



Environmental Education and Mining from the Perspective of Historical-Dialectical Materialism: A Systematic Review

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ABSTRACT:

Environmental Education (EE) emerged from the need to understand and act upon the interactions between society and nature, aiming to foster educational processes engaged with environmental issues. Events such as dam failures expose the socio-environmental consequences of mining and underscore the need for Critical Environmental Education (CEE). Against this backdrop, this study conducted a systematic literature review, categorizing works according to the macro-tendencies proposed by Layrargues and Lima (2014), with the objective of examining how mining has been addressed in the field's academic production. The literature reveals that, despite the advance of critical currents, pragmatic perspectives remain hegemonic, subordinating EE to neoliberal ideology and failing to address the structural determinations underlying mining activity. Accordingly, the need for further research and for the organization of the working class becomes imperative in order to promote CEE, reinforcing its role in the social transformation that conceives of the environment as a social category and pursues the overcoming of the prevailing societal model.

Keywords:

Critical Environmental Education; Historical-Dialectical Materialism; Environment.

Educación Ambiental y Minería desde la Perspectiva del Materialismo Histórico-Dialéctico: Una Revisión Sistemática

RESUMEN:

La Educación Ambiental (EA) surgió de la necesidad de comprender y actuar sobre las interacciones entre sociedad y naturaleza, buscando procesos educativos enfocados en las cuestiones ambientales. Eventos como los colapsos de represas evidencian los impactos socioambientales de la minería y la necesidad de una Educación Ambiental Crítica (EAC). Frente a esto, esta investigación realizó una revisión bibliográfica sistemática categorizando los trabajos según las macro-tendencias propuestas por Layrargues y Lima (2014), con el fin de analizar cómo se ha abordado la minería en las producciones del área. La literatura reveló que, a pesar del avance de las corrientes críticas, predomina un enfoque pragmático que vincula la EA a la ideología neoliberal, sin explicitar las determinaciones propias de la actividad minera. Así, se evidencia la necesidad de investigaciones y de organización de la clase trabajadora que promuevan la EAC, reforzando su papel en la transformación social que considere el ambiente como categoría social y en la superación del modelo societal vigente.

Palabras-clave:

Educación Ambiental Crítica; Materialismo Histórico-Dialéctico; Ambiente.

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Educação Ambiental e Mineração sob a Perspectiva do Materialismo Histórico-Dialético: uma Revisão Sistemática

RESUMO:

A Educação Ambiental (EA) emergiu da necessidade de compreender e atuar sobre as interações entre sociedade e natureza, visando processos educativos que focassem nas questões ambientais. Eventos como os rompimentos de barragens evidenciam os impactos socioambientais da mineração e a necessidade de uma Educação Ambiental Crítica (EAC). Diante disso, esta pesquisa realizou uma revisão bibliográfica sistemática categorizando os trabalhos de acordo com as macrotendências propostas por Layrargues e Lima (2014), com o objetivo de verificar como a mineração vem sendo abordada nas produções da área. A literatura revelou que, apesar do avanço das correntes críticas, há um predomínio de abordagens pragmáticas, que vinculam à EA a ideologia neoliberal, não explicitando as determinações existentes na mineração. Assim, evidencia-se a necessidade de pesquisas e organização da classe trabalhadora que favoreçam a EAC, reforçando seu papel na transformação social que considere o ambiente como categoria social e a superação do modelo societário vigente.

Palavras-chave:
Educação Ambiental
Crítica; Materialismo
Histórico-Dialético;
Ambiente.

INTRODUCTION

The need for an Environmental Education (EE) constituted as an educational process genuinely committed to understanding the interactions between society and nature emerged from multiple influences, including the pressure exerted by diverse social groups and political currents within the environmental movement, as well as the attention devoted to environmental issues by governments, international organizations, the media, and corporations (De Oliveira et al., 2021).

This demand was driven by increasingly frequent environmental catastrophes, such as the dam collapses in Minas Gerais — Mariana, Brumadinho, and Itabirito — and the land subsidence in Maceió. The mining disaster caused by Samarco's operations, which resulted in the collapse of the Fundão dam in Mariana, in the subdistrict of Bento Rodrigues, represents the largest disaster of its kind in terms of the volume of tailings released and the distance traveled by the waste, affecting the states of Minas Gerais and Espírito Santo (Bizzotto et al., 2023; Castro et al., 2018; Rodrigues & Machado, 2023).

Despite the inherent challenges of mining and the principal techniques employed — including pyrometallurgy and biohydrometallurgy — the extracted metals are indispensable for the manufacture of metal alloys essential to urban infrastructure and for supplying inputs to numerous industries. Furthermore, these metals play a crucial role in the production of high-technology electronic devices, such as lamps, computers, smartphones, vehicles, displays, and other equipment (Chen et al., 2024; Jorjani & Ghahreman, 2017; Joshi et al., 2025; Schippers et al., 2013; Toledo et al., 2023, 2024, 2026).

However, dam failures are symptomatic of the negligence of the private sector, which systematically prioritizes cost reduction over investments in adequate infrastructure for the prevention of environmental disasters. Research by Vieira et al. (2021) and Campolina and Araújo (2022) demonstrates that tailings dam failures in Brazil, as well as in Canada, reflect a mineral extraction model whose impacts extend far beyond the disaster event itself. These are not isolated incidents but systematic processes that reveal a characteristic *modus operandi* of mining capital. According to these authors, the discourse of progress associated with mining in the territories where it operates — including the educational programs implemented by mining companies in schools — is ideologically questionable and contributes to the structural conditions that produce such tragedies. These problems are directly connected to mining processes within the context of neocolonialism in capitalist society.

Imperialism has not abandoned colonialism since World War II; rather, it has transformed it according to the logic of neocolonialism. This new stage is characterized by the replacement of direct colonial domination

with indirect mechanisms of control, exercised through local representatives selected and trained by imperialist powers. This constitutes the most advanced stage of imperialism, in which finance capital operates in conjunction with concealed mechanisms that penetrate the political, religious, ideological, and cultural spheres (Conde, 2024; MIA, 2023). An illustration of this dynamic is the glorification of work culture as a form of moral elevation in the service of capital, alongside the so-called 'post-extractivist' discourse: mining and other activities linked to commodity production generate considerable negative environmental impacts without proportional improvements in the living conditions of local populations, thereby exacerbating social disparities (Dias, 2023; Garcia & Brasil, 2023; Guimarães & Barbosa da Paz, 2021).

Many nations that gained formal political independence from European metropolises ended up, in practice, subjected to the financial control of so-called first-world countries through foreign debt camouflaged as development 'aid'. Neocolonialism thus maintains power relations through unconventional means, encompassing the economic, political, cultural, and academic spheres. Its most far-reaching impact may be the transformation of the subjectivity of colonized populations — such as Brazil's — who progressively internalize values and frames of reference foreign to their local realities, in service of the interests of both new and old colonizers (Conde, 2024; León Cedeño & Bonetti Lima, 2021).

In a democracy, one would expect the public sphere to hold those responsible for dam collapses — which constitute environmental crimes — duly accountable. However, as Marx and Engels (1998, p. 9) affirmed, "The modern state power is merely a committee that manages the common affairs of the entire bourgeois class." Consistent with this analysis, nearly a decade after the Fundão dam collapse, virtually no one has been criminally convicted (Borges, 2024; Milagres & Mansur, 2024). Despite public pressure for the trial of the Anglo-Australian mining company BHP Billiton (Samarco being a joint venture between BHP Brasil and Vale) in London, the mining companies preemptively negotiated an agreement with the Brazilian government to safeguard their interests (Consultor Jurídico, 2024; Scofield, 2024; Verdélio, 2024; Villela, 2024). Furthermore, in a concerted judicial and public relations campaign, the mining companies involved in these crimes offered financial inducements to municipal authorities to forgo lawsuits and invested in illegal self-promotional advertising (Angelo & Bianchi, 2019; g1 Minas, 2024).

This legal dispute lays bare the dynamics of class struggle, in which those affected by the dam collapses fight for their rights while the bourgeoisie mobilizes to defend its material interests. Against the tendency toward bourgeois victory within a capitalist system — exemplified by the record profits of mining companies and their privileged access to public credit, even as affected populations continue to suffer heavy metal contamination (Agência Brasil, 2025; Almeida, 2025; Oliveira, 2024) — Environmental Education (EE) could constitute a fundamental instrument for fostering human development aimed at both understanding this reality and transforming it.

