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TEACHING GEOSCIENCES WITH ACTIVE METHODOLOGIES: INTEGRATIVE REVIEW ON ENVIRONMENTAL ISSUES

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ABSTRACT. This article highlights the importance of active methodologies in the teaching of geosciences, emphasizing their multidisciplinary nature and relevance for both students and society as a whole. Through an integrative review using databases such as Google Scholar, SciELO, and the CAPES journal, the study aims to demonstrate how practical approaches, such as applied projects and educational games, are effective in promoting engagement and facilitating the understanding of complex scientific concepts. By integrating environmental issues, such as climate change and energy transition, into the curriculum, students are sensitized to urgent global challenges and prepared to face them in an informed and proactive manner. Furthermore, the success of these approaches relies on a continuous commitment to the professional development of educators, who must adapt their pedagogical resources to meet the specific needs of students. The combination of active methodologies with the teaching of environmental themes in geosciences offers a significant opportunity to make education more technical and engaging, preparing students for conscious involvement in global environmental issues and bridging the gap between basic and higher education.

Keywords: gamification in education; integrative review in education; innovative pedagogical practices; project-based learning; educational games in Geosciences

INTRODUCTION

Increasingly frequent environmental crises have intensified global concern about climate change and its impacts on fundamental aspects of life, such as biodiversity, natural resources, and the quality of life of populations (IPCC, 2018). Understanding these phenomena becomes even more urgent in a context where climate denialism and the rollback of environmental policies complicate the promotion of mitigating and adaptive actions (Layrargues, 2020).

Geoscience education provides a unique opportunity to integrate environmental topics while preparing students to understand and address global challenges such as climate change and the energy transition. Understanding climate dynamics, natural resource exploration, and sustainability are all inextricably linked to the geological processes that shape our planet over time (Batista *et al*., 2023). To

help students develop a thorough understanding of these phenomena, it is necessary to move beyond traditional teaching methods and adopt active methodologies that encourage greater engagement and practical application of scientific information. Gamification has emerged as an effective strategy for teaching subjects such as general geology, mineralogy, and petrography. Gamification, defined as the use of typical game elements in educational settings, improves the learning experience by making it more interactive and collaborative. At the Federal Institute of Amapá, for example, using games like "Pass or Play" and "Geological Scattergories" in Geosciences classes increased student engagement while also improving logical reasoning, teamwork abilities, and academic performance (Bezerra, 2021).

The success of these methodologies, however, is dependent on educators' ongoing professional development and the adaptation of pedagogical resources to the specific needs of students (Vörös, 2020). Geoscience education can better prepare students for global challenges by combining active methodologies with highly relevant environmental topics such as climate change and sustainable resource exploration (Bacich and Moran, 2017; Carvalho, 2022). Until the nineteenth century, school curricula prioritized classical languages and mathematics, in part because interdisciplinarity was required before progressing to geosciences, whose understanding was shaped by prevailing traditions (Ernesto *et al*., 2018). It is critical that environmental education, and more broadly, geoscience education, begin at the most fundamental levels and progress to more advanced knowledge by secondary school. Consider the ongoing debate over anthropogenic global warming. Regardless of current environmental indicators, it is critical to educate the public about natural cycles that affect the climate on a geological time scale (Ernesto *et al*., 2018).

The National Common Curriculum Base (BNCC, Base Nacional Comum Curricular) for Science Education for the Final Years recommends that teaching be structured around investigative activities, which is perfectly aligned with Geoscience education. Students can use critical thinking to understand geological processes such as rock formation, Earth's cycles, and climate change by observing the natural world and participating in scientific investigations. The BNCC's proposal to develop skills such as question formulation, problem analysis, investigation planning, and experiment execution has a clear practical application in geoscience education, where students are encouraged to investigate concepts such as plate tectonics, erosion, and climate change (Brasil, 2018).

Geography is integrated into the BNCC curriculum beginning in the early years of primary education, with an emphasis on the development of spatial thinking and geographical reasoning. This approach is critical for geoscience education because students must understand the interactions between Earth's physical processes and the spatial implications for climate and human life. Geographical reasoning allows students to better understand the distribution of natural resources and the effects of human activities on the planet, which is critical for addressing topics like sustainability and energy transition, both of which are highly relevant in geoscience education (Brasil, 2018).

