Revista Ibero-Americana de Humanidades, Ciências e Educação — REASE

OPEN ACCESS

doi.org/10.51891/rease.v12i11.32208

FORMAÇÃO CONTINUADA DE PROFESSORES DE CIÊNCIAS PARA A EDUCAÇÃO AMBIENTAL: UMA REVISÃO SISTEMÁTICA DA LITERATURA

CONTINUING EDUCATION OF SCIENCE TEACHERS FOR ENVIRONMENTAL EDUCATION: A SYSTEMATIC REVIEW OF THE LITERATURE

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RESUMO: Este artigo apresenta uma revisão sistemática da literatura sobre a formação continuada de professores de Ciências para a Educação Ambiental (EA), tomando como foco estudos empíricos publicados entre 2021 e 2026 que investigaram docentes da educação básica por meio de entrevistas, questionários ou instrumentos equivalentes. A busca foi orientada pelas bases SciELO, Scopus e Redalyc, com critérios de inclusão previamente definidos e registro das etapas de identificação, triagem, elegibilidade e síntese. A literatura recente indica que a formação continuada tende a produzir melhores condições para a inserção da EA quando se articula às práticas reais da escola, aos conhecimentos docentes, à contextualização territorial, à interdisciplinaridade e à reflexão crítica. Em contraste, ações pontuais, descontextualizadas e centradas apenas na transmissão de conteúdos apresentam menor potencial para alterar práticas pedagógicas. A análise também evidencia que os estudos que escutam professores por entrevistas e questionários são importantes para identificar necessidades formativas, concepções ambientais, dificuldades de implementação e relações entre formação e prática. Como resultado, propõe-se uma agenda formativa baseada em processos continuados, colaborativos, investigativos e contextualizados. O artigo apresenta quadros de síntese, matriz de extração, fluxograma metodológico e gráficos descritivos do corpus analisado. Ressalta-se que o número reduzido de estudos que atende simultaneamente a todos os critérios demonstra uma lacuna específica da produção recente e recomenda novas pesquisas com docentes da rede estadual.

Palavras-chave: Formação continuada. Professores de Ciências. Educação ambiental. Desenvolvimento profissional docente. Revisão sistemática.

ABSTRACT: This paper presents a systematic literature review on continuing education of Science teachers for Environmental Education (EE), focusing on empirical studies published between 2021 and 2026 that investigated basic education teachers through interviews, questionnaires, or equivalent instruments. The search was guided by SciELO, Scopus, and Redalyc, using predefined inclusion criteria and recording identification, screening, eligibility, and synthesis stages. Recent literature indicates that continuing education is more likely to strengthen EE when it is connected to real school practices, teacher knowledge, territorial contextualization, interdisciplinarity, and critical reflection. Conversely, isolated and decontextualized actions focused only on content transmission have limited potential to change pedagogical practices. The review also shows that studies based on interviews and questionnaires are relevant for identifying teachers' training needs, environmental conceptions, implementation barriers, and relationships between training and practice. The paper proposes a training agenda based on continuous, collaborative, investigative, and contextualized processes. Tables, an extraction matrix, a methodological flowchart, and descriptive graphs are included.

Keywords: Continuing teacher education. Science teachers. Environmental education. Teacher professional development. Systematic literature review.

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1 INTRODUCTION

Environmental Education occupies a strategic position in the contemporary debate on school, citizenship education and the teaching of Science, especially in the face of socio-environmental problems that require scientific knowledge articulated with social, cultural, economic and political dimensions. In the school space, however, the presence of the environmental theme does not guarantee, by itself, a critical or integrated approach. The Brazilian literature points to tensions between discourses on sustainability, pedagogical practices and concrete conditions of teaching work.

Continuing education is a relevant dimension of this process because it allows teachers to revisit scientific knowledge, reflect on their conceptions, share experiences, and reconstruct didactic strategies. Recent review studies show that production on school Environmental Education focuses heavily on pedagogical practices, while teacher training appears as an important, but proportionally smaller, axis. In a systematic survey of 108 articles, Rosa, Kauchakje, and Fontana (2024) identified 21 studies classified in the teacher training axis, compared to 77 in the pedagogical practices axis.

In the teaching of Science, the need for continuing education is particularly relevant. Issues such as climate change, biodiversity, water, waste, energy, environmental health, and socio-environmental justice demand scientific updating and the ability to establish relationships between school concepts and problems experienced by students. Teaching work, therefore, is not reduced to the application of materials: it involves the selection, contextualization, interpretation, and mediation of knowledge.