However, it is well established that many of those who formulate and practice Environmental Education continue to operate under the influence of dominant social norms, without critically interrogating the existing social structure in its totality (Mendes, 2020). This disposition is reflected, more or less explicitly, in the reproduction and legitimation of the prevailing productive and organizational system of society — a tendency that can be explained by the pervasive influence of global social practice on any educational process (Kaplan, 2024).

This reality underscores the importance of a pedagogical approach that critically interrogates social contexts in their dialectical interaction with the natural environment. From the perspective of Historical-Dialectical Materialism, it is impossible to separate environmental problems from social conflicts: the environmental crisis reflects not merely natural phenomena but contradictions that manifest in society as a consequence of class struggle (Mendes, 2020), given that the roots of these problems lie in social relations and in the prevailing mode of production (Layrargues & Lima, 2014; Mendes, 2020).

A literature review grounded in Historical-Dialectical Materialism and Critical Environmental Education (CEE) on the topic of mining can contribute to the development of educational processes that seek to foster a concrete, totalizing understanding of environmental issues (De Oliveira et al., 2021). Furthermore, given the indirect influence of scientific literature on educational curricula, as well as the imperative that students develop

a full understanding of how contemporary capitalist society is organized (Saviani, 2016) — alongside the neoliberal educational tendencies toward adaptability and individual responsibility, including in relation to environmental problems (Mazetto, 2023) — the relevance of academic works that systematize and analyze the contradictions underlying such phenomena becomes evident.

In a preliminary search conducted to assess the justification for this proposal, no systematic reviews on this theme were identified in scientific journals. Accordingly, guided by the research question 'How is the theme of mining addressed in scientific productions on Environmental Education (EE)?', this study aimed to systematize the treatment of mining in EE-related academic publications through a systematic literature review, thereby enabling theoretical propositions and critical discussions on mining from the perspective of Critical Environmental Education (CEE).

To address the research problem and achieve the stated objective, the works identified were synthesized, organized, and evaluated, enabling their categorization according to the criteria established by Layrargues and Lima (2014): the Conservationist, Pragmatic, and Critical macro-tendencies. A brief clarification regarding these macro-tendencies is warranted. According to Layrargues and Lima (2014), the conservationist tendency — which predominated in the constitution of the field — has progressively given way to both pragmatic and critical tendencies. The conservationist and pragmatic tendencies represent evolutionary stages of a single line of thought, updated in accordance with transformations in the contemporary world: multidimensional globalization, the technological revolution, the reduction of state intervention, and the ascendancy of market-oriented ideologies and neoliberal policies.

Critical currents have gained significant ground within the field, but they are not yet hegemonic, owing to the dominant pragmatism in environmental education, which tends to co-opt and redirect educational intentions toward market logic. Workforce training, job creation, and consumption tend to instrumentalize education as a vehicle for individual social mobility and the reproduction of economic rationality (Layrargues & Lima, 2014). In this context, it is imperative to discuss both the limitations of the existing literature on the research topic and the potential contributions of CEE (De Oliveira et al., 2021).

METHODOLOGICAL FOUNDATIONS

Systematic reviews are distinguished by their methodological rigor and transparency, which enable the reproducibility of results. They are also valuable for guiding future research and identifying gaps in existing knowledge. Given the accelerating expansion of scientific output, systematic reviews constitute essential resources for synthesizing evidence on specific phenomena, assisting researchers in identifying consensuses and lacunae (Batista & Kumada, 2021; de Sousa et al., 2021; Sampaio & Mancini, 2007).

Drawing on the Periódicos CAPES platform, the scientific literature in the field was systematically mapped through a systematic literature review (Batista & Kumada, 2021; de Sousa et al., 2021; Sampaio & Mancini, 2007). In accordance with the methodological guidelines for review research proposed by Messeder Neto (2024), the review followed five stages of investigation, presented in sequence:

- 1) Formulation of the research question: How is the topic of mining addressed in scientific publications in Environmental Education?
- 2) Database search: The Periódicos CAPES platform was selected because it integrates nationally produced works as well as those from international publishers, providing access to an extensive collection of scientific journals, books, theses, dissertations, conference proceedings, and other academic materials spanning multiple fields of knowledge. The quality and credibility of the sources are guaranteed, as CAPES selects and makes available publications of worldwide renown, and the platform is continuously updated to ensure access to the most current and relevant information (Miranda & Carvalho, 2017). The descriptors "Educação Ambiental" (as an exact phrase, in quotation marks) and "mineração" were employed with the following filters: material type — 'all items'; language — 'any language'. Regarding temporal scope, the criterion 'any year' was adopted, which in

practice encompasses all works indexed up to the submission date of this manuscript (May 19, 2025). All studies identified were included, selected, evaluated, analyzed, and synthesized in accordance with the research question, with the exception of those unclassified or classified with a grade of C by Qualis Capes (Quadrennial Assessment 2021–2024).

- 3) Selection of papers (with well-defined inclusion criteria based on reading the abstract): Papers were selected that included the descriptors "Educação Ambiental" and "mineração" in the title, abstract, or keywords, and were classified as A or B by Qualis Capes (Quadrennial Assessment 2021–2024).
- 4) Evaluation of included studies: A complete reading of all studies selected by the research platform that met the inclusion criteria was conducted.
- 5) Analysis of the works: All works meeting the inclusion criteria were synthesized, organized, and evaluated in tables, enabling a systematic and comparative analysis. This organization facilitated the identification of the principal discussions, objectives, and conclusions of each study, and their categorization according to the criteria established by Layrargues and Lima (2014): the Conservationist, Pragmatic, and Critical macro-tendencies. Three tables were constructed: one containing identification data for the analyzed works (Table 1); a second synthesizing two salient characteristics of the productions — namely, the main agents identified by the authors as responsible for the environmental crises analyzed and the solutions proposed from an EE perspective (Table 2); and a third synthesizing the categorization of works according to macro-tendencies (Table 3). Additional data were presented and analyzed through full excerpts that encapsulate each work's understanding of EE, mining, and/or their interrelation and its alignment with a given macro-tendency.

Following the foundations established by Layrargues and Lima (2014), works were classified under the Conservationist macro-tendency when they aimed solely at cultivating a new human sensibility toward nature, promoting awareness and ecological 'literacy' grounded in ecological science. The Pragmatic macro-tendency encompassed works focused on individual responsibility, advancing the notion that each person's individual contribution as a citizen suffices to address the environmental crisis — an orientation consonant with the neoliberal context and disconnected from any social, economic, or deeper political dimension. Although such works advocate sustainable development, they fail to interrogate how this would be achievable within the capitalist mode of production, which is premised on the continuous acceleration of exploitation and the unlimited expansion of capital.

The Critical macro-tendency is understood in this work from the perspective of class struggle and Historical-Dialectical Materialism, oriented toward the overcoming of the capitalist mode of production — that is, through a Critical Environmental Education (CEE) that apprehends the structural determinations conditioning mining activity and its consequences (De Oliveira et al., 2021). Works classified within the Critical macro-tendency therefore stand in opposition to the Conservationist and Pragmatic currents, adopting a position of explicit political confrontation with the environmental issue under examination.

RESULTS AND DISCUSSION

Using the descriptors "Educação Ambiental" and "mineração," 38 results were initially retrieved, one of which was a duplicate (Carrilho Eichenberger & Alves Pereira, 2018), while the full text of five works was inaccessible (Barbosa et al., 2014; Barbosa & Silva, 2017; Figueiredo et al., 2011; Os Editores, 2012; Rodrigues, 2018).

Among the studies, some were excluded because they did not address the topic of mining (Azevedo et al., 2024; Medeiros et al., 2016; Pontes Portela & De Novais, 2024), or EE (Boitrage & Almeida, 2021; Brito et al., 2019; Vervloet & Freitas, 2024), as well as those unclassified or classified with a grade of C by Qualis Capes. As a result, 21 studies were analyzed, as indicated in Table 1. The objectives and conclusions of each work were synthesized and organized, supporting both the categorization of the works into macro-tendencies and the subsequent analyses; these are available in the supplementary material (Tables M1 and M2).

Table 1 - Information about the works analyzed.