The integrative review methodology is used in this study to investigate how active methodologies have been used in geoscience education whether in geology, geophysics, oceanography, or meteorology at the basic education level, with a focus on innovative practices that promote understanding of geological and environmental processes. This study aims to contribute to the development of educational strategies

that empower students to face contemporary environmental challenges and act responsibly in support of a more sustainable future by reviewing the most effective pedagogical approaches.

LITERATURE REVIEW

Considering that disciplines such as meteorology and climatology are integral to the geosciences, it is essential to explore how these fields can address contemporary socio-environmental concerns, particularly climate change. A review of curricular documents from institutions and educational networks reveals that the integration of geoscientific topics related to climate change remains insufficient (Farhat Junior *et al*., 2024). The inclusion of climate change concepts in the curriculum is crucial to forming more aware citizens, better equipped to confront future climatic and environmental challenges. Reports from the IPCC (2021) indicate that extreme weather events will become more frequent and intense, disproportionately affecting vulnerable populations, such as the elderly, children, and those living in poverty. Unregulated urbanization and population growth in large urban centers further exacerbate the effects of these changes. Therefore, a comprehensive and critical education in geosciences and climate change is essential to mitigate these impacts.

Leite *et al*., (2020) emphasize the importance of global climate governance through multilateral cooperation in promoting energy transition in developing countries like Brazil. International guidelines established to reduce environmental impacts, particularly in the energy sector, have a direct influence on domestic policies. Geoscientific knowledge is critical in this context because it lays the technical groundwork for the implementation of climate mitigation and energy security policies. Furthermore, Compiani (2015) emphasizes the importance of a critical pedagogy that integrates theoretical and practical approaches in geoscience education, fostering a link between scientific knowledge and its practical application in daily life. This allows students to connect the study of climate change to Earth's dynamics and their reality. Educational technologies, such as mobile apps, can also be used to boost student interest and autonomy, resulting in more meaningful learning (München and Schwanke, 2020).

Geology, as an integral part of geosciences, plays a central role in environmental education, particularly in addressing the preservation of the planet and the sustainable management of natural resources. The study of the Earth's spheres, such as the atmosphere, hydrosphere, and lithosphere, is crucial for understanding the impacts of human activities and the environmental disasters resulting from the indiscriminate use of natural resources (Portella, 2022). Developing a solid understanding of climate change and Earth’s geodynamics prepares students to become active and responsible citizens.

Within the Brazilian educational context, Law No. 13,415/2017 aims to update the National Common Curriculum Base (BNCC) for high school and provide greater flexibility to students by allowing curricular choices that may increase engagement and reduce dropout rates. The BNCC defines competencies and learning objectives in four areas of knowledge, with Portuguese and mathematics remaining mandatory throughout the three years of high school. However, concerns persist regarding educational gaps among different groups of young people, as well as a potential lack of emphasis on essential scientific principles, such as Earth Sciences, which are critical for addressing the environmental and natural resource

challenges of the 21st century.

According to Ernesto *et al*. (2018), it is clear that complex and multidisciplinary topics, such as Earth Sciences, necessitate a strong educational foundation. The absence of a more systematic approach to topics such as planetary dynamics and the effects of human interventions may impede our understanding of environmental processes. This is especially important when considering the need for a strong knowledge base for technical and policy decisions on environmental issues. Furthermore, comparing Brazil's performance in international assessments such as PISA reveals a position below the global average in mathematics and science, emphasizing the importance of investing in scientific and technological education for the country's economic and social growth. Although active methodologies are not a new concept, their use has grown as technology is increasingly integrated into education, providing students with numerous opportunities to contextualize situations and improve learning (Soares *et al*., 2024). These approaches include a variety of techniques and processes used by teachers in the classroom to help students learn.

According to Do Nascimento and Araújo (2024), there is a wide range of possible approaches with active methodologies, such as project-based learning, problem-based learning, gamification, flipped classroom, peer learning, rotation, À la Carte model, flex model, and enhanced virtual model, all effectively adapting to the needs of environmental education. Building on the new proposal of the BNCC, it is feasible to keep students engaged through planning and an interdisciplinary approach to the content. According to Arantes *et al*. (2021), an effective strategy would be to work with global themes that address issues impacting many or all members of a society. The application of active methodologies in Environmental Education is intrinsically linked to the diversity of real-life problem situations, promoting teaching that takes into account environmental, cultural, social, and political contexts, as well as the conditions in which knowledge is produced, utilized, and taught (De Assis *et al*., 2023).

