CONHECIMENTO & DIVERSIDADE
ISSN 2237-8049
UnilaSalle Editora

# ACTIVE METHODOLOGIES IN ENVIRONMENTAL EDUCATION: ENHANCING STUDENT ENGAGEMENT AND ADDRESSING CLIMATE CHANGE THROUGH INTERDISCIPLINARY APPROACHES

## *METODOLOGIAS ATIVAS NA EDUCAÇÃO AMBIENTAL: PROMOVENDO O ENGAJAMENTO DOS ESTUDANTES E ABORDANDO AS MUDANÇAS CLIMÁTICAS POR MEIO DE ABORDAGENS INTERDISCIPLINARES*

**Cássio da Cruz Nogueira**
Universidade Federal do Pará (UFPA), Belém, PA, Brasil
cassio.nogueira@itec.ufpa.br

**Ian Evanovich Vogado**
Universidade Federal do Pará (UFPA), Belém, PA, Brasil
ianevanovich852@gmail.com

**Luciane Vieira Malcher**
Universidade Federal do Pará (UFPA), Belém, PA, Brasil
lucianemalcher@live.com

**Gabriel Leal Rezende**
Universidade Federal do Pará (UFPA), Belém, PA, Brasil
gabriel_ppgg@hotmail.com

## ABSTRACT

This article addresses the application of active methodologies in the teaching of environmental sciences, highlighting their potential to make learning more engaging and relevant. The study employs an integrative review to examine research on environmental education and sustainability, focusing on themes related to climate change and its integration into active learning methodologies. These methodologies promote critical thinking and connect learning with real-world challenges. The National Common Curriculum Base (BNCC) is discussed for its role in promoting interdisciplinary environmental education. Although active methodologies are effective, challenges remain, such as the need for continuous professional development for teachers and the updating of pedagogical practices. The article emphasizes the importance of adapting pedagogical resources to meet students's needs, providing a more contextualized education that empowers them as active citizens.

**Keywords:** Active methodologies, Environmental education, Integrative review, BNCC, Climate change, Student engagement.

**RESUMO**

Este artigo aborda a aplicação de metodologias ativas no ensino de ciências ambientais, destacando seu potencial para tornar a aprendizagem mais envolvente e relevante. O estudo utiliza uma revisão integrativa para examinar pesquisas sobre educação ambiental e sustentabilidade, com foco em temas que envolvem as mudanças climáticas e sua integração ao aprendizado baseado em metodologias ativas. Essas metodologias promovem o pensamento crítico e a conexão da aprendizagem com desafios do mundo real. A Base Nacional Comum Curricular (BNCC) é discutida por seu papel em promover a educação ambiental interdisciplinar. Embora as metodologias ativas sejam eficazes, ainda existem desafios, como a necessidade de desenvolvimento contínuo de professores e a atualização das práticas pedagógicas. O artigo ressalta a importância de adaptar os recursos pedagógicos para atender às necessidades dos alunos, proporcionando uma educação mais contextualizada e que os capacite como cidadãos ativos.

**Palavras-chave:** Metodologias ativas, Educação ambiental, Revisão integrativa, BNCC, Mudanças climáticas, Engajamento estudantil.

## Background

The increasing frequency of environmental disasters has raised concerns about climate change and its effects. These changes have had a significant impact on key aspects of human life, including biodiversity, natural resources, and population health (IPCC, 2018).

The late 2010s saw a decline in environmental governance in Brazil, as well as an increase in climate change denial and its environmental consequences (Layrargues, 2020). In this context, addressing this issue in educational settings is critical, as understanding and creating knowledge about climate change is key for supporting mitigation and adaptation strategies (De Jesus; Cafofo & Ferracioli, 2023).

Solar radiation, which is critical to understanding the warming of the Earth's surface and atmosphere, is responsible for a variety of changes on the globe. Oceans and continents absorb approximately 50% of UV energy, turning it into infrared radiation and generating heat. Approximately 29% is reflected in space, while the remaining is kept within the atmosphere (Fernandes *et al*., 2023). Because the sun is hot, it emits energy in the form of short-wave radiation, primarily in the ultraviolet and visible spectrums.

Until the 19th century, school curricula prioritized classical languages and mathematics, neglecting the teaching of natural sciences, whose understanding was conditioned by prevailing traditions (Ernesto *et al*., 2018). With the Industrial Revolution, the transformative potential of science and technology in the economy was recognized, leading to the formalization of physics, chemistry, and geology education to prepare future educators in these fields. According to the author:

> It is essential that environmental education, and more broadly, Geoscience education, begin at the most fundamental levels of schooling and progress toward more in-depth knowledge in secondary education. Take, for example, the debate surrounding anthropogenic global warming, which has been a contemporary topic of discussion. Despite the current environmental indicators, it is also crucial to educate the population about the natural cycles that affect the climate on a geological time scale (Ernesto *et al*., 2018).

Educational institutions play an important role in disseminating information and stimulating critical debate regarding climate phenomena and their societal consequences (Batista; Donato and De Siqueira Pinto, 2023). It is critical to create educational programs that increase awareness of climate change and stimulate the development of long-term solutions (Da Silva *et al*., 2021). Education is critical for preparing future generations to confront environmental concerns and to behave responsibly in creating a more resilient and sustainable future (Vörös, 2020).

Practical workshops in physics education are an engaging instructional technique that offers students a deeper grasp of physical processes related to climate and the atmosphere, as well as their interaction with climate change (De Oliveira, 2021). Currently, it remains a significant challenge to pique students' interest in natural science topics, allowing them to develop critical thinking on these subjects, a vital competence in the exact sciences that involves connecting critical reasoning with an understanding of nature for the benefit of humanity (Moreira, 2021). Teaching climate physics, when linked with the Education for Sustainable Development method, underlines the necessity of integrating sustainability and climate change topics into the school curriculum (Aeschbach, 2023).

The advancement of educational approaches is required since the employment of active methods promotes student involvement and results in more effective learning, outperforming old practices in which students primarily interact passively. This situation requires students to adapt to new technologies and, as a result, apply them to the setting of natural sciences. According to this viewpoint, active pedagogies allow students to play a central part in their learning process, while professors use an approach that goes beyond the mechanical teaching that is still prevalent in many educational institutions (Carvalho, 2022; Bacich & Moran, 2017).