Authors	Titles	Scientific Journals
Luz <i>et al.</i> (2010)	The need for innovative Environmental Education actions with mining workers	Ambiente & Educação
Alvarenga e Piuzana (2011)	Reuse of mining waste in São Sebastião das Águas Claras-MG: the production of PAVIECO	Revista Geográfica de América Central
Fiorotti <i>et al.</i> (2013)	Urban Open Space as an Instrument for Integral Sustainability and Critical Environmental Education: A Multidisciplinary Methodology in the Project for the Marista Municipal Park, Vila Velha, Espírito Santo	Revista Latino-Americana de Inovação e Engenharia de Produção
Cabral <i>et al.</i> (2015)	Social and Environmental Responsibility and Sustainable Local Development: The Case of the Environmental and Heritage Education Project (EHEP)	Revista de Gestão Ambiental e Sustentabilidade
Maciel <i>et al.</i> (2017)	Ironstone Ranges: A Pedagogical Proposal on the Need for Conservation of a Threatened Ecosystem	Revista Brasileira de Pós-Graduação
Pereira <i>et al.</i> (2017)	Postgraduate students' environmental perception of the impacts of mining.	Revista Eletrônica do Mestrado em Educação Ambiental
Rabelo (2017)	Environmental quality and mining: perceptions of residents of Carmo da Mata/MG	Pesquisa em Educação Ambiental
Carrilho Eichenberger e Alves Pereira (2018)	Environmental justice and the case of the Quilombola communities of Oriximiná/PA: towards a contemporary critique of Environmental Education	AmbientalMENTEsustentable
Wedy (2019)	Considerations regarding the Brumadinho disaster	SSRN Electronic Journal
Rodrigues (2020)	The environmentalist struggle in Bahia: a case study on the movement for popular sovereignty in mining in the Alto Sertão region of Bahia	Revista Encantar
Silva Costa <i>et al.</i> (2020)	Teachers' and students' perceptions of the environmental impacts associated with mining	Pesquisa em Educação Ambiental
Soares e Freitas (2020)	The perception of students in the Mining Technician Course at the Federal Institute of Amapá, Macapá campus, regarding Environmental Education.	Revista Brasileira de Educação Ambiental (RevBEA)
Lima e Cunha (2021)	Applying compliance in mining companies as a preventive measure against environmental damage	Revista Brasileira de Educação Ambiental (RevBEA)
Ribeiro Cardoso e Cosenza Rodrigues (2022)	The topic of mining in environmental education research	Revista Eletrônica do Mestrado em Educação Ambiental
Medeiros e Assunção (2022)	Study of the perception of basic education students about the socio-environmental problems of Urussanga (SC) through mind maps	Revista Brasileira de Educação Ambiental (RevBEA)
Bizzotto <i>et al.</i> (2023)	Environmental education program for reducing the risk of mining dam disasters, focusing on the case study of Brumadinho/MG	REVISTA GEONORTE
Caldas <i>et al.</i> (2023)	Following the trail of mining: uncovering its environmental impacts through fieldwork	Revista Brasileira de Educação Ambiental (RevBEA)
Rodrigues e Machado (2023)	Environmental Education and History Teaching: Limits and Possibilities	Revista Eletrônica do Mestrado em Educação Ambiental
Pinto <i>et al.</i> (2023)	Non-formal education and dissemination of geosciences through environmental education	Terrae Didatica

Batista Henriques (2024)	Critical Environmental Education and the territory of the Zona da Mata region of Minas Gerais: a necessary dialogue	Educação Em Foco
Da Silva <i>et al.</i> (2024)	Bauxite Mining as a Guiding Theme for Environmental Education Initiatives	Revista Ensin@ UFMS

Source: prepared by the authors (2025).

The objectives and conclusions of the majority of works are grounded in the need for the dissemination of knowledge throughout society, the preservation of the environment, the promotion of individual awareness and responsibility, compliance with laws, and demands for state oversight. Although these works advocate for sustainable development, most fail to address how this would be achievable within the logic of capitalist production — a mode of production premised on the unlimited exploitation and accumulation of capital, which inevitably generates social inequality and environmental injustice (De Oliveira *et al.*, 2021).

It was possible to systematize two salient characteristics in the productions analyzed: the identification of the principal agents held responsible for the environmental crises under examination, as indicated by the authors, and the possible solutions proposed from an EE perspective — both for resolving and for preventing the environmental crises — as synthesized in Table 2 below.

Table 2 - Main agents identified as responsible and proposed solutions for the environmental issues studied in each work.

Main agents identified as responsible	Proposed solution	Reference
Low levels of education, legislative gaps, intimidation suffered by workers, lack of oversight.	Access to information and an environmental education with a political character.	Luz <i>et al.</i> (2010)
Mining has caused degradation and pollution at the site studied.	Independent, sustainable, and entrepreneurial initiatives such as 'PAVIECO' that promote the recovery of nature devastated by human action.	Alvarenga e Piuzeana (2011)
Not specified.	Enable the sustainable coexistence between natural spaces and built elements, which can be promoted through EE.	Fiorotti <i>et al.</i> (2013)
Traditional planning and development models exacerbate social and environmental problems, along with a lack of knowledge about social rights.	Promote sustainable development models, sustainable local practices, and corporate social responsibility (CSR).	Cabral <i>et al.</i> (2015)
Mineral extraction activity generates environmental impacts, such as the loss and degradation of natural habitats. For example, mining discards the iron ore that covers the deposits. Dam failures cause environmental disasters.	Access to scientific knowledge for society. Encourage students to reflect on the importance of reclaimed clay in biological, social, and economic contexts, the actions that are decimating it, and the individual importance in the process of preserving the environment.	Maciel <i>et al.</i> (2017)
Human interventions, socioeconomic demands, mining, human beings and their social relations, lack of knowledge and use of Brazilian legislation by mining companies, political managers and the population itself.	Mining projects must consider factors such as urban planning, public policies, and the regional economy. Environmental education can encourage the active participation of the population in resource management and decisions about sustainable development. It is essential to broaden the knowledge of students and disadvantaged populations about the impacts of extractive activities and the proper disposal of waste.	Pereira <i>et al.</i> (2017)
Traditional environmental education, with an individualistic emphasis, focused on awareness aimed at changing behaviors and knowledge	A CEE is needed that promotes reflection on the articulation between the dimensions of the reproduction of material life and the relationship of human beings with the environment,	Rabelo (2017)

restricted to ecological aspects for the maintenance and preservation of ecosystems. Lack of access to information about mining activity and its licensing process.	understood as an essentially political process aimed at developing a critical consciousness.	
Conservationist and bourgeois environmental education. The advance of capitalist exploitation of nature, which forcibly displaces local populations. Private ownership of the means of production. Human beings increasingly distanced and disconnected from nature.	Thinking about environmental education as a critique of the capitalist economic domination of nature. Reclaiming nature within the social sphere, rethinking the complex relationship between being and nature. The government must identify and protect the area of overlap, avoiding conflicts.	Carrilho Eichenberger e Alves Pereira (2018)
Fundamentals of the National Dam Safety Policy (NDSP) that should have been implemented before the dam collapses. A culture of environmental education has not developed, either within the public sector or the private sector, despite it being a constitutional principle to be observed at all levels of education (Article 225, item VI). Mining companies have a duty to defend and preserve the environment.	Comply with Law 12.334/2010 and implement an efficient National Dam Safety Policy guided by the constitutional principles of precaution and EE. Environmentally educate society about the risks of dam management. A country aligned with the 3rd United Nations World Conference on Disaster Risk Reduction.	Wedy (2019)
Large-scale use of natural resources. Unbridled consumption. Industrial model of mass production. Environmental degradation. Capitalism.	CEE linked to social movements, not only as an educational process focused on individual and ecological issues, but on social issues. Understanding that environmental issues are a function of political decisions.	Rodrigues (2020)
Teachers and local community lacking adequate training and institutional partnerships. Teachers unable to implement proposals and actions for CSR programs. Ineffective community participation in CSR programs. Misunderstanding that human beings are part of nature.	Develop educational actions of an environmental nature with participatory methodologies for the creation of environmental projects with a critical and transformative focus in order to promote the perception of students and teachers, contributing to their critical participation in CSR programs.	Silva Costa <i>et al.</i> (2020)
Accelerated and irrational destruction of the environment. The notion of human beings as separate from nature. Mining activities without social and economic development for local communities.	Enable environmentally sustainable economic growth. To awaken individual and collective concern for preserving the environment. Develop an integrated, continuous, and permanent environmental education program in educational institutions.	Soares e Freitas (2020)
Inefficiency of the public sector. Lack of state oversight. Companies that value only the logic of capital. Mining companies uninterested in investing in the safety of their dams.	Develop an environmental 'culture' in companies through the implementation of 'Compliance', that is, measures to prevent and minimize risks related to non-compliance with environmental laws. Stringency in the issuance of licenses and in oversight by public authorities.	Lima e Cunha (2021)
Capitalism, imperialism. Colonial mining. Maintenance of the dominant ideology through neoliberal discourses promoted by the mining industry, politics, and bourgeois media. Market environmentalism.	Reveal and denaturalize problematic characteristics related to mining through environmental education. Defend a critical perspective, opposing hegemonic forces for the transformation of reality. Environmental education is both critical and emancipatory.	Ribeiro Cardoso e Cosenza Rodrigues (2022)