Another important aspect is to listen to the teachers themselves. Interviews and questionnaires make it possible to identify training needs, conceptions of the environment, previous experiences, institutional obstacles and possibilities for innovation. Recent production includes, for example, studies that investigate teachers in the state network and point to the need to expand training so that the environmental theme is understood as a socio-environmental problem and not just as ecological content.

In this context, this article aims to systematically analyze the recent scientific production on continuing education of Science teachers for Environmental Education, prioritizing empirical studies that used interviews and/or questionnaires with teachers of public basic education, especially from the state network. It seeks to answer: what contributions of continuing education are evidenced in the recent literature? What difficulties are reported

by teachers? Which conceptions and practices appear most frequently? And what gaps remain for professional development policies and programs? The general objective of the present work was to analyze, through a systematic review of the literature, the contributions, limits, and needs related to the continuing education of Science teachers for Environmental Education in recent and specific empirical studies; to identify studies published between 2021 and 2026 that investigate teachers through interviews and/or questionnaires; to map methodological characteristics and school contexts of the studies; to systematize teacher conceptions, training needs, barriers, and identified possibilities; analyze relationships between continuing education, pedagogical practices and Environmental Education; indicate gaps and recommendations for continuing education programs.

2 THEORETICAL FRAMEWORK

2.1 Continuing education and teacher professional development

Continuing education can be understood as a process of professional development that goes beyond the logic of isolated courses. Tardif (2014) highlights that teaching knowledge is plural and consists of different sources, including professional training, disciplinary, curricular and experiential knowledge. From this perspective, training actions that disregard the knowledge produced by teachers in their daily lives tend to have low adherence to the real needs of the school.

Nóvoa (2017) argues that teacher training needs to strengthen the profession and collective learning spaces. For Environmental Education, this means creating opportunities for teachers to analyze concrete problems, plan together, experiment with methodologies, monitor results, and reflect on their decisions. Training, therefore, can function as a space for investigating one's own practice.

Imbernón (2010) emphasizes the need for training linked to the context and working conditions. In Environmental Education, this perspective is particularly important, as environmental problems take on different characteristics according to the territory. Training needs to start from situations that make sense to teachers and students, relating scientific knowledge and local reality.

2.2 Environmental Education and Science Teaching

School Environmental Education can take on different perspectives. More naturalistic approaches tend to emphasize conservation, individual behaviors, and ecological knowledge; critical perspectives seek to problematize social, economic, and political relations that produce socio-environmental conflicts. Loureiro (2012) and Carvalho (2012) defend an Environmental Education capable of articulating knowledge, participation, citizenship, and transformation of society-nature relations.

In the teaching of Science, the environmental theme offers possibilities for contextualization and interdisciplinarity. However, Pereira and Lima (2025), when analyzing the conceptions of Natural Sciences teachers about the biodiversity crisis, identified familiarity with the theme, but also a predominance of lectures and conceptual focus, with less emphasis on social relations. This finding reinforces the importance of training that helps to shift EE from an exclusively informative approach to a problem-solving perspective.

Continuing education must, therefore, simultaneously contemplate scientific knowledge, pedagogical knowledge, critical reading of the territory and didactic planning. It is not a matter of replacing science content with environmental themes, but of creating significant relationships between scientific concepts and socio-environmental issues.

2.3 Teacher listening through interviews and questionnaires

Interviews and questionnaires are recurrent strategies to understand teaching conceptions and practices. Questionnaires allow reaching larger groups and identifying trends, while interviews offer greater interpretative depth. The combination of instruments can favor triangulation and broaden the understanding of the phenomenon.

In the recent literature, Silva and Campos (2023) used a semi-structured questionnaire with high school teachers from the state network of Juazeiro, Bahia, to analyze perceptions and practices in Environmental Education. The study points to the need for adequate training so that the theme is understood as a socio-environmental problem and not just as an ecological issue.

In a study published in 2025 on teachers from the state network of Ilhéus, Bahia, questionnaires were used to analyze knowledge about EE, existence of projects, and teacher participation. The results pointed to difficulties associated with continuing education and the

availability of resources, although teachers developed actions capable of stimulating reflection on socio-environmental problems.

3 METHODOLOGY

3.1 Review design

A systematic review of the literature of a qualitative, descriptive, and interpretative nature was structured, guided by the principles of transparency recommended by PRISMA 2020 (Page et al., 2021). The time frame considered was from January 2021 to September 2026. The defined databases were SciELO, Scopus, and Redalyc.

The searches combined descriptors in Portuguese, Spanish and English related to continuing education, science teachers and environmental education. Examples of combinations were: "continuing education" AND "science teachers" AND "environmental education"; "continuous training" AND teachers AND "environmental education"; and "continuing teacher education" AND "science teachers" AND "environmental education".