The National Common Curriculum Base (BNCC), specifically in the subject of Natural Sciences for the Final Years, suggests that teaching be centered on exploratory activities. This enables students to develop a variety of competencies and skills, including observing the world, formulating questions, analyzing problems, planning investigations, proposing solutions, conducting experiments, developing and deploying digital tools, and participating in scientific debates (Brasil, 2017).

This study seeks to investigate published works that address the issue of climate change in the context of natural sciences education, with a focus on the use of active techniques, namely Minayo (2001) methodology, in conjunction with an integrative review. We propose to study how these strategies have been utilized to improve students' awareness of climate change and its consequences, focusing on the most effective pedagogical approaches in this regard. This study aims to present a holistic view of how educational methods might be changed to address contemporary environmental concerns, emphasizing the importance of environmental sciences as a tool for raising awareness and promoting climate action.

## Literature review

Climate change represents one of the greatest challenges of our time, impacting various aspects of life, from agriculture to rising sea levels, exacerbating erosion and natural disasters, and destabilizing populations and the environment on an unprecedented global scale (Fleury; Miguel & Taddei, 2019).

In the 19th century, mathematician Jean Fourier was the first to realize that the Earth's atmosphere acts like a greenhouse, creating a conducive environment for plant and animal life. He observed that atmospheric gases absorb energy in the form of heat, raising the Earth's surface temperature (Silva, 2015). Another significant scientist, Svante Arrhenius, developed a mathematical model to study the influence of carbon dioxide in the atmosphere on the Earth's temperature. In 1896, Arrhenius calculated the temperature increase that would occur if the amount of CO2 in the atmosphere doubled, based on the greenhouse effect concept introduced by Fourier (Silva, 2015).

The greenhouse effect is a natural phenomenon that keeps the Earth's average temperature around 15°C. However, the increasing concentration of greenhouse gases intensifies this effect, hindering the dissipation of heat into space and resulting in atmospheric warming and climate change (Fernandes *et al*., 2023). Human activity has accelerated the pace of environmental changes, with studies indicating that the global average temperature has increased by approximately 5°C over the last 10,000 years, and it could rise by the same 5°C in just 200 years if the current rate of greenhouse gas emissions continues (Silva, 2015). In this context, the role of schools becomes crucial in disseminating and engaging in reflective discussions on environmental issues, as well as in developing students' knowledge. Environmental education emerges as a contemporary transversal theme in the new National Common Curriculum Base (Brasil, 2018). The topic of climate change is well-suited to be implemented in a climate physics module, as it has the potential to contribute to the training of physics teachers and environmental education in physics in schools (Aeschbach, 2023).

Our planet faces significant crises, such as biodiversity loss and the climate emergency. These crises are interconnected and stem from an economic model that prioritizes development and quick profits over sustainability, resulting in global social and economic impacts (Artaxo, 2020). The numerous human actions in nature, especially since the eighteenth century with industrialization, have contributed to a variety of environmental crises, particularly climate change, which has adversely affected all ecosystems worldwide (De-Carvalho & Matei, 2019). Industrialization, population growth, and urbanization have jeopardized the idea of sustainable development (Vieira, 2020). From a capitalist perspective, profit and consumption are often prioritized over the preservation of natural resources and the well-being of people. Environmental education is an essential component of the process to promote changes in consumption and production patterns to achieve truly sustainable societies.

> Environmental education is a fundamental condition for the formation of future citizens, and it is our responsibility as educators to empower students by incorporating in our lesson plans content that addresses socio-environmental problems and solutions. (Lins & Fernandes, 2021).

Current data show considerable alterations in hydrological variables in the Atlantic Forest biome, demonstrating pronounced changes in drought and flood patterns and the resulting extinction of ecosystems (De Jesus & Ferracioli, 2023). In this context, De Jesus & Ferracioli (2023) designed a workshop for elementary and high school students to think about climate change, as illustrated in Figure 1. The program combined topics from physics, biology, chemistry, and mathematics, emphasizing the link between theory and practice while also drawing on citizen science and the National Common Curriculum Base.

Figure 1 – The data collection scheme at the São Pedro Stream features silhouettes representing participating students (gray, dark, and dashed gray). Sampled areas are marked by red dashes, indicating various angles

Source: De Jesus e Ferracioli (2023).

As challenges faced by modern society require collective actions to redefine productive, cultural, and social standards in pursuit of sustainable coexistence. Souza (2020) examined an environmental education project conducted by Vale and Emef Eber Louzada Zippinotti in Vitória (ES). The project's goal was to raise students' awareness about the environment and encourage them to adopt sustainable practices to leave a positive legacy for future generations.

Thus, environmental education is crucial for raising awareness and mitigating the impacts of climate change while protecting the environment (Fernandes *et al*., 2023). To combat greenhouse gas emissions, conservation policies and international cooperation are necessary (Fernandes *et al*., 2023). Pereira, Cavalcante, & S. Júnior (2021) emphasize the importance of increasing public awareness, especially among young people, so they can adopt sustainable practices and ensure a future where sustainability is a priority for all forms of life on the planet.

Cunha (2021) investigated students' perceptions of science, concentrating on the connections between science, technology, and society (STS). The study found that issues like climate change and deforestation are more relevant to high school students than traditional scientific topics. It is critical to teach essential concepts in environmental physics, which can be difficult to understand. As a result, it is critical to provide explicit explanations of time and climate, as well as terms like heat quantity, heat exchange, and temperature. At the same time, it is critical to address many aspects of the greenhouse effect, climate variability, and climate change (Vörös, 2020).

## Heat Transfer in the Dynamics of Climate Change

The understanding of heat transfer plays a fundamental role in the study of global climate change. Through processes such as radiation, convection, and conduction, heat is distributed and redistributed across the Earth's surface, directly influencing climate patterns and environmental conditions (IPCC, 2018). This understanding is essential for grasping the current and future context of environmental issues and how they affect our planet.

However, human activities, such as the burning of fossil fuels and deforestation, have increased concentrations of greenhouse gases in the atmosphere, intensifying the global warming process and altering natural patterns of heat transfer. As a result, we are witnessing significant changes in climate patterns, extreme weather events, and environmental impacts on a global scale. For instance, the harvest in 2024 is expected to be 3.8% lower than in 2023 due to climate change and an increase in average high-temperature days in Brazil, with 65.9 additional days recorded (IBGE, 2024).