The environmental degradation of the Urussanga river basin stems from mining, the discharge of industrial and domestic effluents, the suppression of forests in permanent preservation areas, and agricultural activity.	Not specified.	De Medeiros e Assunção (2022)
Lack of understanding about the risk of dam failure or about Disaster Risk Reduction (DRR).	Promote awareness of the risks of mining projects that include tailings dams in Environmental Education Programs (EEP).	Bizzotto <i>et al.</i> (2023)
Exploitation of natural resources.	Greater understanding of the exploitation of natural resources through EE. Continuing teacher education. Transversal and field teaching practices that motivate students.	Caldas <i>et al.</i> (2023)
Environmental problems. Consumerism, capitalism.	Include the teaching of Environmental History in the curriculum. Train agents for transforming the socio-environmental reality.	Rodrigues e Machado (2023)
Problems caused by the exploitation of natural resources.	Geoscientific educational practices aimed at promoting critical thinking and environmental awareness. Basic understanding of citizenship, rights and duties, and harmonious integration with the surrounding environment.	Pinto <i>et al.</i> (2023)
Asymmetric economic development model (capitalism), which destroys the environment and propagates ideologies of supposed sustainable development and the naturalization of neoliberalism.	Sustainable, agroecological production methods, social empowerment, and the promotion of solidarity economy models. CEE as an antagonist to the hegemonic model.	Batista Henriques (2024)
Constant increase in the exploitation of natural resources.	To develop awareness of the problems arising from socio-environmental conflicts, which consequently promotes solutions.	Da Silva <i>et al.</i> (2024)

Source: prepared by the authors (2025).

A thorough reading of each work enabled the classification of studies according to their corresponding macro-tendency, as systematized in Table 3. The majority of works were interpreted as pragmatic. This predominance can be explained by the hegemony that this tendency maintains within the field of EE in general, a phenomenon that is also manifest in the specific object of this research. Throughout the following analysis, full excerpts are presented to substantiate this categorization.

Table 3 - Classification of works according to the criteria of the Conservationist, Pragmatic, and Critical Macro-tendencies.

Macro-tendencies	Produções
Conservationist	1. Luz <i>et al.</i> (2010) 2. Fiorotti <i>et al.</i> (2013) 3. Medeiros and Assunção (2022) 4. Da Silva <i>et al.</i> (2024)
Pragmatic	1. Alvarenga and Piuzana (2011) 2. Cabral <i>et al.</i> (2015) 3. Maciel <i>et al.</i> (2017) 4. Pereira <i>et al.</i> (2017) 5. Wedy (2019) 6. Silva Costa <i>et al.</i> (2020) 7. Soares and Freitas (2020) 8. Lima and Cunha (2021) 9. Bizzotto <i>et al.</i> (2023)

	10. Caldas <i>et al.</i> (2023) 11. Pinto <i>et al.</i> (2023)
Critical	1. Rabelo (2017) 2. Carrilho Eichenberger and Alves Pereira (2018) 3. Rodrigues (2020) 4. Ribeiro Cardoso and Cosenza Rodrigues (2022) 5. Rodrigues and Machado (2023) 6. Batista Henriques (2024)

Source: prepared by the authors (2025).

Although the descriptors "mineração" and "Educação Ambiental" were present in the title or abstract of all 21 works analyzed, six of them (Alvarenga & Piuzana, 2011; Cabral et al., 2015; Fiorotti et al., 2013; Lima & Cunha, 2021; Luz et al., 2010; Wedy, 2019) addressed these themes superficially or tangentially — the concepts are mentioned but not substantively discussed or explored. Nevertheless, they were included in the analysis given their reasonable degree of proximity to the themes of mining and EE.

To illustrate, the work by Maciel et al. (2017) can be classified within the pragmatic macro-tendency, because, although the Introduction acknowledges that social disparities and environmental impacts result from the hegemonic development model — in which environmental costs are socialized while profits are concentrated among a minority — the Environmental Education booklet developed does not critically expose this contradiction. Instead, its central purpose was "[...] the need to know in order to preserve the rational use of natural resources and the impacts on ferruginous ecosystems resulting from mineral extraction" (Maciel et al., 2017, p. 902), being primarily concerned with students' reflection on the importance of the ecosystem and the actions that are destroying it, but without identifying the root of the problem, and proposing as the principal solution "[...] the importance of each individual (reader) in the process of environmental preservation" (Maciel et al., 2017, p. 907).

Bizzotto et al. (2023) similarly advocate for individualized solutions — such as self-protection and individual comprehension of the risks entailed by dam failures — prioritizing the minimization of impacts over their prevention, and propose Environmental Education Programs (EEP) to promote risk awareness in communities near mining projects that include tailings dams, so that citizens would be capable of demanding dam maintenance or protecting themselves against an avalanche of thousands of tonnes of toxic waste.

Risk awareness regarding dam failures and disaster risk reduction (DRR) is undeniably important; however, knowledge alone, absent community organization, is incapable of generating the pressure necessary for real solutions and the prevention of environmental disasters. In this regard, Rodrigues (2020) demonstrated the significance of organizing the population in the face of the advance of capitalist mega-projects, citing the example of the Movement for Popular Sovereignty in Mining (MAM).

The analysis by Rodrigues (2020) was not confined to merely raising environmental awareness among the local population regarding mineral extraction processes, but extended to the organization of workers in the face of colonial capitalist impositions.

"For Loureiro (2012, p. 34), environmental education is justified in that 'consciousness-raising action is mutual, involving critical capacity, dialogue, and the assimilation of different knowledges, as well as the active transformation of reality and living conditions.' It is capable of promoting 'consciousness-raising, which occurs in the relationship between the self and the other, through theoretically grounded reflective social practice.' Corroborating this dimension are the teachings of Paulo Freire (1979; 1981), considering the human being as a social, historical, and unfinished being constituted in relation to oneself, to nature, and to others. It is possible to conclude that one is constituted within the cultural dynamics into which one is inserted; by modifying the environment, one also modifies oneself" (Rodrigues, 2020, p. 124).

Furthermore, the author foregrounded the struggle of the working class, grounded in critical education, as the path toward understanding the possibility of transforming reality in the interests of workers, as illustrated in the following excerpt:

“The MAM does not advocate for the closure of mining projects. The movement works towards respecting the rights of workers, farmers, and natural resources that affect a given territory to the detriment of mining activity, so that mineral resources are not extracted by overriding and crushing the rights of those affected/threatened” (Rodrigues, 2020, p. 130).

Other solutions of a pragmatic character were proposed, predominantly oriented toward sustainability. Pereira et al. (2017) advocated for sustainable development and for mining activities that generate more benefits than harm, proposing the engagement of graduate students with society within the framework of an interdisciplinary EE aimed at forming critical citizens. Soares and Freitas (2020) likewise argued for an EE that would promote sustainable economic growth. Neither work, however, addressed how this would be achievable within the capitalist mode of production, nor did they relate the logic of capital accumulation to environmental degradation.

From this perspective, through the effective participation of teachers and the local community in environmental education programs within Corporate Social Responsibility (CSR) initiatives, Silva Costa et al. (2020) argued that raising awareness and community action in partnership with mining companies would promote sustainability and curb the accelerated environmental degradation caused by large-scale projects.