To maintain adherence to the problem, scientific articles with empirical data collected from public basic education teachers were considered as a priority, through interviews, questionnaires, scales, focus groups or equivalent instruments. The main focus was the state network; municipal studies or studies from other levels of education were used only in the theoretical discussion when relevant, and did not compose the synthesis core.

3.2 Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Scientific article published between 2021 and 2026.	Works prior to 2021.
Indexing/localization in the SciELO, Scopus or Redalyc databases, according to indexing availability.	Theses, dissertations, books, chapters and event papers.
Focus on school Environmental Education and/or teacher training related to the theme.	Studies exclusively with students or managers, without teaching data.
Participation of public basic education teachers; priority for the state network.	Exclusively university studies or initial training.
Use of interviews, questionnaires or equivalent instruments with teachers.	Purely theoretical essays without empirical data.
Results related to training, conceptions, practices or training needs.	Texts without thematic adherence to the teaching of Science/EE.

3.3 Selection process

The selection strategy was organized in four stages: identification, screening, eligibility reading, and inclusion. The web search allowed us to verify records and abstracts available on the consulted platforms. As the databases may present overlap and different forms of indexing, the number of records retrieved should not be interpreted as a number of unique studies without a complete bibliographic export (RIS/BibTeX) and automated deduplication. Thus, the empirical corpus below is presented with transparency as a core of studies that meet the central criteria, while contextual references are maintained separately.

Step	Procedure	Synthesized result
Identification	Search in SciELO, Scopus and Redalyc with combined descriptors.	Potentially relevant records.
Screening	Reading of title and abstract; exclusion by theme, period or audience.	Reduction of the initial set.
Eligibility	Reading of the abstract/method and verification of participants and instruments.	Selection of adhering studies.
Summary	Extraction of authorship, year, context, participants, instrument and findings.	Qualitative matrix and thematic categories.

3.4 Extraction matrix

Variable	Description
Identification	Author(s), year and title
Base	SciELO, Scopus, or Redalyc when identifiable
Background	State/municipality, education stage and network
Participants	Number and profile of teachers
Instrument	Questionnaire, interview, or combination
Theme	EA, sustainability, biodiversity, training, etc.
Education	Type, duration or training experience
Results	Conceptions, practices, barriers and contributions
Limitations	Stated or inferred limitations of the methodology

4 RESULTS AND SYNTHESIS

4.1 Characterization of the empirical core

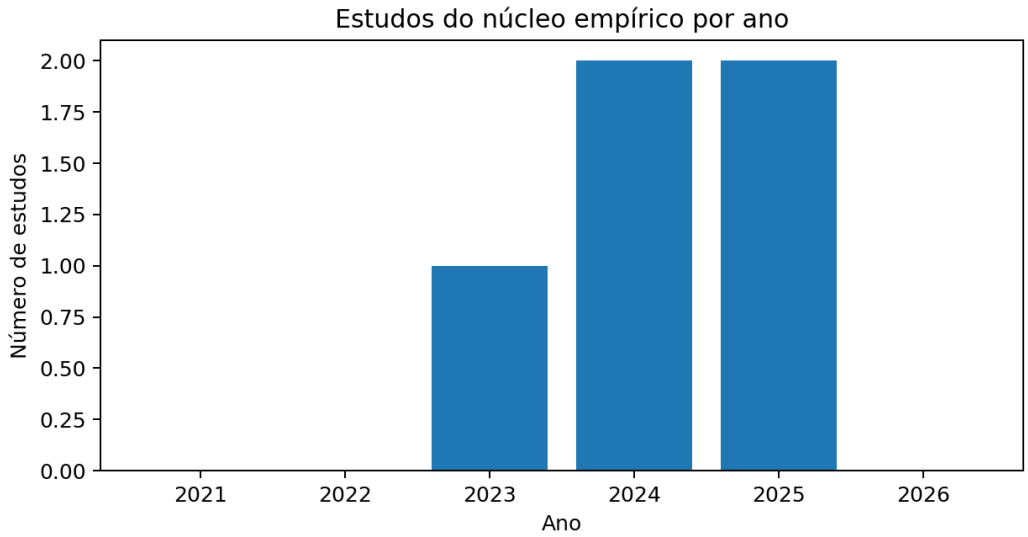
The recent literature found shows that production is still relatively limited when the criteria are applied simultaneously: five-year period, Environmental Education, public basic education teachers, priority to the state network, and use of interviews/questionnaires. This restriction is methodologically important: a review that expanded the audience to students,

universities, private schools, or only theoretical studies would produce a much larger corpus, but would answer another question.