Therefore, understanding the physics behind heat transfer in the dynamics of climate change is crucial for predicting and mitigating the effects of climate change, which are likely to intensify. Ongoing research in this area is essential for developing awareness and mitigation strategies and ensuring environmental sustainability for future generations (De Jesus; Cafofo & Ferracioli, 2023).

Topics such as thermology, calorimetry, and thermodynamics hold significant importance in scientific understanding, particularly because they stem from practical origins, evidenced in everyday phenomena and advancements from the First Industrial Revolution (Silva, 2018). This allows us to conduct low-cost experiments, addressing complex subjects in contexts with limited financial resources for more robust materials (Brito; Oliveira & Heredia, 2023). The use of educational games for more abstract subjects is also beneficial, providing interactive learning experiences that capture students' attention (Kettenhuber & Santos, 2020).

**Methodology**

This article follows the principles of Minayo (2001) qualitative approach and uses integrative review methodology to conduct a comprehensive analysis of existing knowledge in previous research on environmental education, with a focus on sustainability and environmental awareness. This method allows for the synthesis of numerous published studies, resulting in the production of new insights based on the findings of these research endeavors.

A bibliographic survey was undertaken using digital platforms such as Google Scholar, Scielo, and CAPES journals to provide a theoretical framework. The selection criteria included studies published between 2004 and 2024 that used the following Portuguese keywords: "Active Methodologies in Environmental Education

Teaching," "Environmental Education," "Active Methodologies in Environmental Physics Teaching," "Active Methodologies in Environmental Sciences Teaching," "Climate Change in Science Education," "BNCC in Environmental Education." Articles that directly addressed these themes were selected using an integrative review approach. The exclusion criteria took into account works that did not offer practical uses of active approaches in environmental education, with a focus on more recent research.

The term "integrative" refers to the integration of many perspectives, concepts, or ideas gleaned via the method's research. As Whittemore & Knafl (2005) point out, here is where the opportunity for scientific advancement emerges. A well-executed integrated review presents the current level of knowledge in environmental education, helping to advance theoretical growth. This methodological approach allows for the inclusion of research that employs a variety of techniques, including experimental and non-experimental designs.

To ensure the success of the integrative review, researchers must take strict care throughout its implementation, as noted by Whittemore & Knafl (2005). The absence of defined and systematic methodologies can lead to a large margin of error at any level of the review process. For example, if relevant primary sources are neglected during the initial portion of the literature search, it may jeopardize the results. Furthermore, data from these primary sources may be obtained insufficiently or interpreted improperly.

Another critical part is data analysis in the integrated review. According to Whittemore & Knafl (2005), this approach provides substantial difficulty for academics because it requires the study and synthesis of many sources, which are intrinsically complex.

In this study, the integrative literature review was used to conduct a bibliographic review on environmental education, which addressed concerns of sustainability and environmental consciousness. This approach was chosen due to its capacity to combine and analyze existing scientific knowledge on the subject. This integrative review is mostly based on the research of Cooper (1988), Ganong (1987), Broome (2000), Beyea & Nichll (1998), Stetler *et al*. (1998), and Whittemore and Knafl (2005).

The integrated review method, as stated by Mendes, Silveira, and Galvão (2008), follows a systematic flow to assure review quality and validity. These phases are critical to ensuring that the integrative review is carried out carefully and comprehensively, yielding major insights and contributions to the advancement of knowledge in the field of environmental education.

The integrative review process follows a series of well-defined steps. These steps are represented in Table 1 and will be described in detail below.

Table 1 – Description Used as Classification of the Stages Applied in the Integrative Review Process

| INTEGRATIVE REVIEW | | | | | |
|---|---|---|---|---|---|
| 1ª Stage | 2ª Stage | 3ª Stage | 4ª Stage | 5ª Stage | 6ª Stage |
| Identification of the Topic and Selection of the Research Question. | Establishment of Inclusion and Exclusion Criteria. | Identification of Pre-Selected and Selected Studies. | Categorization of Selected Studies. | Analysis and Interpretation of Results. | Presentation of the Review/Synthesis of Knowledge. |
| Definition of the problem. Formulation of a research question. Definition of descriptors. Definition of databases. | Use of databases. Search for studies based on inclusion and exclusion criteria. | Reading the abstract, keywords, and title of publications. Organization of pre-selected studies. Identification of selected studies. | Development and use of the Synthesis Matrix. Categorization and analysis of information. Formation of an individual library. Critical analysis of the selected studies. | Discussion of the results. | Creation of a document detailing the review. Proposals for future research. |

Source: The Authors.

## Pedagogical Practices on Environmental Education According to the BNCC

As a guiding document for the pedagogical projects of Brazilian schools, the new Base Nacional Comum Curriculum (BNCC) establishes clear directives regarding the role of all curricular components. Its goal is to provide students with a broad and integrated education, enabling them to understand and interpret natural phenomena, develop critical and reflective thinking, and apply scientific knowledge to solve everyday problems (Soares *et al*., 2024).

Considering the current version of the BNCC for High School, particularly regarding Environmental Education (EA), the document aims to define the knowledge, skills, and competencies that all students should develop throughout their basic education (Brasil, 2018). The BNCC proposes that EA be incorporated as a continuous educational practice at all levels of teaching rather than being treated as a separate discipline in the school curriculum. Some authors, such as Sorrentino and Portugal (2016), view this approach as a reduction in the emphasis on EA.

It is important to highlight that schools have the responsibility to promote EA, as established by Law No. 9,795, of April 27, 1999. This law, which institutes the National Policy on Environmental Education (PNEA), defines EA as the processes through which individuals and groups build social values, knowledge, skills, attitudes, and competencies aimed at environmental conservation, essential for healthy quality of life and sustainability. The law stipulates that EA is a fundamental and permanent component of national education, to be integrated coherently at all levels and modalities of the educational process, both formal and non-formal (Brasil, 1999). EA should be implemented as an integrated educational practice at all stages of schooling rather than being treated as a specific discipline within the curriculum. It is crucial to emphasize that EA should be promoted interdisciplinarily, not solely through the curriculum components of the Natural Sciences area. According to Article 11 of Law No. 9,795, "the environmental dimension must be included in the teacher training curricula at all levels and all subjects" (Brasil, 1999).