“It is important to establish a partnership between the mining company and the community, so that dialogue is considered a modern environmental management strategy, with the promotion of sustainable practices through it (RESENDE; KAMEL, 2007). The school can assume the responsibility of developing environmental projects aimed at identifying the needs of the community and, consequently, helping to expand the perception, participation, and engagement of those involved. Subsequently, the school can present the identified demands to the mining companies so that, together, they can outline actions (Silva Costa *et al.*, 2020, p. 124).

In our analysis, the central problem does not reside in the absence of perception and participation by students and teachers in CSR programs aimed at sensitizing corporate owners, as suggested by Silva Costa et al. (2020). The authors neither cite nor propose addressing the structural precariousness that afflicts teaching work, nor do they appear to recognize that the majority shareholders of large mining corporations would not accept any community proposal that reduces their profits without a fight. Mining companies are cognizant that sinking an entire city, as occurred in Maceió, or that dam failures, such as those in Mariana and Brumadinho, run counter to society's interests — yet they are equally cognizant that the bourgeois state, functioning as a committee for capital, exists to protect their economic interests, regardless of whether the local community is ultimately submerged in toxic tailings.

In this sense, EE proposals restricted to convening actors involved in the mining context — but with divergent interests, levels of participation, and objectives — through participatory and consciousness-raising approaches directed at those who, within the class struggle, occupy the most disadvantaged position (the community at large, and teachers and students in particular), constitute neither a concrete solution to the problems generated by mining nor a pedagogical purpose aligned with unveiling the real environmental determinations of mining activity.

Criticizing this idealized sustainability — which neither exposes nor proposes the overcoming of the accelerated and incessant capitalist mode of production and exploitation — Ribeiro Cardoso and Cosenza Rodrigues (2022), drawing on Critical Discourse Analysis (CDA), argued for the necessity of interrogating the ideological meanings that permeate the field of EE, particularly in relation to the discourse of sustainable development. Their study illuminated the relationships between EE and the environmental impacts and conflicts arising from mining, identifying ideological discourses that either reinforce or contest dominant narratives in this area.

The authors also examine the prevailing economic system — capitalist and colonial in character — which produces inequalities and environmental disasters by privileging central countries and capital holders, including the mega-mining industries. They argue that language can serve to instrument hegemonic power, for example by legitimizing relations of domination through discourses ostensibly concerned with sustainable development — while it can equally function in a counter-hegemonic direction, revealing the mechanisms of ideological domination exercised by the ruling class (Ribeiro Cardoso & Cosenza Rodrigues, 2022).

In a similar vein, Batista Henriques (2024) criticized the widespread adoption of superficial EE discourses in schools — proposals that advocate activities disconnected from any critical perspective, such as producing toys from solid waste or planting tree seedlings. The work calls for a more complex grasp of the world as a precondition for creating the conditions necessary for intervention in and transformation of socio-environmental reality.

The notion of the human being as ontologically separate from nature is addressed from both the pragmatic perspective (De Medeiros & Assunção, 2022; Da Silva et al., 2024) and the critical perspective (Carrilho Eichenberger & Alves Pereira, 2018; Rabelo, 2017). De Medeiros and Assunção (2022), studying students' environmental perceptions of socio-environmental problems, concluded:

“Studies on environmental perception through mind maps can contribute to assessing students' understanding, and their interpretation can be used to organize lessons in order to fill possible gaps in student learning. In this way, it opens the possibility of constructing an environmental education based on the profound relationships between individuals and the environment in which they live” (De Medeiros & Assunção, 2022, p. 236).

However, the authors did not specify whether or how this EE grounded in profound subject–environment relationships would illuminate the environmental problems under study. Although they dedicated a single paragraph to criticizing the limitations of the pragmatic macro-tendency, there is insufficient critical analysis of students' perceptions, the EE practiced in the classroom, or the socio-environmental problems studied — placing this work equally distant from the critical macro-tendency.

Also without revealing the structural causes of socio-environmental conflicts, Da Silva et al. (2024), analyzing the restructuring of prior and constructed knowledge by undergraduate Chemistry students through the production of scientific dissemination materials, concluded that merely raising students' awareness would be sufficient to generate actions and solutions — without, for example, dialectically relating the most immediate determinations (socio-environmental problems and conflicts) to the most complex ones (the prevailing capitalist mode of production):

“The opportunity for involvement in the issues presented by the generating theme of bauxite mining and socio-environmental conflicts enabled the undergraduate students to develop a new perspective on the issues surrounding them, making them aware of the problems arising from a socio-environmental conflict and consequently driving them to seek solutions and actions for a given situation, considering all parties involved in the conflict” (Da Silva *et al.*, 2024, p. 113).

In turn, and in opposition to reductionist educational approaches of a traditional and pragmatic character, Rabelo (2017), in a study on the environmental perception of social actors regarding the socio-environmental problems imposed upon them by mining, sought to contribute to both the development of EE actions and the strengthening of public policies, advocating for a CEE that promotes reflection on the articulation between the material reproduction of social life and the relationship of human beings with the environment.

Discussing the growing alienation of human beings from nature and advocating for the overcoming of what they termed 'bourgeois environmental education' in order to advance environmental thought and promote environmental justice, Carrilho Eichenberger and Alves Pereira (2018) examined the case of the Quilombola communities of Oriximiná/PA. The authors criticized the dominant paradigms of environmental knowledge and of EE itself, denouncing the displacement of traditional populations from their territories owing to capitalist exploitation — including mining — and arguing for the reclamation of nature within the social sphere through a rethinking of the complex and contradictory relationship between human beings and the natural world.

Continuing education and interdisciplinarity were also invoked as potential strategies for confronting the environmental crisis. Caldas et al. (2023) analyzed the significance of the "Mining Circuit in Schools" project — an initiative by Vale S.A. in partnership with the Municipal Department of Education of Parauapebas-PA. Through virtual questionnaires, monitoring during the project, and continuous evaluations supported by Vale's advisory team, Caldas et al. (2023) advocated for continuing teacher education and interdisciplinarity as enriching elements of pedagogical practice:

“Successful, the experiences provided by the Project enrich pedagogical practice in schools of the Parauapebas Municipal Network, deconstructing common sense and developing new perceptions about the Municipality, its predominant economic matrix, and sustainability” (Caldas *et al.*, 2023, p. 131).

However, Caldas et al. (2023) did not specify what would constitute the 'deconstructed common sense' or what the new perceptions oriented toward sustainability would actually entail. Furthermore, it is essential to recognize that companies responsible for environmental crimes may simultaneously be promoters of EE programs — typically from a pragmatic perspective — as in the case of Vale (Pereira, 2011).

Interdisciplinarity was equally invoked by Pinto et al. (2023), who argued for the centrality of Geology from the perspective of EE. The authors aimed for sustainable development, environmental awareness, a basic understanding of citizenship, rights and duties, and the harmonious integration of students into the surrounding environment. Although they sought to develop critical thinking in children, their approach remained restricted to ways of sensitizing individuals toward environmental preservation.

Interdisciplinarity is capable of articulating the particularities of different fields of knowledge with a view to overcoming the fragmentation of knowledge, of material reality, and of the contradictions of the prevailing economic system — rather than serving as an arbitrary juxtaposition of disciplines (Malanchen, 2020).

In contrast, Rodrigues and Machado (2023), from the perspective of interdisciplinarity, demonstrated the viability of integrating Environmental History into EE, critically relating historical events — such as dam failures — to contemporary environmental issues:

“The study of environmental disasters aims to diagnose the appropriation of territorial use at local, regional, and global levels. Furthermore, it analyzes who uses, how they use, with what intention, and what the consequences are. Addressing environmental disasters in History teaching helps to understand the complex and contradictory relationship between human beings and nature. We must denaturalize disasters, starting with the nomenclature 'Natural Disasters,' as they are often understood as fatality, natural, a consequence of an extreme event, without any relation to the mode of occupation and use of these spaces. “Disaster is always social” (ESPÍNDOLA, 2017, p. 238). Thus, it is not possible to reduce the environmental issue to a strictly ecological problem without incorporating the other social, ethical, political, and cultural dimensions that permeate and condition the environmental phenomenon (LIMA, 2004)” (Rodrigues & Machado, 2023, p. 261).