INTEGRATIVE REVIEW METHODOLOGY

The integrative review is a research method that allows for a comprehensive analysis of existing knowledge, providing a broad overview of a specific topic. The integrative review was applied to examine educational practices related to Environmental Education and the use of active methodologies in teaching Geosciences, particularly in the context of climate change and sustainability. This approach enables the synthesis of various studies, generating new insights from previously published literature. In this work, a search was conducted in the databases of Google Scholar, SciELO, and CAPES Journals, using keywords such as "Active Methodologies in Environmental Education," "BNCC in Geosciences Teaching," "Environmental Education in Geosciences Teaching," and "Active Methodologies in Geosciences Teaching." The selection criteria included studies preferably published in journals ranked by CAPES Qualis, focusing on the application of Active Methodologies in Geosciences teaching, specifically from 2010 to 2024.

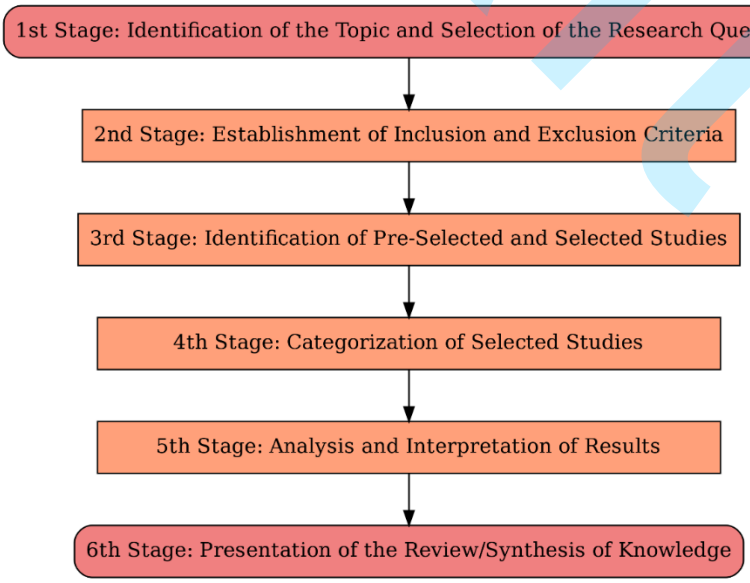
As highlighted by Whittemore and Knafl (2005), the integrative review has the potential to advance scientific knowledge as it integrates different concepts, methods, and results from previous research. This

methodology allows for the inclusion of studies with diverse approaches, both experimental and non-experimental, providing a broader and more contextualized view of the current state of knowledge. When conducted rigorously, the integrative review promotes a more consolidated and systematic theoretical understanding of the topic in question. To ensure the quality of the review, we followed the steps defined by Mendes *et al*., (2008), which organized the process in a clear and structured manner. The systematic flow of these steps is fundamental to the validity of the results and the identification of gaps in the literature, as well as to propose future directions for research.

Thus, the integrative literature review method was used to conduct a bibliographic review on environmental education and geosciences, addressing issues of sustainability and environmental awareness that are associated with critical thinking. This approach was chosen because of its ability to synthesize and analyze existing scientific knowledge on the subject at hand. This integrative review was primarily built on the work of Cooper (1988), Ganong (1987), Broome *et al*. (2000), Beyea and Nicoll (1998), Stetler *et al*. (1998), and Whittemore and Knafl (2005). The integrative review process is divided into distinct stages. These steps are shown in Figure 1.

Following the integrative review framework proposed by Mendes *et al*. (2008), the review process was conducted in six sequential stages, as illustrated in Figure 1. The first stage involved the identification of the research topic and the formulation of the guiding research question. The second stage consisted of establishing inclusion and exclusion criteria to define the scope of the review. In the third stage, pre-selected and selected studies were identified through systematic searches in the selected databases. The fourth stage involved the categorization of the selected studies according to their thematic focus and methodological characteristics. The fifth stage comprised the analysis and interpretation of the results. Finally, the sixth stage consisted of the synthesis and presentation of the knowledge obtained from the reviewed studies.