However, while it is vital to promote interdisciplinary EA activities, it is the educator's challenging task to continually seek educational approaches and strategies that effectively enrich students' learning in this context (Callejo & Vila, 2003). In this regard, it is the educator's direct responsibility to invest in continuous professional development, aiming to enhance their teaching skills and ensure excellence in their profession (De Assis *et al*., 2023). The restructuring of the BNCC for High Schools, introduced by Law No. 13,415/2017, aims to update the curriculum and offer greater flexibility to students, allowing curricular choices that can increase engagement and reduce school dropout rates (Brasil, 2017). The BNCC establishes competencies and learning objectives across four areas of knowledge, maintaining Portuguese and mathematics as mandatory subjects throughout the three years of high school. However, there are concerns regarding gaps in young people's education across different groups and the potential shortfall in essential scientific principles, such as Earth Sciences, which are crucial for addressing environmental and natural resource challenges in the 21st century.

According to Ernesto *et al*. (2018), it is evident that complex and multidisciplinary topics, such as Earth Sciences, require a robust multidisciplinary educational foundation. The lack of a more systematic approach to themes such as planetary dynamics and the impacts of human interventions may compromise the understanding of environmental processes. This becomes even more critical when considering the need for a solid knowledge base for technical and political decisions on environmental issues. Furthermore, comparisons of Brazil's performance in international assessments, such as PISA, reveal a position below the global average in mathematics and science, highlighting the urgency for investments in scientific and technological education for the country's economic and social development.

Although active methodologies are not a novelty, their use has been enhanced by the increasing employment of technologies in teaching, providing students with ample opportunities to contextualize situations and improve learning (Soares, 2024). These approaches encompass a variety of techniques and processes employed by teachers during classes to facilitate student learning.

According to Do Nascimento & Araújo (2024), 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 can effectively adapt to the needs of environmental education. The new BNCC proposal suggests that engaging students through planning and an interdisciplinary approach is possible.

The application of active methodologies in EA is intrinsically linked to the diverse problem situations present in everyday life, 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 Teaching Environmental Sciences

Starting from the understanding that everyone has the right to a balanced environment for their survival, this study aims to present a didactic sequence for teaching socio-environmental themes within the topic of "Climate Change," following the BNCC (Faria; Ramos & Coltri, 2021). The authors developed this sequence based on project-based learning (PBL), intending to promote a proactive role for students grounded in contemporary themes, which will foster the critical thinking necessary for comprehending a complex reality and facilitating the integration of climate change into the high school curriculum.

The teaching of physics and environmental sciences faces various challenges, some rooted in the past and others more recent (Machado *et al*., 2023). According to Moreira (2021), one of the oldest challenges is sparking students' interest in the content of natural science subjects. Teaching environmental physics through active methodologies allows students to take a central role in the learning process, exploring scientific concepts in a practical and contextualized manner. Active methodologies, such as project-based learning, cooperative learning, and hands-on workshops, create a more dynamic and engaging learning environment, stimulating curiosity and critical thinking (Carvalho, 2022; Bacich & Moran, 2017).

These methodologies can be especially effective when dealing with climate change. Workshops that include heat transfer and greenhouse effect experiments, for example, can help students better understand the physical processes that drive climate change. Furthermore, projects that investigate the local impacts of climate change can connect scientific learning to real-world environmental issues, increasing students' relevance and motivation (De Jesus; Cafofo & Ferracioli, 2023).

The integration of digital technologies and educational games can make learning more interactive and accessible. These tools can help visualize abstract and complex concepts, facilitating understanding and engagement (Kettenhuber &

Santos, 2020). To tackle these challenges, the use of active methodologies has emerged as an effective approach to engaging students, making them more participative in the learning process. Such methodologies facilitate reflection, decision-making, and student autonomy (Berbel, 2011).

A relevant example of an active methodology is the case study method, which proves valuable in teaching sciences (Sá; Francisco & Queiroz, 2007). These studies provide narratives about situations in which individuals must make decisions in the face of dilemmas, promoting the practical application of acquired knowledge.

Active methodologies are designated as such because they require different forms of interaction, involving techniques and procedures that engage students in more complex activities. These activities not only encourage decision-making but also motivate students to evaluate and choose strategies that support their learning (Moran, 2018).

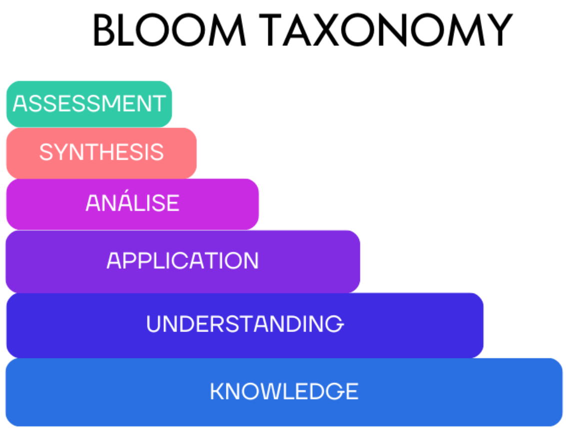
Integrating active methodologies into physics education can create a more dynamic and engaging learning environment, awakening student interest and empowering them to understand and confront contemporary challenges such as climate change (Aeschbach *et al*., 2018). According to Aeschbach *et al*. (2018), employing methodologies like blended learning allows students to acquire in-depth competencies by exploring the complexities of the climate system and the implications 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 super complexity of the problem, connecting natural and social aspects for meaningful and engaged learning.

Gamification through digital games has been explored as a promising educational tool, revealing positive outcomes for the learning process (De Oliveira *et al*., 2023). These studies highlight increased student interest in content, a shift from passive to active student roles, the integration of environmental issues into learning contexts, and a reduction in the perception of sciences as abstract and disconnected from reality (De Oliveira *et al*., 2023).

The proposal by Dos Santos Bardini & Spalding (2017) emphasizes the effectiveness of active methodologies in the classroom, showcasing a case study in environmental engineering. This includes Team-Based Learning (TBL) for group learning and discussions, the interactive group dynamic "Hot Potato," and technological resources such as Hot Potatoes and Kahoot for activities with interactive software, aiming for technological advancement. These approaches enhance student engagement, particularly TBL, with the teacher's role being crucial for guidance. The group dynamic was animated, and the use of technology like Kahoot made teaching more interesting, despite some initial challenges with Hot Potatoes.