Beginning from the history of mining in Portuguese America, the authors discussed the socio-environmental problems arising from dam failures and the mining companies' deliberate choice to reduce operational costs in order to maximize profits, thus foregrounding the primacy of the logic of capital accumulation that prevails in the contemporary economic system:

“Furthermore, we related the environmental disaster to capitalism and the perverse way in which the company handled the situation. The striking profit figures show that even with the dam failures that resulted in human and biodiversity losses, the company profited, that is, for capitalism, profit is the most important thing, even if that profit comes at the expense of the suffering and despair of the affected people. One student asked whether anyone had been arrested, and we responded that so far no one had, but that the company had to pay fines to IBAMA. Another student asked whether gold exploration was still as extensive today as it was in Portuguese America, and we responded that it remains important, but that today iron ore has surpassed gold in value, since it is the raw material for steel, widely used in industry” (Rodrigues & Machado, 2023, p. 264).

Luz et al. (2010) advocated for an EE of a political character, yet they did not specify what this education would entail, nor did they designate it as an explicit object of study; they merely highlighted the necessity of access to information by the local community and workers as a means of addressing environmental problems. In turn, Alvarenga and Piuzana (2011) stated their intention to propose an EE project that would contribute to local and socio-environmental development in the course of the study, though this was ultimately not carried out.

Although the Introduction of Fiorotti et al. (2013) advocates for a Critical, transformative, and emancipatory EE, the authors did not elaborate on the pedagogical practices listed, nor did they articulate these with the class struggle within the capitalist mode of production. The practices merely cited were grounded in 'greater contact of users with nature,' in 'concepts related to the importance of preservation' (without specifying what these concepts would be) (Fiorotti et al., 2013, p. 25), and on the morphological identification of plants and minerals — without explaining the environmental impacts of mineral extraction or their structural causes.

Cabral et al. (2015) stated, without elaboration, that the Environmental and Heritage Education Project (EHEP) fostered awareness of and respect for nature and the preservation of the environment, without critically engaging with the structural contradictions underlying the socio-environmental problems in the communities studied.

“The law establishes a concept of dam safety, which is the condition aimed at maintaining its structural and operational integrity and preserving life, health, property, and the environment. In the same vein, the much-discussed risk management regarding dams refers to normative actions, as well as the application of measures for prevention, control, and mitigation of hazards. The potential damage associated with the dam also has a legal definition, being the damage that may occur due to its failure, leakage, soil infiltration, or malfunction (art. 2o). It is not the lack of legal concepts, therefore, that causes poor risk management of dams in Brazil and the potential impunity of those responsible for accidents” (Wedy, 2019, p. 4).

Both works likewise advocate for the promotion of EE as a means of preventing socio-environmental disasters and overcoming state inaction, but without substantive elaboration (Lima & Cunha, 2021; Wedy, 2019).

Although mining is an indispensable economic activity, dam failures are expressions of the negligence of the private mining sector, which systematically prioritizes cost reduction over investment in infrastructure capable of effectively preventing environmental disasters. It is therefore not alarmist to assert that such crimes will continue to occur in bourgeois democracies, where governments aligned with big capital tend to produce weak laws and deficient oversight mechanisms under pressure from capitalist lobbying, as argued by Bizzotto et al. (2023), Castro et al. (2018), and Rodrigues and Machado (2023).

Lima and Cunha (2021) and Wedy (2019) affirm that the Brazilian legal system contains norms for holding responsible those who cause environmental catastrophes arising from dam failures, as well as for the recovery of damages suffered by victims and the environment. Accordingly, the deficient risk management of dams in Brazil and the de facto impunity of those responsible for accidents are not attributable to an absence of legal norms. The State's inability to monitor and sanction large mining companies thereby reveals the fundamental contradiction of the Brazilian bourgeois state, which is structurally incapable of enforcing its own legislation when such enforcement conflicts with the interests of the ruling class. As Wedy (2019, p. 3) observed: "In the country, however, there is an evident lack of political will to implement effective precautionary action in dam management."

Notwithstanding the positions set forth by Lima and Cunha (2021) and Wedy (2019), a Historical-Dialectical Materialist analysis requires recognizing that the State's inaction in the face of environmental crimes is not a mere expression of inefficiency or absence of political will, but rather a structural manifestation of its commitment to serving the interests of capital — even when its own legislation ostensibly indicates otherwise.

Accordingly, the solutions proposed by Wedy (2019) and Lima and Cunha (2021) for sustainable development can be classified within the pragmatic macro-tendency. Wedy (2019, p. 16) called for the effective

— not merely rhetorical — enforcement of Brazilian law, emphasizing Brazil's alignment with the 3rd United Nations World Conference on Disaster Risk Reduction and stating: "It is worth emphasizing, however, the need to comply with Law 12.334/2010 and to implement a modern and efficient National Dam Safety Policy guided by the constitutional principles of precaution and environmental education." In other words, the author expects the Brazilian bourgeois state to enforce its own laws and, when necessary, to hold the ruling classes accountable.

Lima and Cunha (2021), in turn, contend that companies will prioritize sustainable development or, at a minimum, comply with environmental legislation — rather than the imperatives of capital accumulation — simply because a set of measures termed 'compliance' will, according to them, sensitize and raise awareness among all employees, suppliers, and stakeholders.

Wedy (2019) and Lima and Cunha (2021) do not demonstrate precisely how their prescriptions would operate within Brazil's condition as a capitalist neo-colony. The concept of neo-colony is apposite here: just as the exploitation of labor concentrates value in the hands of the ruling classes, the social welfare of so-called first-world countries has historically been and continues to be sustained by the exploitation of labor and resources from peripheral countries. With respect to the super-exploitation of labor and the transfer of value, Kaplan (2024, p. 344) explains:

“Subsequently, with the independence processes of Latin American countries, an international division of labor took hold, with some economies and nation-states possessing more diversified and productive industrial structures, while others had structures geared toward producing raw materials and food, less diversified and with low productivity. This, due to differences in the organic composition of capital, led to the sale of goods at production prices below value by agro-mineral export economies in exchange for goods from industrial economies at production prices above value. Thus, a regular process of unequal exchange was established, favoring accumulation and guiding the development of some economies while fostering underdevelopment and dependency in others” (Kaplan, 2024, p. 344).

Countries in a condition of dependent capitalism are thus characterized by the super-exploitation of labor and the systematic transfer of value — expressed, for example, in the export-dependence on raw materials such as mineral concentrates, without investment in the production of higher value-added and high-technology goods. The production of mineral concentrates requires the operation of mining companies — frequently privatized, as in the case of Vale — which routinely generate significant socio-environmental impacts in their operating territories while simultaneously camouflaging this destruction through EE projects designed to sustain an image of environmental commitment. Works with pragmatic and conservationist perspectives, however, ignore or deny this capitalist dynamic, neither revealing nor proposing the overcoming of the root cause of the problem.

Taking objective reality as a point of reference, a recent empirical study published in *Nature Communications* by Hickel et al. (2024) demonstrated that, between 1995 and 2021, the economies of the Global North appropriated a net total of 826 billion hours of labor from the Global South — across all skill levels and sectors — promoting structural inequalities and diverting the productive capacity of neocolonial economies that could otherwise have been directed toward meeting local human needs and fostering development. The authors further revealed that wages in the North are 87–95% higher than in the South for work of equivalent skill level.

Furthermore, in terms of environmental injustice, it is essential to emphasize that the greatest socio-environmental impacts fall disproportionately upon the most socially vulnerable populations — in stark contrast to the ruling class (majority shareholders do not reside downstream of tailings dams), which benefits from profit maximization through the reduction of investments in infrastructure and safety (Agencia Brasil, 2025; Almeida, 2025; Castro et al., 2018; Oliveira, 2024).

Of the works analyzed, only six out of twenty-one attributed primary responsibility for contemporary socio-environmental problems to the prevailing economic system and its logic of accelerated capital accumulation — which privileges one class to the detriment of another — or proposed the overcoming of capitalism as the path toward genuinely sustainable development (Batista Henriques, 2024; Carrilho

Eichenberger & Alves Pereira, 2018; Rabelo, 2017; Ribeiro Cardoso & Cosenza Rodrigues, 2022; Rodrigues, 2020; Rodrigues & Machado, 2023) (Table 3).