Figure 1 - Description Used as Classification of the Stages Applied in the Integrative Review Process.



Source: The Authors.

CLIMATE CHANGE FROM THE PERSPECTIVE OF GEOSCIENCES

Given that meteorology and climatology are part of the geosciences, it is critical to investigate how these fields can address contemporary socio-environmental issues, particularly climate change. A review of curricular documents from educational institutions and networks reveals that geoscientific themes related to climate change are still underrepresented (Farhat Junior *et al*., 2024). The inclusion of climate change concepts in the curriculum is critical for developing more informed citizens who are prepared to face future climate and environmental challenges. According to the IPCC (2021), extreme weather events will become more frequent and intense, disproportionately affecting vulnerable populations such as the elderly, children, and those living in poverty. Uncontrolled urbanization and population growth in major urban areas exacerbate the effects of these changes. Thus, comprehensive and critical education in geosciences and climate change is required to mitigate these effects.

Leite *et al*., (2020) emphasize the importance of multilateral cooperation in promoting the energy transition in developing countries such as Brazil. International guidelines established to reduce environmental impacts, particularly in the energy sector, have a direct influence on domestic policies. Geoscientific knowledge is critical in this context because it provides the technical foundations required to implement climate mitigation and energy security policies. Furthermore, Compiani (2015) emphasizes the importance of a critical pedagogy that integrates theoretical and practical practices in geosciences education, promoting the connection between scientific knowledge and practical application in everyday life. This allows students to connect the study of climate change to Earth's dynamics and their reality. Educational technologies, such as mobile apps, can also be used to boost student interest and autonomy (München and Schwanke, 2020), resulting in more meaningful learning.

Geology, as an integral part of the Earth Sciences, plays an important role in environmental education, particularly in addressing environmental preservation and sustainable resource management. The study of the Earth's spheres, such as the atmosphere, hydrosphere, and lithosphere, is critical for understanding the effects of human activity and environmental disasters caused by the indiscriminate use of natural resources (Portella, 2022). Students who gain a thorough understanding of climate change and Earth's geodynamics are better prepared to be active and responsible citizens.

PEDAGOGICAL PRACTICES ON ENVIRONMENTAL EDUCATION ACOORDING TO THE BNCC

The new National Common Curriculum Base (BNCC) serves as a guiding document for Brazilian schools' pedagogical projects, establishing clear guidelines for the roles of all curriculum components. Its goal is to provide students with a broad and integrated education that allows them to understand and interpret natural phenomena, develop critical and reflective thinking skills, and apply scientific knowledge to everyday problems (Soares *et al*., 2024).

The current version of the National Common Curriculum Base (BNCC) for High School, particularly in terms of Environmental Education (EE), aims to define the knowledge, competencies, and skills that all students should develop throughout their basic education. The BNCC suggests that EE be included as

a continuous educational practice throughout all stages of education rather than being treated as a separate subject in the school curriculum. Some authors, such as Sorrentino and Portugal (2016), believe that this approach reduces the emphasis on EE.

As established by Law No. 9,795, dated April 27, 1999, schools are responsible for promoting Environmental Education (EE). This law, which establishes the National Policy on Environmental Education (NPEE), defines Environmental education (EE) as the processes by which individuals and groups develop social values, knowledge, skills, attitudes, and competencies aimed at environmental conservation, which is necessary for a healthy quality of life and sustainability. According to the law, EE is a fundamental and permanent component of national education that must be integrated in a coordinated manner at all levels and modalities of the educational process, both formal and non-formal (Brazil, 1999).

Environmental Education (EE) should be implemented as an integrated educational practice throughout the schooling process, rather than as a separate subject in the curriculum. It is critical to emphasize that EE should be promoted interdisciplinary ally, rather than just through Natural Sciences components. According to Article 11 of Law No. 9,795, "the environmental dimension must be included in the teacher training curricula at all levels and in all subjects" (Brazil, 1999).

Although it is critical to promote interdisciplinary activities in Environmental Education (EE), educators face the difficult task of constantly seeking approaches and educational strategies that effectively enrich students' learning in this context (Callejo and Vila, 2003). In this sense, it is the educator's direct responsibility to invest in ongoing training, to constantly improve their teaching skills, and to ensure professional excellence (De Assis *et al*., 2023).