The study conducted by Dos Santos Bardini & Spalding (2017) underscored the relevance of active teaching-learning methods in equipping students for emancipatory and autonomous learning. The "World Café" dynamic was highlighted as an innovative and critical educational approach, emphasizing collaboration and idea exchange between educators and students. According to Ferraz & Belhot (2010), the prior definition of learning objectives, aligned with Bloom's taxonomy, significantly contributed to the selection of appropriate teaching strategies, encouraging students to develop progressively more complex skills, as demonstrated in Figure 2. This experience highlights the effectiveness and importance of active methodologies in ensuring comprehensive learning and enhancing critical thinking, especially in contexts related to the environment.

Figure 2 – Simplified representation of Bloom's Taxonomy, divided into subcategories to guide instructional objectives and clarify their distinctions




Source: The authors.

The approach by García, Ortega, & Zednik (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 stress that while these resources are valuable, they are not universal solutions to educational challenges but are aligned with the contemporary approach to environmental education, which seeks to develop competencies through immersive experiences.

The work of Fiori *et al*. (2023) involved the development and implementation of a pedagogical intervention plan for the "Environmental Sanitation" course in the Technical Environment Program at IFAL Campus Marechal Deodoro. This plan included three weeks of classes, featuring lectures on sanitation policies, health consequences due to inadequate infrastructure, and student-produced videos about sanitation-related diseases in their communities. The use of active methodologies was crucial in promoting cooperation among students and fostering a critical analysis of the sanitation situation and diseases in the region, resulting in meaningful learning about environmental sanitation.

Lima *et al*. (2023) proposed to apply pedagogical practices in Class III of the Technical Environment Program at IFMA, located at the provisional headquarters of Escola Sertão Maranhense, Campus Avançado Carolina. They employed the flipped classroom method alongside 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 like Edpuzzle, Wordwall, and Plickers.

The results obtained revealed how students' interaction with a variety of resources, including videos, films, games, and animations, positively contributed to their performance and motivation in the activities. This underscores the effectiveness of interactive and technological approaches in promoting learning while reinforcing the importance of active methodologies for a more critical, inclusive education aligned with contemporary demands. This approach, as highlighted by Freire (1994), facilitates the exploration of complex themes in a contextualized manner, close to the students' realities, stimulating meaningful questioning and debate.

In the teaching of physics, it is crucial to go beyond simple mathematical calculations and develop competencies such as investigation and understanding of the studied phenomena. Students need to acquire practical and socially relevant knowledge, applying laws and theories to solve real-world problems (Barbosa, 2019). Unfortunately, active methodologies have not yet received the necessary attention. As highlighted by Moraes & Araújo (2012), the way physics is taught in schools has not evolved sufficiently over time, resulting in a disconnect between the content covered and students' daily lives, making it difficult for them to value this knowledge.

However, Soares *et al*. (2024) emphasize the importance of rethinking the teaching-learning process, considering the fundamental roles of students, teachers, and pedagogical resources, where teachers bear the full responsibility for incorporating these methodologies without oversight from educational policies. Their study proposes the inclusion of environmental education activities in the new National Common Curriculum (BNCC) for high school, utilizing active methodologies as teaching tools in the natural sciences and their technologies. These methodologies, such as project-based learning, flipped classroom, and problem-based learning, aim to integrate theory and practice in alignment with the competencies and skills defined by the BNCC for the comprehensive formation of students.

## Discussion

The discussion around active methodologies in teaching, especially in the context of environmental physics, reveals several key points (Machado *et al*., 2023). The benefits of these approaches in engaging and improving student performance are notable, particularly when compared to traditional teaching methods. This scenario aligns with the perspective of Da Silva *et al*. (2021), who advocate for the development of educational strategies to enhance understanding of climate change and promote the search for sustainable solutions.

According to Do Nascimento & Araújo (2024), active methodologies offer a wide range of approaches adaptable to the needs of environmental education. Among these approaches are project-based learning, problem-based learning, gamification, peer learning, rotation, À la carte models, flex models, and enhanced virtual models. Strategies such as the flipped classroom and the use of educational videos and games have stood out for stimulating student interest and promoting more meaningful learning. However, it is important to recognize that the effective implementation of active methodologies still faces challenges (Machado *et al*., 2023). One of the main obstacles is the lack of evolution in the way Natural Sciences are taught in schools, resulting in a disconnect between the content covered in class and the reality of students (Moraes & Araújo, 2012). This gap undermines the value students place on scientific knowledge and highlights the need for updating and adapting teaching methods.

In this regard, incorporating environmental education activities into the National Common Curriculum (BNCC) for high school is a significant step forward (Soares *et al*., 2024). Students can relate environmental concepts to practical and pressing issues like climate change by linking environmental themes with active methodologies in science education. This not only makes learning more relevant and contextualized but also prepares students to confront real-world challenges in an informed and proactive manner.

Therefore, the combination of active methodologies and environmental education presents an exciting opportunity to transform the teaching of natural sciences, making it more engaging, inclusive, and aligned with contemporary demands (García, Ortega, & Zednik, 2017). To ensure the success of this approach, it is essential to invest in teacher training, update pedagogical resources, and create a learning environment that encourages active student participation (Aeschbach, 2023; Brasil, 1999; De Assis *et al*., 2023).

ISSN 2237-8049
UnilaSalle Editora

## Conclusion

Active methodologies in the teaching of environmental sciences play a crucial role in making learning more engaging, inclusive, and relevant for students. The interaction of learners with a variety of resources, combined with strategies that encourage active participation, has shown significant results in promoting meaningful learning. However, for these approaches to be successfully implemented, it is essential to continue exploring and refining these practices, adapting them to the individual needs of students, and ensuring a more critical and contextualized education. This requires a continuous commitment to the professional development of educators and the adaptation of pedagogical resources to meet students' demands.

Therefore, the combination of active methodologies and environmental themes in the teaching of environmental sciences represents an exciting opportunity to promote a more engaged, inclusive, and relevant education for the contemporary world. This approach not only contributes to the academic development of students but also empowers them to be conscious and active citizens in their communities and the world, serving as a means of extending the Natural Sciences and bridging academic knowledge with everyday life.

## REFERENCES

AESCHBACH, Nicole *et al*. Climate Physics meets Education for Sustainable Development: How to address wicked problems through blended learning. HINT. *Heidelberg Inspirations for Innovative Teaching*, v. 4, n. 1, p. 47-71, 2023. Available at: https://journals.ub.uni-heidelberg.de/index.php/hint/article/view/101927. Accessed: 20 Jul. 2024.