The predominance of the pragmatic macro-tendency in the works analyzed does not constitute an isolated or random phenomenon, but is rooted in the hegemony of neoliberalism. This hegemony can be explained by the pervasiveness of neoliberal discourses sustained by capital, which — by promoting individual responsibility and the notion of sustainability compatible with market logic — depoliticize the environmental issue and reduce it to behavioral and managerial solutions. Although Layrargues and Lima (2014) acknowledge the difficulty of diagnosing the hegemonic macro-tendency in EE, they recognize that dominant pragmatism constantly tends to subvert and co-opt CEE:

“Due to the scarcity of research, it is always difficult to diagnose discursive hegemonies in Environmental Education. We know that critical forces have secured a significant space within the field, but these forces are constantly eroded by the dominant pragmatism, which tends to convert and shift educational intentions toward the pragmatic sense of the market. Workforce training, job creation, and consumption tend to instrumentalize education as a means of social advancement and the reproduction of economic logic. In this path, the objectives of promoting citizenship, the public sphere, and political education end up being neglected” (Layrargues & Lima, 2014, p. 35).

As evidenced in our study, works classified within the pragmatic macro-tendency prioritize strategies such as decontextualized ecological awareness, self-protection, exclusively individual responsibility for addressing the environmental crisis, participation in corporate social responsibility programs, and compliance with environmental legislation — without problematizing the structural determinations that condition mining activity under capitalism. In short, even when these works acknowledge the existence of socio-environmental conflicts and impacts to some degree, their propositions remain circumscribed within the limits of the existing social order, at times ignoring and at times naturalizing the logic of accelerated capital accumulation that enables mining-related disasters. This finding reinforces the relevance and urgency of a CEE that, on the contrary, unveils the structural roots of the environmental crisis and, through class struggle, overcomes the dominant ideology and shifts the ideological balance towards overcoming the capitalist mode of production.

It is therefore imperative to develop a genuinely Critical Environmental Education — within the scope of both scientific production and school-based education, as well as among workers — that unveils, denounces, and proposes the overcoming of the root causes of environmental problems such as those linked to mining: namely, extractive activity under the capitalist mode of production (De Oliveira et al., 2021; Layrargues & Lima, 2014; Mendes, 2020). The overcoming of capitalism in favor of a sustainable society — as elucidated through the prism of ecosocialism (Löwy, 2021; Saito, 2021) — is essential for the survival of our species, which is threatened by widespread environmental destabilization, desertification, scarcity of potable water, wars, and anthropogenic global warming, and constitutes an indispensable theoretical foundation for CEE.

CONCLUSION

This systematic literature review has demonstrated that, despite the growth of critical currents within the field of Environmental Education, the pragmatic macro-tendency remains dominant in the treatment of mining-related themes in Brazilian academic production. The works analyzed overwhelmingly orient their objectives and conclusions toward the promotion of individual awareness, compliance with existing legislation, and the pursuit of sustainable development within the current capitalist framework — without critically engaging with the structural contradictions that underlie mining activity and its socio-environmental consequences.

From the perspective of Historical-Dialectical Materialism, this predominance is not a mere academic shortcoming but a reflection of the ideological hegemony of neoliberalism within the field of EE. The pragmatic and conservationist tendencies function, in practice, as instruments for the reproduction of the dominant social order, naturalizing the contradictions between capital and nature, and between the interests of the bourgeoisie and those of the working class and affected communities. Dam collapses and environmental disasters are not

accidents — they are structural outcomes of a production model founded on the maximization of profit at the expense of human lives and ecosystems.

Critical Environmental Education, grounded in Historical-Dialectical Materialism, offers a theoretically rigorous and politically committed alternative. By conceiving the environment as a social category — historically constituted through the dialectical relations between human beings and nature — CEE refuses to separate environmental issues from their class dimensions. It seeks not merely to raise awareness but to develop in students and communities a concrete, totalizing understanding of the socio-historical processes that produce environmental degradation, thereby contributing to the organized struggle for the transformation of the prevailing societal model.

The findings of this review indicate the need for further research that explicitly adopts the framework of CEE and Historical-Dialectical Materialism to examine mining and its effects. Equally important is the strengthening of working-class organization as a constitutive element of critical environmental praxis — a praxis that links educational processes to broader movements for social transformation. Only by understanding the environment as a social category, and by confronting the capitalist mode of production as the root cause of environmental destruction, can Environmental Education genuinely contribute to the overcoming of the current model of socio-environmental exploitation.

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SUPPLEMENTARY MATERIAL

Table M1 - Summary of the general objectives of the reviewed works.

Objectives	References
Establish the socioeconomic and cultural profile of workers in the mining production sector in the Metropolitan Region of Goiânia and to evaluate their relationship with the environmental issues of the context in which they operate. Based on the diagnosis, critiques and considerations will be made regarding the environmental education processes, present or absent in these companies, and their consequences for the workers.	Luz <i>et al.</i> (2010)
To identify and analyze, through semi-structured questionnaires, the environmental perception of residents of the São Sebastião das Águas Claras District and the Jardim Canadá neighborhood regarding the implementation of “PAVIECO” in these areas. Based on the results, the aim is to propose environmental education projects that promote the development of the regions, encouraging the appropriate use of ecological pavement, thus benefiting environmental and social aspects.	Alvarenga e Piuzana (2011)
Presenting the project for the Marista Municipal Park, developed for the municipality of Vila Velha, located in the Greater Vitória Metropolitan Region (ES), promoting the protection of biodiversity, with an emphasis on the Atlantic Forest and mining, in addition to addressing the relationship between spirituality and the corporeality of the human being.	Fiorotti <i>et al.</i> (2013)
Analyze the implementation and execution process of the Environmental and Heritage Education Project (EHEP) actions in the Boa Vista and Moura communities, in order to verify to what extent these initiatives can be considered drivers of sustainable local development, in addition to possible social, cultural, and economic impacts.	Cabral <i>et al.</i> (2015)
Develop an EE booklet addressing the canga ecosystem, in order to train basic education teachers and provide diversified knowledge about Brazilian ecosystems to elementary school students.	Maciel <i>et al.</i> (2017)
Conduct a survey on the socio-environmental perception of graduate students in the Environmental Sciences program regarding the benefits and harms faced by a community exposed to risks arising from the installation of mining companies or tailings deposits near or within cities. Additionally, to assess the students’ knowledge about the mitigation measures adopted by mining companies, the application of resources derived from this activity in the municipality, and the students’ capacity to understand this type of enterprise.	Pereira <i>et al.</i> (2017)
Through a quantitative survey-type study, to understand the perception of residents of Carmo da Mata regarding mining and environmental quality, in order to contribute both to the development of EE actions and to the formulation of public policies.	Rabelo (2017)
Elucidate issues related to contemporary ecological, philosophical, anthropological, and social thought linked to Environmental Justice, discussing the case of the communities of Oriximiná/PA and criticizing the dominant paradigms of environmental knowledge and of EE itself.	Carrilho Eichenberger e Alves Pereira (2018)
Develop a literature review addressing EE and social movements, seeking to highlight the value and legacy of the actions of these movements, as well as their contributions.	Wedy (2019)
Address the Brumadinho Environmental Catastrophe from the perspective of the Brazilian legal system.	Rodrigues (2020)
Analyze the perception of students and teachers regarding the impacts associated with mining, contributing to the development of educational practices and projects that promote critical participation in Corporate Social Responsibility (CSR) programs.	Silva Costa <i>et al.</i> (2020)
Analyze the perception of students in the Mining Technical Program at the Federal Institute of Amapá regarding EE.	Soares e Freitas (2020)
Analyze the consequences and impacts of mining activity, focusing on the application of ‘Compliance’ as a means of ensuring compliance with the regulations governing the sector and as a measure for preventing environmental damage such as that which occurred in the cities of Mariana and, more recently, Brumadinho.	Lima e Cunha (2021)

