational settings, has become an important area of study for promoting geoconservation and fostering local development. The similarity tree generated by the IRaMuTeQ software shows the connections among words in the corpus and reveals the internal coherence of the textual data (Batista; Brandalise, 2023). It also highlights how the concept of geodiversity within geoeducation is approached not only with geoconservation goals in mind but also as a didactic and educational resource.

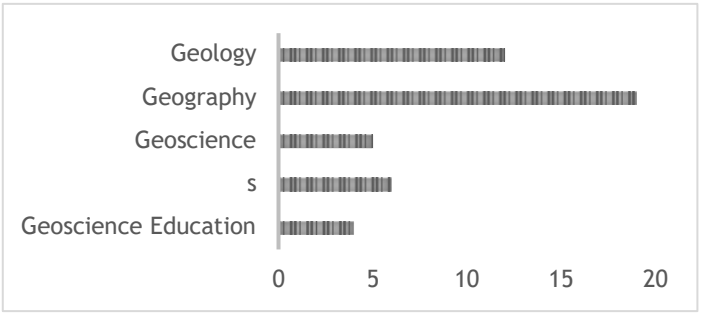
FIGURE 2: Similarity Analysis Graph.



Source: organized by the authors.

The mapping points to a strong concentration of research in the fields of Geology, Geography, and Environmental Sciences, with a particular predominance of studies carried out within Geography. This prevalence can be attributed to the presence of undergraduate teacher training programs in Geography and the field's sustained scientific investment in Environmental Education.

FIGURE 3: Fields of knowledge represented in the scientific publications on geoeducation.



Source: organized by the authors.

Regarding geodiversity topics, the selected corpus addresses, among others: aquifers (Castilho-Barbosa, 2023), caves (Menin; Tognetta; Bacci, 2022), fossils (Bernardelli, 2022), landscapes (Engleitner *et al.*, 2023), rocks (Nascimento, 2024), and geomorphological processes (Silva; Baptista, 2023).

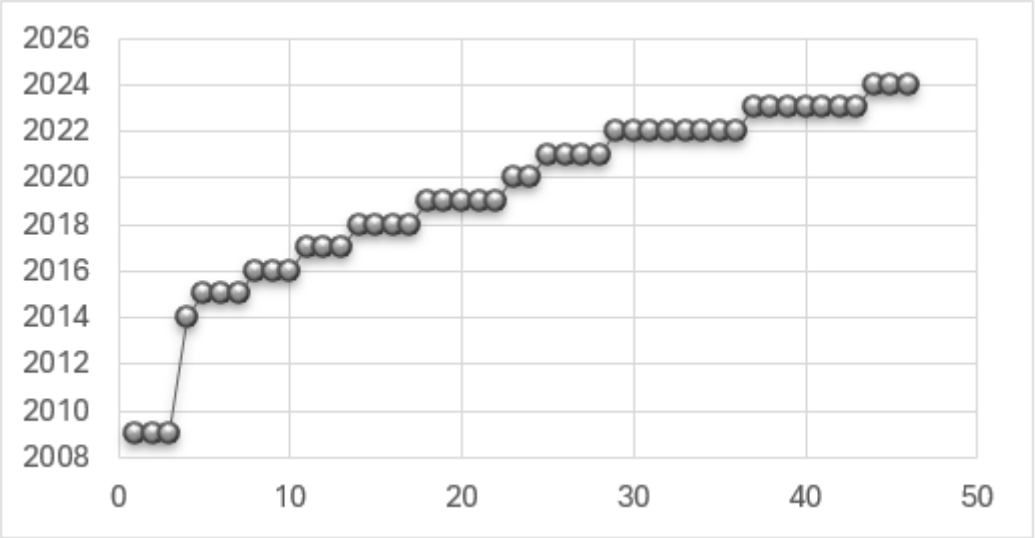
Across the studies analyzed, the importance of geoparks for the development of geoeducation initiatives was particularly evident. The United Nations Educational, Scientific and Cultural Organization (UNESCO) defines geoparks as geographic areas with unique landscape features and international significance, managed through a holistic approach that integrates protection, education, and sustainable development[6]. Several studies focused on territories that have already been designated as geoparks or are candidates for this status (Bernardelli, 2022; Pereira Junior *et al.*, 2019; Santos; Bacci, 2019; Kolya; Maia; Perinotto, 2023).