ARTAXO, Paulo. As três emergências que nossa sociedade enfrenta: saúde, biodiversidade e mudanças climáticas. *Estudos avançados*, v. 34, p. 53-66, 2020. Available at: https://www.scielo.br/j/ea/a/TRsRMLDdzxRsz85QNYFQBHs/?format=html. Accessed: 7 Jun. 2024.

ISSN 2237-8049
UnilaSalle Editora

BATISTA, Antônio Vitor Santos; DONATO, Christiane Ramos; DE SIQUEIRA PINTO, Alexandre. A abordagem das mudanças climáticas nos livros didáticos de Ciências da Natureza da rede pública estadual de Sergipe. *Scientia Plena*, v. 19, n. 12, 2023. Available at: https://www.scientiaplena.org.br/sp/article/view/7312. Accessed: 12 Jul. 2024.

BACICH, Lilian; MORAN, José. Metodologias ativas para uma educação inovadora: uma abordagem teórico-prática [recurso eletrônico]. Porto Alegre: Penso Editora, 2017. Available at: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://edisciplinas.usp.br/pluginfile.php/7722229/mod_resource/content/1/Metodologias-Ativas-para-uma-Educacao-Inovadora-Bacich-e-Moran.pdf. Accessed: 13 Jul. 2024.

BRASIL. Base Nacional Curricular Comum. Ensino Fundamental. Brasília: Conselho Nacional de Educação, 2017. Available at: http://basenacionalcomum.mec.gov.br/abase . Accessed: 17 Jul. 2024.

BRASIL. Lei n. 9.795, de 27 de abril de 1999. Dispõe sobre a educação ambiental, institui a Política Nacional de Educação Ambiental e dá outras providências. Diário Oficial da União, Brasília, 28 abr. 1999. Available at: http://www.planalto.gov.br/ccivil_03/leis/l9795.htm . Accessed: 1 sep. 2024.

BERBEL, Neusi Aparecida Navas. As metodologias ativas e a promoção da autonomia de estudantes. *Semina: Ciências sociais e humanas*, v. 32, n. 1, p. 25-40, 2011. Available at: https://ojs.uel.br/revistas/uel/index.php/seminasoc/article/view/10326 . Accessed: 10 Jun. 2024

BEYEA, Suzanne; NICHLL, Leslie H. Writing an integrative review. *AORN journal*, v. 67, n. 4, p. 877-881, 1998. Available at: https://go.gale.com/ps/i.do?id=GALE%7CA20972821&sid=googleScholar&v=2.1&it=r&linkaccess=abs&issn=00012092&p=AONE&sw=w&userGroupName=anon%7E96e67c3e&aty=open-web-entry . Accessed: 2 Jun. 2024.

BRITO, L. G.; OLIVEIRA, RPF; HEREDIA, J. R. Análise de experimento de baixo custo para o ensino de processos de transferência de calor. 2023. Available at: https://eventos.ifnmg.edu.br/if_integra_2023/6506344653d19.pdf . Accessed: 3 Jun. 2024.

BROOME, Marion E. *et al*. Integrative literature reviews for the development of concepts. *Concept development in nursing: foundations, techniques and applications*. Philadelphia (USA): WB Saunders Company, p. 231-50, 2000. Available at: https://www.scielo.br/j/reeusp/a/3ZZqKB9pVhmMtCnsvVW5Zhc . Accessed: 29 Jul. 2024.

CALLEJO, María; VILA, Antoni. Origen y formación de creencias sobre la resolución de problemas. Estudio de un grupo de alumnos que comienzan la educación secundaria. *Boletín de la Asociación matemática Venezolana*, v. 10, n. 2, p. 173-194, 2003. Available at: http://emis.muni.cz/journals/BAMV/conten/vol10/mcallejo+vila.pdf . Accessed: 2 Aug. 2024.

CARVALHO, Anna Maria Pessoa de. Ensino de ciências por investigação: condições para implementação em sala de aula. 2022. Available at: https://repositorio.usp.br/item/003156981 . Accessed: 2 Jun. 2024.

COOPER, Harris M. The integrative research review: a systematic aproach. The integrative research review: *A systematic aproach*, p. 144-144, 1988. Available at: https://pesquisa.bvsalud.org/portal/resource/pt/pah-8902 . Accessed: 22 Jul. 2024.

CUNHA, Rodrigo Bastos. Pesquisa de percepção sobre ensino de ciências: mudanças climáticas e desmatamento estão entre os temas mais relevantes para estudantes secundaristas. Amazônia: *Revista de Educação em Ciências e Matemáticas*, v. 17, n. 39, p. 14-27, 2021. Available at: https://periodicos.ufpa.br/index.php/revistaamazonia/article/view/10934 . Accessed: 11 Jun. 2024.

DA SILVA, Ana Paula Santos *et al*. Mudanças climáticas como tema gerador no ensino de ciências na educação básica Climate change as a generator topic in physics teaching in basic education. *Brazilian Journal of Development*, v. 7, n. 7, p. 69453-69471, 2021. Available at: https://ojs.brazilianjournals.com.br/ojs/index.php/BRJD/article/view/32678 . Accessed: 15 Jun. 2024.

DE ASSIS, Ronaldo Paulucci et al. Environmental education and methodological tools in transversal mathematics teaching in a public school–Belford Roxo, RJ: Educação ambiental e as ferramentas metodológicas no ensino matemático transversal em uma escola pública–Belford Roxo, RJ. *Concilium*, v. 23, n. 19, p. 425-437, 2023. Available at: https://clium.org/index.php/edicoes/article/view/2141 . Accessed: 2 Aug. 2024.

DE-CARVALHO, Roberth; MATEI, Ana Paula. Transversalizando conteúdos de Física no ensino médio: o efeito estufa causado pela pecuária. *Ciência & Educação* (Bauru), v. 25, p. 255-266, 2019. Available at: https://www.scielo.br/j/ciedu/a/hrwT4STsjbG4bb8YvfFLGGB/ . Accessed: 26 Jul. 2024.

DE JESUS, Thiago Auer Camilo; GIOVANI CAFOFO SILVA, Emanuel; FERRACIOLI, Laércio. Ensino de Física e Ciência Cidadã na compreensão das mudanças climáticas por meio do estudo da vazão de um córrego da Mata Atlântica. *Revista de enseñamza de la física*, v. 35, n. 1, p. 39-52. 2023. Available at:

https://www.scielo.org.ar/scielo.php?pid=S2250-61012023000100039&script=sci_abstract&tlng=en . Accessed: 22 Jul. 2024.