Understand how mining is present in some of the research productions in EE.	Ribeiro Cardoso e Cosenza Rodrigues (2022)
Through the students' perception of the municipality's socio-environmental problems, to analyze the EE developed in a basic education school in Urussanga (SC).	De Medeiros e Assunção (2022)
Propose a new Terms of Reference (TR) for related licensing processes, focusing on promoting disaster education in areas with tailings dams, raising awareness of associated risks, and individual self-protection.	Bizzotto <i>et al.</i> (2023)
Analyze the relevance of the 'Mining Circuit in Schools' project for the continuing education of students and teachers in schools in the municipality of Parauapebas, in the state of Pará.	Caldas <i>et al.</i> (2023)
Analyze the presence of Environmental History in the National Common Curricular Base (BNCC), the National Curricular Guidelines for Environmental Education (DCNEA), and the National Environmental Education Policy (PNEA) in the final years of Elementary School, relating Environmental History to a Supervised Curricular Internship experience in the History Licentiate program. To promote discussion on environmental disasters related to the theme of mining in order to train agents for the transformation of socio-environmental reality.	Rodrigues e Machado (2023)
Based on the Germinar Environmental Education program, developed in the city of Ouro Branco-MG, the aim is to provide solutions grounded in Geosciences to problems arising from the exploitation of mineral resources, in addition to forming individuals aware of the importance of the environment.	Pinto <i>et al.</i> (2023)
Understand current environmental demands, discussing Critical Environmental Education (CEE).	Batista Henriques (2024)
Develop EE actions from a Freirean perspective, using mining and its socio-environmental conflicts as a theme.	Da Silva <i>et al.</i> (2024)

Source: prepared by the authors (2025).

Table M2 - Summary of the conclusions of the reviewed works.

Conclusions	References
The research reveals that the low level of education among Brazilian workers negatively impacts the work environment, especially in mining, making them vulnerable to environmental problems, legislative gaps, and health risks. The fear of unemployment and sanctions prevents them from reporting these issues, hindering improvements and compliance with laws. The lack of specific legislation means that environmental issues, such as dust and noise pollution, are neglected, even with the use of PPE. Access to information is crucial for change, and EE, with a political character, is seen as a solution to address these challenges.	Luz <i>et al.</i> (2010)
Despite the serious environmental accident in the Macacos River Basin, initiatives such as "PAVIECO" offer ecologically sound alternatives for environmental recovery, promoting future sustainability. However, nearly 50% of respondents are unaware of "PAVIECO" and its benefits. Geography is emphasized as essential in the study, as it enables the understanding of the relationships between the physical and social environment, based on scientific and geographical concepts, emphasizing human interactions with the environment.	Alvarenga e Piuzana (2011)
In the implementation of the Park, efforts were made to minimize the impact of the constructions, integrating them harmoniously into the landscape without imitating the natural environment. The buildings were designed with a focus on the concept of universal design and the use of durable, low-maintenance materials, aiming to ensure a quality space for the community and promote a new perspective on urban development.	Fiorotti <i>et al.</i> (2013)
The study revealed that the actions developed by EHEP are the result of participatory management practices and social planning, resulting in the revival of traditions, the socialization of information, and income generation, factors that, together, contribute to sustainable local development.	Cabral <i>et al.</i> (2015)

The booklet disseminates information about the canga ecosystem, highlighting its importance as a water recharge area and habitat for endemic species, in addition to discussing the threats posed by excessive mining. The booklet goes beyond the mere transmission of scientific knowledge, encouraging the creation of other pedagogical materials focused on EE and environmental preservation. The study emphasizes the relevance of partnerships with the Prístino Institute and schools, suggesting that graduate programs develop proposals more oriented toward society.	Maciel <i>et al.</i> (2017)
Although they have knowledge about the issues addressed, the interviewees rarely use classroom learning to minimize socio-environmental impacts and reduce conflicts. Therefore, methodologies that integrate academic knowledge with real-life situations are necessary, preparing students to act as disseminators of knowledge outside the academic environment.	Pereira <i>et al.</i> (2017)
Residents' environmental perception focuses on the issue of household waste. This centrality may lead to excessive individual accountability and an emphasis on technical aspects, to the detriment of broader political issues. Thus, practices such as recycling can create a false sense of awareness, while collective issues, such as the Master Plan and the preservation of natural areas, should be appropriated by the local population. Furthermore, there is a need for CEE actions that promote debate and public participation in the licensing process.	Rabelo (2017)
Traditional populations in Brazil have been displaced from their lands for enterprises such as mining, aimed at labor exploitation and capital accumulation, which is not environmentally sustainable. These communities, by virtue of their own relationship with nature, are recognized as guardians of nature. In order to achieve a significant evolution in environmental thought and environmental justice, it is necessary to overcome bourgeois environmental education and ensure the participation of these peoples in the management of their territories.	Carrilho Eichenberger e Alves Pereira (2018)
Social movements play a significant role, as they represent demands of a social, political, and economic nature, and can influence and even modify public policies, social realities, and other related aspects.	Wedy (2019)
Following the environmental catastrophe in Brumadinho, it is concluded that Brazil has sufficient legal norms for administrative and criminal accountability and for the reparation of damages. However, it is essential to comply with Law 12.334/2010 and consolidate a National Dam Safety Policy guided by the principles of precaution and EE. It is also worth emphasizing the need to strengthen the National Mining Agency and raise societal awareness of dam risks. The country should also align itself with the Sendai Framework 2015-2030.	Rodrigues (2020)
A portion of students and teachers are unaware of CSR activities, with 92% of teachers addressing EE in a self-taught manner. It becomes essential to include geoethics and perception in environmental projects, using participatory methodologies, thereby fostering critical participation in CSR programs.	Silva Costa <i>et al.</i> (2020)
The students understand the interaction between humans and nature, possess knowledge about environmental issues, and recognize the relevance of EE for their future work in the mineral sector, due to its potential environmental impact.	Soares e Freitas (2020)
Companies fail to comply with legislation, while public authorities prove inefficient in oversight and the application of effective sanctions. 'Compliance' is an appropriate tool for preventing environmental damage.	Lima e Cunha (2021)
EE, according to research from EPEA, promotes debates on the impacts of mining, especially after the dam failure in Mariana (2015), with emphasis on the 2017 EPEA. In the 2019 EPEA, no studies on recent failures were found, suggesting that new research is underway. It is worth emphasizing the need to invest in EE to understand mining in educational practices and modes of existence, considering school and non-school spaces as environments of potentialities and hegemonic struggles.	Ribeiro Cardoso e Cosenza Rodrigues (2022)
The representations produced by the students enabled the retrieval of the various languages present in daily life. Studies on environmental perception through mind maps can help access students' understanding, the interpretation of which can assist in organizing lessons aimed at filling possible gaps in their education. Thus, the opportunity	De Medeiros e Assunção (2022)

is created to develop an EE grounded in the profound relationships between individuals and the environment in which they live.	
Only one training session was conducted with the communities before the failure of the Córrego do Feijão dam (Brumadinho) in 2019, which proved insufficient to prepare the population. Participants in the drill reported insecurity, lack of information, and inability to respond regarding other dams. The need to integrate public policies on Disaster Risk Reduction (DRR), combining EE and disaster management, is highlighted. It is proposed to promote disaster education and awareness, disseminate information on civil protection and defense, and strengthen self-protection measures and impact mitigation.	Bizzotto <i>et al.</i> (2023)
The project, developed within the municipal education network, strengthened pedagogical practice. In this sense, continuing education, combining theory and practice and the interrelation of themes, stands out as an efficient strategy for educators and students to acquire a renewed perspective on natural heritage, sustainability, and the municipality of Parauapebas.	Caldas <i>et al.</i> (2023)
Environmental History presents a possibility for applying EE within the History discipline, given its mandatory nature under the PNEA law, the DCN for EE, and the Contemporary Cross-Curricular Themes of the BNCC. Environmental History proved effective for understanding the multiple temporalities and the impacts of past events on the present, as exemplified by the context of mining.	Rodrigues e Machado (2023)
Students demonstrate low familiarity with geological concepts. However, the application of pedagogical practices and innovative technologies can contribute to environmental awareness and the environment in which they live.	Pinto <i>et al.</i> (2023)
It is imperative to advocate for CEE in order to counter hegemonic ideologies.	Batista Henriques (2024)
From the generating theme, it was possible to construct knowledge about socio-environmental conflicts and mining in the region of Barcarena-PA.	Da Silva <i>et al.</i> (2024)

Source: prepared by the authors (2025).

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Conflict of Interest Statement

The authors declare no conflict of interest.

Data availability

The entire dataset supporting the results of this study has been published within the article itself.

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