The restructuring of the National Common Curriculum Base (BNCC) for High Schools, introduced by Law No. 13,415/2017, aims to update the curriculum and provide students with more flexibility, allowing for curricular choices that can increase engagement and reduce school dropout rates. The BNCC establishes competencies and learning objectives in four knowledge areas, with Portuguese and mathematics remaining mandatory throughout the three years of high school. However, there are concerns about gaps in the education of young people from various groups, as well as a potential lack of essential scientific principles, such as Earth Sciences, which are critical for addressing the environmental and natural resource challenges of the twenty-first century.

According to Ernesto *et al*. (2018), complex and multidisciplinary topics, such as Earth Sciences, necessitate a comprehensive multidisciplinary school education. The lack of a more systematic approach to topics such as planetary dynamics and the consequences of human interventions can jeopardize our understanding of environmental processes. This is especially important when considering the need for a strong knowledge base for technical and policy decisions on environmental issues. Furthermore, comparing Brazil's performance in international assessments such as PISA reveals that it ranks lower than the global average in mathematics and science, emphasizing the importance of investing in scientific and technological education for the country's economic and social development.

Although active methodologies are not a new concept, their use has been boosted by the increased

incorporation of technology in the classroom, giving students numerous opportunities to contextualize situations and improve learning (Soares *et al*., 2024). These approaches include a variety of techniques and processes used by teachers during class to help students learn. Do Nascimento and Araújo (2024) suggest a variety of active methodologies, including project-based learning, problem-based learning, gamification, flipped classrooms, peer learning, rotation, À la carte models, flex models, and enhanced virtual learning, that can effectively address the needs of environmental education.

Building on the BNCC's new proposal, it is possible to engage students through planning and an interdisciplinary approach to content. According to Arantes *et al*. (2021), an effective strategy would be to work on global themes that address issues affecting many or all members of a society. The use of active methodologies in environmental education is inextricably linked to the variety of real-world problem situations, promoting teaching that considers environmental, cultural, social, and political contexts, as well as the conditions under which knowledge is produced, used, and taught (De Assis *et al*., 2023).

ACTIVE METHODOLOGIES IN ENVIRONMENTAL SCIENCE EDUCATION

Geoscience concepts are part of people's daily lives; topics in this field, such as climatology, are routinely taught to high school students. Zezzo *et al*., (2020) created educational materials based on a board game to be used as a pedagogical tool for promoting the learning of geoscience concepts, with a focus on climatology. The game was developed based on the BNCC and UNESCO-recommended topics for teaching climate change, as well as specific issues concerning South American geoscience. Students should be able to critically discuss the main topics of geosciences, climatology, and geography after using this material.

Based on the understanding that everyone has the right to a balanced environment for survival, the purpose of this study is to present a didactic sequence for teaching the socio-environmental theme within the topic of "Climate Change" under the BNCC. The authors created a didactic sequence based on project-based learning (PBL), and its implementation aims to promote a leadership role for students, grounded in contemporary themes, which will foster the development of critical thinking for understanding a complex reality, thereby assisting in the incorporation of the topic of climate change into the high school curriculum.

Teaching Environmental Sciences presents many challenges, some historical and others more recent (Machado *et al*., 2023). According to Moreira (2021), one of the oldest challenges is getting students interested in the content of natural science subjects. Teaching environmental physics using active methodologies empowers students to play an active role in the learning process, exploring scientific concepts in a practical and contextualized setting. Active methodologies, such as project-based learning, cooperative learning, and hands-on workshops, foster a more dynamic and engaging learning environment by encouraging students' curiosity and critical thinking (Bacich and Moran, 2017; Carvalho, 2022).

These methodologies can be especially effective when dealing with climate change. Workshops that include experiments on heat transfer and the greenhouse effect, for example, can help students better understand the physical processes that contribute to climate change. The use of digital technologies and

educational games can make learning more engaging and accessible. These tools can help students understand and engage by allowing them to visualize abstract and complex concepts. To address these challenges, active methodologies have emerged as an effective method of engaging students and increasing their participation in the learning process. Such methods encourage reflection, decision-making, and student autonomy (Berbel, 2011).