DE OLIVEIRA, Giovani Gabriel Santos et al. Uso do pluviômetro como método de ensino Use of the rain gauge as a teaching method. *Brazilian Journal of Development*, v. 7, n. 9, p. 91707-91720, 2021. Available at: https://ojs.brazilianjournals.com.br/ojs/index.php/BRJD/article/view/36304 . Accessed: 29 Jun. 2024.

DO NASCIMENTO, Joseane Maria; ARAÚJO, Monica Lopes Folena. A dialogicidade e as metodologias ativas no ensino de ciências: pontos de convergência. *Observatório de la Economía Latinoamericana*, v. 22, n. 3, p. e3781-e3781, 2024. Available at: https://ojs.observatoriolatinoamericano.com/ojs/index.php/olel/article/view/3781 . Accessed: 16 Jun. 2024

DOS SANTOS BARDINI, Vivian Silveira; SPALDING, Marianne. Aplicação de metodologias ativas de ensino-aprendizagem: experiência na área de Engenharia. *Revista de Ensino de Engenharia*, v. 36, n. 1, 2017. Available at: http://revista.educacao.ws/revista/index.php/abenge/article/view/524 . Accessed: 17 Jun. 2024.

ERNESTO, Marcia *et al*. Perspectivas do ensino de Geociências. *Estudos Avançados*, v. 32, n. 94, p. 331-343, 2018. Available at: https://www.scielo.br/j/ea/a/Zn9WC9HCxVcSxzy439YgX3v/?lang=pt . Accessed: 1 Aug. 2024.

FARIA, Daniela Resende de; RAMOS, Maria Carolina; COLTRI, Priscila Pereira. Sequência didática como estratégia para ensino sobre desafios socioambientais relacionados às mudanças climáticas. *Terrae Didatica*, Campinas, SP, v. 17, n. 00, p. e021052, 2021. Available at: https://periodicos.sbu.unicamp.br/ojs/index.php/td/article/view/8667126 . Accessed: 1 Jul. 2024.

FERRAZ, Ana Paula do Carmo Marcheti; BELHOT, Renato Vairo. Taxonomia de Bloom: revisão teórica e apresentação das adequações do instrumento para definição de objetivos instrucionais. *Gestão & produção*, v. 17, p. 421-431, 2010. Available at: https://www.scielo.br/j/gp/a/bRkFgcJqbGCDp3HjQqFdqBm . Accessed: 3 Jun. 2024.

FERNANDES, Nícolas *et al*. Apreciação e reflexões: mudanças de clima e a transição energética. *Revista Técnica Ciências Ambientais*, v. 1, n. 7, p. 1-14, 2023. Available at: https://ipabhi.org/repositorio/index.php/rca/article/view/100 . Accessed: 28 Jun. 2024.

FIORI, Ana Paula Santos de Melo *et al*. Metodologias ativas na educação profissional e tecnológica: o saneamento ambiental na formação do técnico em meio ambiente. 2023. Available at: https://repositorio.ifal.edu.br/items/20caf764-d533-4f13-b331-2cda9869e98e . Accessed: 13 Jun. 2024.

FLEURY, Lorena Cândido; MIGUEL, Jean Carlos Hochsprung; TADDEI, Renzo. Mudanças climáticas, ciência e sociedade. *Sociologias*, v. 21, p. 18-42, 2019. Available at: https://www.scielo.br/j/soc/a/SHRnFKJmJdF7pmQkCBXt6hb/?format=html&lang=pt . Accessed: 25 Jul. 2024.

FREIRE, Paulo. Pedagogia do Oprimido. Rio de Janeiro: *Editora Paz e Terra*, 1994. Available at: https://acervoapi.paulofreire.org/server/api/core/bitstreams/083a43a9-693c-450e-8a20-bdc438091eeb/content#page=299 . Accessed: 9 Jun. 2024.

GANONG, Lawrence H. Integrative reviews of nursing research. *Research in nursing & health*, v. 10, n. 1, p. 1-11, 1987. Available at: https://onlinelibrary.wiley.com/doi/abs/10.1002/nur.4770100103 . Accessed: 2 Jul. 2024.

GARCÍA, Camino López; ORTEGA, Carlos Alberto Catalina; ZEDNIK, Herik. Realidade virtual e aumentada: Estratégias de metodologias ativas nas aulas sobre meio ambiente. *Informática na educação: teoria & prática*, v. 20, n. 1 jan/abr, 2017. Available at: https://seer.ufrgs.br/InfEducTeoriaPratica/article/view/70613 . Accessed: 4 Jun. 2024.

LAYRARGUES, Philippe Pomier. Pandemias, colapso climático, antiecologismo: Educação Ambiental entre as emergências de um ecocídio apocalíptico. *Revista Brasileira de Educação Ambiental* (RevBEA), v. 15, n. 4, p. 1-30, 2020. Available at: https://periodicos.unifesp.br/index.php/revbea/article/view/10861. Accessed: 1 Jul. 2024.

LIMA, Thamires Barroso et al. Aplicação de sala de aula invertida e de tecnologias digitais na educação profissional. *Boletim de Conjuntura* (BOCA), v. 13, n. 39, p. 511-521, 2023. Available at: https://revista.ioles.com.br/boca/index.php/revista/article/view/1075 . Accessed: 1 Jul. 2024

LINS, Natana da Silva; FERNANDES, Nayra Nascimento Bomfim. Análise da práxis pedagógica de educação ambiental nas disciplinas ciências e geografia, modalidade EJA. *Revista Brasileira de Educação Ambiental*. Vol. 16. Nº 3: 126-141. São Paulo. 2021. Available at: https://periodicos.unifesp.br/index.php/revbea/article/view/10802 . Accessed: 17 Jun. 2024.

MACHADO, C. B. H. *et al*. Corrida Contra o Aquecimento: uma proposta de jogo didático para auxiliar o aprendizado sobre mudanças climáticas. 2023. Available at: https://editorarealize.com.br/editora/anais/enpec/2023/TRABALHO_COMPLETO_EV181_MD1_ID2532_TB635_09032023065316.pdf . Accessed: 14 Jun. 2024.