Study	Year	Teaching context	Instrument	Main contribution
Silva; Fields	2023	High school in the state network, Juazeiro-BA	Semi-structured questionnaire	Perceptions and practices; need for training for a critical socio-environmental approach.
Rose; Kauchakje; Fontana	2024	Brazilian and international literature; training axis	Systematic review	It highlights training as a relevant axis and points out contradictions between theory and practice.
Gandolfi et al.	2024	Science/Geography teacher trainers, Brazil and England	Conversations/interviews	It discusses teacher training and environmental justice from a critical perspective.
Pereira; Lima	2025	Natural Sciences Teachers	Interviews	It shows familiarity with biodiversity, but a predominance of lectures and conceptual focus.
Lucena et al.	2025	Teachers of the state network of Ilhéus-BA	Questionnaire	It identifies challenges, insufficient continuing education and the need for resources/support.

4.2 Temporal distribution

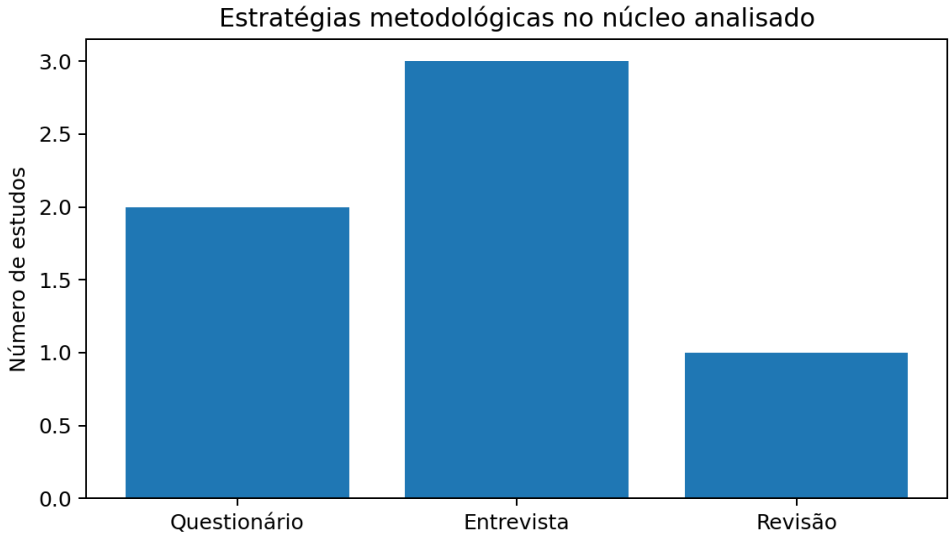
In the core of studies directly used in this synthesis, there is a concentration in the years 2024 and 2025, with an empirical study of the state network in 2023. This pattern does not mean the absence of production in other years, but it shows that the simultaneous application of the criteria reduces the number of eligible studies.



Source: prepared by the authors based on the matrix of studies analyzed.

4.3 Collection instruments

Predominant instrument	No. of studies	Analytical use
Questionnaire	2	Mapping perceptions, practices and needs.
Interview/Conversations	3	Deepening of conceptions, experiences and meanings.
Systematic review	1	Contextualization of the production on school EE and training.



4.4 Thematic categories

Category	Recurring evidence
Training needs	Update, contextualization, methodologies and greater conceptual mastery.
Conceptions of AS	Tension between naturalistic/behavioral perspectives and critical approaches.
Pedagogical practice	Predominance of exhibitions and occasional activities in part of the studies.
Contextualization	Importance of the territory and local socio-environmental problems.
Interdisciplinarity	Need for articulation between Sciences and other areas.
Working conditions	Time, materials, institutional support and continuity of projects.
Collaboration	Collective planning, peer exchange and partnership with universities.

5 DISCUSSION

5.1 Continuing education as a situated process

The studies analyzed converge on the idea that continuing education needs to be linked to the work context. The problem is not simply the absence of information on Environmental Education. In many cases, teachers recognize the relevance of environmental issues, but find it difficult to transform them into systematic curricular practices.

This result dialogues with the literature on professional development. Situated training allows working with concrete problems, observing results and reconstructing strategies. In the case of EE, the territory can function as an articulating axis: water, waste, biodiversity, fires, urban occupation, sanitation or air quality can be investigated through scientific concepts and social analysis.

Training of this nature requires continuity. Isolated meetings can raise awareness, but sustainable changes require monitoring, planning, experimentation and evaluation. The study on the state network of Ilhéus, for example, shows that continuing education and institutional support are related to the real possibilities of implementing environmental actions.