The findings indicate a clear need for studies on education within geoparks, as evidence regarding their specific effects on scientific literacy and local community engagement remains scarce and difficult to interpret or correlate (Rodrigues; Costa Silva; Pereira, 2023). School-based geoeducation research has been carried out in institutions across all regions of Brazil, covering fifteen states, with the highest concentration in the Southeast and Northeast.

The data reveal a steady increase in the number of studies on school-based geoeducation, as illustrated in Figure 3. The earliest identified publications date back to 2009, and research output has grown steadily since then, particularly in Geosciences and Geography. The observed growth in publications reflects the increasing recognition of geodiversity and the acknowledged need for conservation initiatives, supporting the establishment of geoconservation as an emergent branch of geoscience (Henriques *et al.*, 2011; Rodrigues; Costa e Silva; Pereira, 2023).

[6] Available at: https://www.unesco.org/en/iggp/geoparks/about. Accessed on: 02 Apr. 2025.

FIGURE 4: Volume of research on school-based geoeducation.



Source: organized by the authors from the data collected on the SciELO platforms, Portal of Journals Capes, Catalogue of Theses & Dissertations Capes and Brazilian Digital Library of Theses and Dissertations.

The growing number of studies highlights the rising prominence of geoconservation through the lens of geoeducation in academia and in non-school educational initiatives, while research specifically addressing school-based education remains scarce.

According to Catana and Brilha (2020), geoconservation education initiatives need to be strengthened within school settings, as many educational activities outside schools do not engage with or integrate into the pedagogical possibilities developed within formal education networks.

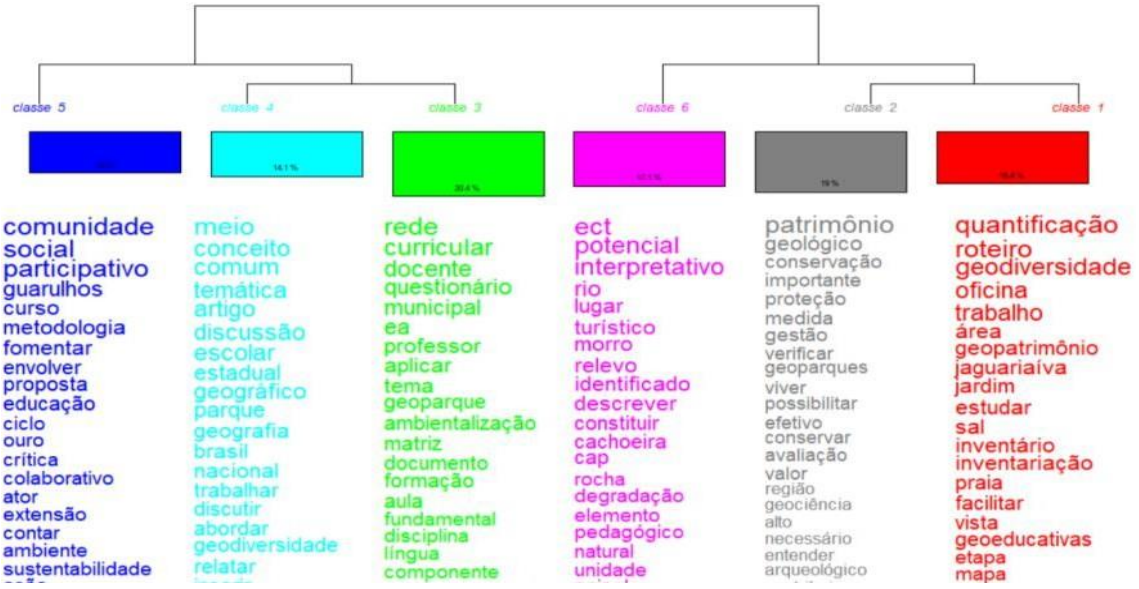
The role of education in geoeducation has been highlighted in some studies (Pinto, 2020) as a strategy to achieve geoconservation in contexts where local geodiversity presents values requiring protection. In these studies, geoeducation is not addressed in a specific manner, nor are geoeducational actions explicitly described.

Analysis of the data processed by IRaMuTeQ, using a tool that counts word frequency in the analyzed corpus, indicates that geodiversity constitutes the key element in school-based geoeducation, accompanied by the concepts of education and teaching, linked to the issues of local

valorization and the importance of heritage education for geoconservation.