MENDES, Karina Dal Sasso; SILVEIRA, Renata Cristina de Campos Pereira; GALVÃO, Cristina Maria. Revisão integrativa: método de pesquisa para a incorporação de evidências na saúde e na enfermagem. *Texto & contexto-enfermagem*, v. 17, p. 758-764, 2008. Available at: https://www.scielo.br/j/tce/a/XzFkq6tjWs4wHNqNjKJLkXQ . Accessed: 23 Jun. 2024.

MINAYO, Maria Cecilia. de Souza.; DESLANDES, Suely Ferreira.; NETO, Otavio Cruz.; GOMES, Romeu. *Teoria, método e criatividade*. Petrópolis: Editora Vozes, 2001. Available at: https://wp.ufpel.edu.br/franciscovargas/files/2012/11/pesquisa-social.pdf . Accessed: 20 Jun. 2024.

MORAES, José Uibson Pereira; ARAÚJO, Mauro Sérgio Teixeira. *O Ensino de Física e o Enfoque CTSA*: caminhos para uma educação cidadã. São Paulo: Livraria da Física, v. 144, 2012.

MORAN, José. Metodologias ativas para uma aprendizagem mais profunda. *In*: BACICH, Lilian; MORAN, José. Metodologias ativas para uma educação inovadora: uma abordagem teórico-prática [recurso eletrônico]. Porto Alegre: Penso, 2018, p. 2-25. Available at: https://edisciplinas.usp.br/pluginfile.php/7722229/mod_resource/content/1/Metodologias-Ativas-para-uma-Educacao-Inovadora-Bacich-e-Moran.pdf . Accessed: 13 Jul. 2024.

MOREIRA, Marco Antonio. Desafios no ensino da física. *Revista Brasileira de Ensino de Física*, v. 43, p. e20200451, 2021. Available at: https://www.scielo.br/j/rbef/a/xpwKp5WfMJsfCRNFCxFhqLy/. Accessed: 2 Jun. 2024.

IPCC. Intergovernmental Panel on Climate Change. (2021). *Climate Change 2021*: *The Physical Science Basis*. In: Masson-Delmotte, V. P., Zhai, P., Pirani, A., Connors, S. L., Péan, C., Chen, Y., …. Caud, N. (Eds.) (2021). Available at: https://www.ipcc.ch/report/ar6/wg1/ . Accessed: 27 Jul. 2024.

KETTENHUBER, Ricardo Henrique Barrozo Viana; SANTOS, Bianca Martins. Relato de experiência: atividade lúdica sobre os processos de propagação de calor. *Scientia Naturalis*, v. 2, n. 2, 2020. Available at: https://periodicos.ufac.br/index.php/SciNat/article/view/3712 . Accessed: 2 Jul. 2024.

PEREIRA, Mateus.P. B.; CAVALCANTE, Everton.; JÚNIOR, Valdeci. M. da S. Uso de mini placas solares para alimentar uma calculadora: exemplo de experimento didático de baixo custo. *Revista Física no Campus*. Vol. 1. N°. 1, p. 12-18, Campina Grande - PB, 2021. Available at: https://revista.uepb.edu.br/fisicanocampus/article/view/524 . Accessed: 11 Jun. 2024.

SÁ, Luciana Passos; FRANCISCO, Cristiane Andretta; QUEIROZ, Salete Linhares. Estudos de caso em química. *Química nova*, v. 30, p. 731-739, 2007. Available at: https://www.scielo.br/j/qn/a/nyCvcHWck6yN3pNq6KpKMtd/?lang=pt . Accessed: 4 Jul. 2024.

SILVA, Carlos Magno Lima Fernandes. *Mudanças climáticas e ambientais*: conceitos educacionais e históricos. 2015. Available at: https://memoria.ifrn.edu.br/bitstream/handle/1044/1103/Mudanc%CC%A7as%20Clima%CC%81ticas%20e%20Ambientais%20-%20Carlos%20Magno.pdf . Accessed: 21 Jul. 2024.

SILVA, José Cícero Dias da. *Aprendizagem motivada através de aulas experimentais: uma proposta ao ensino de física utilizando a propagação do calor por condução em um fio de cobre linear*. 2018. Dissertação de Mestrado. Universidade Federal de Pernambuco. Available at: https://repositorio.ufpe.br/handle/123456789/32846 . Accessed: 14 Jun. 2024.

SOARES, Paula Fernanda Chaves et al. Educação ambiental na nova base nacional comum curricular: proposta de atividade utilizando metodologias ativas em Ciências da Natureza. *Caderno Pedagógico*, v. 21, n. 5, p. e4249-e4249, 2024. Available at: https://ojs.studiespublicacoes.com.br/ojs/index.php/cadped/article/view/4249 . Accessed: 11 Jun. 2024.

SORRENTINO, Marcos; PORTUGAL, Simone. *Educação Ambiental e a Base Nacional Comum Curricular*. Parecer elaborado a pedido da Coordenação-Geral de Educação Ambiental do Ministério da Educação, 2016. Available at: https://ixfbea-ivecea.unifebe.edu.br/wiew/information/downloads-consulta-publica/3.pdf . Accessed: 22 Jul. 2024.

STETLER, Cheryl B*. et al*. Utilization-focused integrative reviews in a nursing service. *Applied Nursing Research*, v. 11, n. 4, p. 195-206, 1998. Available at: https://www.sciencedirect.com/science/article/abs/pii/S0897189798803297 . Accessed: 17 Jun. 2024.

VÖRÖS, Alpár István Vita. Outcomes of an optional environmental physics course in high school. In: *AIP Conference Proceedings*. AIP Publishing, 2020. Available at: https://pubs.aip.org/aip/acp/article-abstract/2218/1/060008/763964/Outcomes-of-an-optional-environmental-physics . Accessed: 1 Aug. 2024.

WHITTEMORE, Robin; KNAFL, Kathleen. The integrative review: updated methodology. *Journal of advanced nursing*, v. 52, n. 5, p. 546-553, 2005. Available at: https://onlinelibrary.wiley.com/doi/abs/10.1111/J.1365-2648.2005.03621.X?casa_token=kf3z1uuFF9cAAAAA:iYyOZNAWbQlcRta_Mtocv_jTEFEaXhuwbGnYO22elcGYjIXHsvli_1SiMbrxvZKWi407Ictcg5BDGrW5 . Accessed: 18 Jul. 2024.