The case study method is an example of an active methodology that is useful in science education (Sá *et al*., 2007). These studies tell stories about situations in which people must make decisions in the face of dilemmas, encouraging the practical application of learned knowledge. Active methodologies are given this designation because they necessitate different types of interaction, including techniques and procedures that engage students in more complex activities. Such activities not only help students make decisions but also encourage them to evaluate and select strategies that support their learning (Moran, 2018).

The use of active methodologies in physics instruction can create a more dynamic and engaging learning environment, picking students' interest and enabling them to understand and address contemporary challenges such as climate change (Aeschbach *et al*., 2023). According to Aeschbach *et al*. (2023), the use of methodologies such as blended learning enables students to gain in-depth competencies while investigating the complexities of the climate system and the consequences of climate change. The intersection of physics and sustainability not only promotes a broader understanding of the climate crisis but also encourages reflection on the problem's complexities, connecting natural and social aspects for meaningful and engaged learning.

Gamification via digital games has been investigated as a promising educational tool with positive outcomes for the learning process (De Oliveira *et al*., 2023). These studies highlight students' increased interest in the content, the shift of the student's role from passive to active, the incorporation of environmental issues into the learning context, and the reduction of the perception of science as abstract and disconnected from reality (De Oliveira *et al*., 2023).

Dos Santos Bardini and Spalding's (2017) proposal emphasizes the effectiveness of active methodologies in the classroom with an environmental engineering case study. This includes Team-Based Learning (TBL) for group learning and discussions, the group dynamics activity "Hot Potato" for interactive participation, and technological resources such as Hot Potatoes and Kahoot for activities involving interactive software aimed at advancing technology. These methods, particularly TBL, improve student engagement because the teacher's role is critical for guidance. Despite some initial challenges with hot potatoes, the group dynamics activity was engaging, and the use of technology such as Kahoot made teaching more interesting.

The study conducted by Dos Santos Bardini and Spalding (2017) emphasized the importance of active teaching and learning methods in preparing students for emancipatory and independent learning. The "World Café" dynamic was praised as an innovative and critical educational approach that emphasized collaboration and idea exchange among educators and students. According to Ferraz and

Belhot (2010), defining learning objectives following Bloom's taxonomy had a significant impact on the selection of appropriate teaching strategies, encouraging students to develop increasingly complex skills. This experience demonstrates the effectiveness and importance of active methodologies in ensuring comprehensive learning and improving critical thinking, particularly in environmental contexts.

The approach by García *et al.*, (2017) discusses the use of virtual and augmented reality in environmental education, highlighting the importance of active methodologies for more meaningful learning. They emphasize the need to consider educational contexts and digital competencies when incorporating these technologies. The authors also note that, while these resources are valuable, they are not universal solutions to educational challenges but align with the contemporary approach to environmental education, which seeks to develop competencies through immersive experiences.

Fiori (2023) developed and implemented a pedagogical intervention plan for the subject "Environmental Sanitation" in the Technical Course in Environmental Studies at the IFAL Campus Marechal Deodoro. This plan called for three weeks of classes, with expositional activities on sanitation policies, the health consequences of inadequate infrastructure, and student-produced videos on sanitation-related diseases in their communities. The use of active methodologies was critical in encouraging student cooperation and facilitating a critical analysis of the region's sanitation situation and diseases, which resulted in meaningful environmental sanitation learning.

The proposal by Lima *et al*., (2023) aimed to utilize pedagogical practices in Class III of the Technical Course in Environmental Studies at IFMA, located at the temporary headquarters of Escola Sertão Maranhense, Advanced Campus Carolina. The inverted classroom method was employed, along with tools such as educational videos, gamification, and virtual visits via Google Meet. The activities were divided into four phases: an introduction with a guided study on environmental pollution, clarification of doubts, interactive videos to understand pollution, and assessment activities using tools such as Edpuzzle, Wordwall, and Plickers.

The findings revealed that students' interactions with various resources, such as videos, films, games, and animations, improved their performance and motivation in activities. This highlights the efficacy of interactive and technological approaches in promoting learning, as well as the importance of active methodologies for a more critical, inclusive education that meets current demands. This approach, as highlighted by Freire (1996), allows for the exploration of complex themes in a context that is relevant to students' lives, stimulating meaningful questioning and debate.