The DHC tool organized six analytical classes which, combined with the interpretation of the corpus, generated categories that explore the connection between local geodiversity and education in studies addressing geoeducation from a school-based perspective, as illustrated in Figure 5.

FIGURE 5: Descending Hierarchical Classification.



Source: organized by the authors.

The two main clusters are: one comprising classes 1, 2, and 6, and the other comprising classes 3, 4, and 5. They highlight local, didactic, and social aspects. The cluster emphasizing geodiversity, formed by classes 1, 2, and 6, addresses geodiversity, geoconservation of geological heritage, and the identification of possibilities and needs. In the cluster formed by classes 3, 4, and 5, education is the central focus. The connections among the classes reveal significant aspects of school-based education, such as curricular, methodological, and teacher-related issues, linked to local community participation and engagement, as well as the social role of educational practices from the perspective of geoeducation. Thus, geodiversity is not limited to abiotic elements present on the

Earth's surface but is understood as the foundation of ecosystems and human interaction within the landscape (Kolya; Maia; Perinotto, 2023).

Ponte (2018) discusses the relevance of geoscientific knowledge for understanding the sociocultural and environmental contexts of the places where people live, which in turn fosters the perception and appreciation of both tangible and intangible heritage, ultimately contributing to their conservation. Thus, geoeducation, geoethics, and geoconservation are interconnected within a holistic understanding of geodiversity, encompassing its functions, contradictions, and possibilities. The analysis of the selected works will focus specifically on classes 3 and 4, which address aspects related to the didactic implementation of school-based geoeducation.

Geoeducation and the Curriculum in Basic Education

According to the data, the earliest publications addressing the relevance of school-based geoconservation education in Brazil date back to 2009 (Bacci *et al.*, 2009) and reflect sustained interest in the topic in the country, following the establishment of the UNESCO Global Geoparks Network in 2004 and the creation of the Araripe-CE Geopark, the first Brazilian geopark, in 2006.

From the same period, national publications emerged describing school-based geoconservation educational initiatives, drawing on practices implemented in Brazil and Europe. The implementation of geoparks was highlighted by Brilha (2009) as an opportunity to develop strategies that promote sustainable Geoscience education grounded in responsible citizenship.

The earliest master's and doctoral studies identified, which connected education, geosciences, and geoconservation, primarily focused on "non-formal" education or Environmental Education. However, Bacci

et al. (2009) emphasize the university's role in fostering debate on the multiple facets of geoconservation, including the potential of educational projects and strategies that promote the implementation and continuous development of such initiatives. The authors also highlight the insufficiency of geoscientific concepts in the Brazilian Elementary and Secondary Education curricula, indicating the need to incorporate complementary Earth Science topics into these programs.

Farhat Junior's dissertation (2024) points out that the National Common Curricular Base (BNCC), the guiding framework for Brazilian basic education, does not include Geosciences, Earth Sciences, Geology, Geophysics, Natural History, History of the Earth, or Paleontology; moreover, the theme is not systematically addressed across the curricula.

According to Farhat Junior (2024), even though geodiversity is present in the national curricula (BNCC), certain factors hinder its effective treatment, such as the absence of a dedicated Earth Science component and the purportedly "interdisciplinary" approach to geodiversity, which, in practice, remains fragmented. This occurs because topics related to geodiversity are addressed in isolation, without clear connections between different curricular components, and are presented out of context from Earth Sciences.

According to Silva and Aquino (2017), despite Brazil's vast geodiversity, knowledge about it remains limited, particularly in basic education, as the topic is still largely confined to technical and academic circles. Krüger (2023) emphasizes that the treatment of geodiversity in the curricula can lead to a fragmented perspective, disconnected from other themes, resulting in an incipient approach, that is, an incomplete understanding of the environment.

Other studies analyze and propose strategies for geoeducation aligned with curricular issues (Soares, 2017; Krüger, 2023; Faccin; Aquino, 2023; Menin; Tognetta; Bacci, 2022; Rangel; Guerra; Allochio, 2024).

The curricular approach to geodiversity is a key element, as curriculum exerts a deep and multifaceted influence on various aspects of school education, guiding teaching content, school management, instructional materials, and teacher training.