It is critical in physics education to go beyond simple mathematical calculations and develop competencies such as investigation and comprehension of the phenomena under consideration. Students must acquire practical and socially relevant knowledge by solving real-world problems using laws and theories (Barbosa, 2019). Unfortunately, active methodologies are still not receiving the attention they deserve. According to Moraes and Araújo (2012), the way physics is taught in schools has not evolved sufficiently over time, resulting in a disconnect between the content addressed and students' everyday lives, hindering their appreciation of this knowledge.

However, Soares *et al*. (2024) emphasize the importance of rethinking the teaching-learning process,

taking into account the fundamental roles of students, teachers, and pedagogical resources, in which teachers bear full responsibility for implementing these methodologies without the oversight of educational policies. Their research suggests incorporating environmental education activities into the new National Common Curriculum Base for High Schools, as well as using active methodologies as teaching tools in natural sciences and technologies. These methodologies, such as project-based learning, flipped classroom, and problem-based learning, seek to integrate theory and practice in ways that are consistent with the BNCC's competencies and skills for comprehensive student development.

DISCUSSION

The application of active methodologies in the teaching of geosciences has demonstrated great potential for engaging students in complex and relevant topics, such as climate change and sustainability. Recent studies indicate that these approaches, compared to traditional methods, are more effective in stimulating critical thinking and promoting meaningful learning (Machado *et al*., 2023). By involving students in practical and collaborative activities, such as gamification and project-based learning, it is possible to contextualize geoscientific concepts in a way that students understand their application in the real world (Bezerra, 2021).

These methodologies align directly with the recommendations of the National Common Curricular Base (BNCC), which proposes the integration of investigative activities in the natural sciences. The investigative structure fosters the development of essential skills, such as observation, analysis, and experimentation, which are crucial for understanding geological and environmental processes (Brazil, 2017). However, the implementation of these methodologies still faces challenges, particularly due to resistance to changes in the educational system and the difficulty of adapting traditional Natural Sciences teaching to a more interactive and practical approach (Machado *et al*., 2023).

Another important point is the need to begin introducing the concepts of geosciences and environmental education in the early years of schooling, as highlighted by Ernesto *et al*. (2018). Concepts such as global warming, plate tectonics, and energy transition, despite being more complex topics, can be addressed in an accessible and integrated manner in basic education, using methodologies that connect this knowledge to the students' realities. Through these connections, students can develop a deeper understanding of how geological processes affect their lives and how they can contribute to sustainability.

Furthermore, the relationship between geosciences and the United Nations Sustainable Development Goals (SDGs) offers a unique opportunity to apply scientific knowledge to practical issues, such as sustainable urban planning and natural resource management (Frazão, 2022). By connecting the teaching of geosciences with real-world problems, such as building more resilient cities and mitigating the impacts of climate change, students begin to recognize the value of earth sciences and their application in sustainable development.

Therefore, the combination of active methodologies and the incorporation of geoscientific topics into the school curriculum, aligned with the recommendations of the BNCC, represents a significant opportunity to transform the teaching of natural sciences. Creating dynamic and contextualized learning

experiences has the potential to bring students closer to the complex concepts of geosciences, preparing them to face global challenges in an informed and critical manner (García *et al*., 2017).

CONCLUSION

Active methodologies, such as gamification and project-based learning, play a crucial role in making the teaching of geosciences more dynamic and relevant for students. By engaging learners in practical and investigative activities, these approaches facilitate the understanding of complex concepts such as climate change, plate tectonics, and sustainability by connecting them with everyday reality and global environmental challenges.

However, for these practices to be successful, it is critical to continue investing in educators' professional development so that they can effectively apply these methodologies tailored to the needs of students. Teacher training is critical to making geoscience education more interactive and relevant, thereby bridging the gap between academic knowledge and practical application.

The incorporation of environmental themes into geoscience education is also critical for preparing students for the challenges of the twenty-first century. These educational practices enable students to act proactively and informedly by raising awareness of pressing environmental issues and encouraging critical reflection on the role of science in addressing global problems. As a result, the combination of active methodologies and environmental themes in geosciences education provides a unique opportunity to transform the learning experience. This approach not only helps students' academic development but also prepares them to be responsible citizens and change agents in their communities and around the world.

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