Geoeducation and teacher training

School is the environment in which teachers, by integrating multiple theoretical and practical knowledge domains, transform content into learning experiences. The specific ways in which teaching and learning unfold reflect underlying conceptions of education and world views. Didactics, in combination with Subject-Specific Didactics, is central to this process, as it shapes and directs pedagogical practices (Silva; Soares; Torres, 2022).

Teacher training for geoeducation requires viewing the school as a space of transformation. In this context, geoeducation, understood as an interdisciplinary pedagogical approach, enables future teachers to master not only content related to geodiversity but also strategies to promote critical, participatory, and contextually relevant learning.

Soares (2016) analyzed teacher training in geoeducation with a focus on in-service professional development. The study described the processes and outcomes of a continuing education program for teachers in public state schools in Guarulhos-SP, in which Geoscience instruction served as a tool for developing innovative practices and pedagogical resources aligned with local educational contexts.

Some initiatives aimed at teacher training for geoeducation in technical education contexts are highlighted, such as the production of materials designed to promote, develop, and disseminate Geology and Geoconservation by Geology students, and the adoption of the educator role by geologists, which is often overlooked by professionals (Mansur, 2019).

Mansur, in 2019, noted that progress had been made in popularizing Geology through the implementation of certain actions; however, he also pointed out that, at that time, geoscience content was not adequately taught, even though it was embedded, to some extent, in the Earth Science and Geography courses of Elementary and Secondary Education. The author identified potential causes, including deficiencies in teacher training and the limited quality of available instructional materials.

In order to identify and understand the knowledge of basic education teachers regarding geosciences, Borba *et al.* (2015) reported the results of a survey conducted with teachers in Caçapava do Sul-RS on geodiversity. The study found that teachers considered their knowledge of Geology to be moderate and superficial, which led to misunderstandings and misconceptions about the local geology.

These findings were confirmed by Santos and Carvalho (2015), who interviewed teachers from public basic education schools in São José de Itaboraí-RJ and found that they had limited knowledge of both rocks and fossils.

Farhat Junior (2024) addresses the insufficiency of geoscientific training among Brazilian Basic Education teachers. According to him, undergraduate programs provide only a superficial initial geological and geoscientific education. He also notes that teacher training and professional practice are hindered by public policies, curricular proposals, and school organization and management.

Various aspects of teacher training for geoeducation have been examined. Studies have analyzed initial teacher education (Bacci *et al.*, 2009), continuing professional development (Soares, 2016), as well as practices aimed at supporting teacher training. These include continuing education courses for basic education teachers that focus on geodiversity-related content (Soares, 2017; Pereira; Rios; Garcia, 2016; Mazzucato; Bacci; Santos, 2018; Rosa, 2024).

Among the proposed teacher training initiatives, it was observed that they primarily focused on teaching local geodiversity and its potential, while few addressed how teachers could apply geodiversity and geoconservation in the classroom.

In addition, the suggested courses and training programs are of short duration. For effective learning and guidance in local geoconservation, long-term professional development programs are necessary (Mazzucato; Bacci; Santos, 2018).

Teaching Practices and Instructional Materials

The analysis of teaching practices in geoeducation allowed for capturing discussions on the interdisciplinary approach required to address geodiversity. Farhat Junior (2024) highlights that Geosciences, given their relevance to socio-environmental issues, have the potential to integrate traditional curricular components. However, schools face challenges in implementing interdisciplinary teaching methodologies due to the lack of physical and pedagogical infrastructure.

According to Vallerius, Leovan, and Mota (2020), geoeducation initiatives should be guided by several principles, including a holistic approach and an interdisciplinary focus on cultural landscapes, taking into account the multiple scales of contemporary environmental issues, as well as a historical perspective that emphasizes the complexity of environmental problems.

According to Santos and Bacci (2019), social learning processes and education for geoconservation are important pathways for the future protection of ecosystem services.

Thus, it is evident that effective geoeducation initiatives, which require and enable a holistic approach and interdisciplinary practices, depend on teacher training, not only for mastering geoconservation-

related concepts but also for implementing practices that fully realize the educational potential of geoeducation.

Kolya, Maia, and Perinotto (2023) interviewed ten teachers regarding the challenges of implementing geoeducation and identified the main obstacles as the absence of relevant content in instructional materials, fragmentation of the topic in the curriculum, and inadequate infrastructure.

Ponte (2018) similarly emphasizes the lack of geoscience content in curricula, teaching materials, and initial teacher training in Brazilian basic education, while presenting strategies and resources for contextualizing teaching in formal education.

From this perspective, other studies reported results from actions and projects developed with students in school settings (Ferreira *et al.*, 2018; Rangel; Guerra; Allochio, 2024). These experiences enhance understanding of the potential of geoeducation in the classroom.

A concern with this type of approach is that, if not properly implemented, following the stages of identification, planning, implementation, evaluation, and reflection, the transformations may be isolated and short-lived rather than enduring as expected (Mattar; Ramos, 2021).

The availability and quality of instructional materials were addressed in several studies, highlighting their impact on geoeducation (Mansur, 2009). This process stems from the curricular characteristics of the topic, as teacher training and the development of instructional materials are guided by educational curricula.

Several studies addressed the creation of instructional materials for local contexts (Pereira Júnior *et al.*, 2019), including educational games (Guimarães; Mariano; Sá, 2017; Ferreira; Silva; Sabóia de Aquino, 2021; Basso, 2019), digital games (Gomes; Sanchez, 2018), pamphlets (Mansur, 2019), websites (Kolya; Maia; Perinotto, 2023), and participatory methodologies (Moura-Fé *et al.*, 2019).

Instructional materials, as research outputs, play a significant role in strengthening geoeducation, but they must be accompanied by preparatory and follow-up activities to achieve their educational purpose, rather than becoming just another object or moment in the classroom, disconnected from real-world contexts.

Final Considerations

The analysis of the textual corpus aimed to identify the connections between geodiversity, education, and teaching. Our review mapped the knowledge areas in which these studies are situated and highlighted the relevance of geoparks as privileged spaces for geoeducational activities. The analysis highlighted the need to improve education for geoconservation within school settings, integrating it into formal education networks and expanding the impact of geoeducation on scientific literacy and local community engagement.

The studies analyzed demonstrate relevance and importance in proposing discussions and initiatives that position elements of geodiversity as educational tools fundamental to life on Earth.

Scientific production in the field has contributed to advances in the implementation of geoeducation in schools, promoting the popularization of the subject and fostering discussions on curriculum issues as well as the development of educational practices.

The research has led to a better understanding of teacher training and to debates and proposals concerning curriculum design, even if primarily at a local level.

The discussions emerging from the analyzed studies “carry seeds” that can support the construction of new approaches in school contexts through lessons that are contextualized and aligned with local realities, fostering meaningful learning.

Some studies concluded by emphasizing the potential of integrating geoeducation into formal schooling and the possibilities for its development in alignment with the curriculum.

No studies addressing the analysis of geodiversity-related concepts in teaching materials were identified in the databases surveyed. Instructional materials, alongside the curriculum design and teacher professional training, are key elements in the educator's practice.

The importance of popularizing and raising awareness of the topic is highlighted, with the aim of establishing local governance networks, which is a relevant requirement for implementing effective geoeducation programs, in which schools play a central role.

Promoting effective integration of geoeducation into schooling also requires engaging with established foundations in Environmental Education, which, even when incorporated into curricula, still faces major challenges in schools and teacher training.

Discussing the integration of geoeducation into formal education involves enhancing critical and transformative Environmental Education, fostering new perspectives and possibilities to address the needs of a world whose citizens are aware of their true place and role.

Analysis of the textual corpus revealed a recurring theme: scientific production reinforces the relevance of geoparks as privileged spaces for geoeducational initiatives and emphasizes the need to strengthen connections between geoeducation actions in non-school settings and formal education networks. However, it is evident that increased visibility of the topic in the scientific domain does not necessarily translate into its integration into school education. The research revealed significant gaps and discrepancies, such as the absence of studies on geodiversity concepts in teaching materials. This highlights a challenge in translating academic knowledge into school practice. Although the literature presents relevant contributions to teacher training and

curricular discussions, the field requires more in-depth investigations of geoeducation in schools, particularly regarding the knowledge and practices of teachers and students in their daily educational contexts.

Research on knowledge and practices in geoeducation is essential. Understanding the presence of this theme in schools demands attentive listening to teachers and students, as well as an analysis of how the multiple forms of knowledge that constitute school-based geoeducation are interconnected. This is a long and demanding process, but, as the realities of planet Earth demonstrate, it is urgent.

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