5.2 From the ecological approach to the socio-environmental perspective

One of the central issues identified is the difference between working with the environment as content and developing Environmental Education as an educational process. The first possibility can result in classes on recycling, pollution, water or biodiversity without problematizing the social relations involved. The second seeks to understand the phenomena in their complexity.

The results of Pereira and Lima (2025) are illustrative: teachers demonstrate familiarity with the biodiversity crisis, but the classes analyzed in the study are predominantly expository and conceptual. Continuing education can act precisely at this point, supporting the construction of investigative sequences, interdisciplinary projects, and problem-situations that relate scientific knowledge and social reality.

The critical approach does not mean abandoning scientific content. On the contrary, it requires greater conceptual rigor for students to understand environmental phenomena and be able to interpret information, evaluate evidence, and participate in public debates.

5.3 Interviews and questionnaires as formative diagnostic tools

Studies with interviews and questionnaires show that listening to teachers is an indispensable stage of training planning. Before offering a course, it is relevant to know what teachers already know, what experiences they have, what difficulties they encounter and what environmental problems they recognize in their territory.

Questionnaires can be applied on a large scale to produce an initial diagnosis. Interviews can complement the data, exploring contradictions and experiences that do not appear in closed answers. The combination of the two instruments makes it possible to identify objective and subjective needs, contributing to a more responsive education.

However, self-report instruments have limitations. The teacher can declare that he performs a certain practice without this necessarily being observed in the classroom. For this reason, future studies can combine interviews and questionnaires with observation, analysis of planning, teaching materials, school projects and student productions.

5.4 Barriers to implementation

Barrier	Implications for training
Reduced time	Need to insert training in working hours and collective planning.
Lack of materials	Production and curatorship of contextualized didactic resources.
Curricular fragmentation	Interdisciplinary planning and integrative projects.
Insufficient training	Continuous training paths and accompaniment.
Specific projects	Monitoring, continuity and evaluation of results.
Distancing from the territory	Use of local socio-environmental problems as learning situations.
Low institutional support	Participation of management and pedagogical coordination.

6 PROPOSAL FOR A FORMATIVE MODEL DERIVED FROM SYNTHESIS

Based on the results, a model of continuing education is proposed organized in six articulated movements. The proposal is not presented as an experimental result, but as a propositional synthesis derived from the needs identified in the literature.

Movement	Activities	Expected product
1. Diagnosis	Questionnaire and interview with teachers.	Map of training needs.
2. Problematization	Survey of environmental problems in the territory.	Problem-situation database.

Movement	Activities	Expected product
3. Deepening	Studies of scientific content and critical EE references.	Conceptual notebook.
4. Planning	Collaborative elaboration of didactic sequences.	Interdisciplinary plans.
5. Experimentation	Application of activities and reflective record.	Teaching portfolio.

Continuing education should not be attributed exclusively to the teacher. The school needs to create institutional conditions for planning, studying, and collaborative work. Pedagogical coordination and management can act in the organization of training times, monitoring projects, articulation with partners, and valuing teaching experiences. The training policy, in turn, needs to consider material and professional conditions, avoiding making the teacher individually responsible for difficulties that are also institutional.

7 FINAL CONSIDERATIONS

The review shows that the continuing education of Science teachers for Environmental Education remains a relevant field and, at the same time, with specific gaps. When the criteria are restricted to recent, empirical studies based on listening to public school teachers, especially from the state network, the available corpus becomes considerably smaller than the general production on school Environmental Education.

The studies analyzed indicate that teachers recognize the relevance of the environmental theme, but face difficulties in incorporating it in a critical, continuous, interdisciplinary and contextualized way. Among the challenges are insufficient training, lack of time, limited resources, curricular fragmentation and predominance of expository practices.

Interviews and questionnaires proved to be important to reveal training needs and understand the distance between pedagogical intention and effective practice. The main contribution of these instruments lies in the possibility of building training programs based on the reality of teachers, instead of offering generic content.

As an implication, it is recommended that continuing education policies for science teachers include initial diagnosis, conceptual study, territory investigation, collaborative planning, classroom experimentation and monitoring. Training should also consider Environmental Education as a critical and interdisciplinary dimension of science education.

As a limitation, the difficulty of proving, through public consultation on the web, the simultaneous indexing of all records in the three databases is highlighted. The overlap between databases and the need for institutional access to Scopus recommend that, for a version

intended for scientific publication, a reproducible search be performed directly in the interfaces of the databases, with export of results, deduplication, and registration of the numbers of the PRISMA flow. Thus, this document should be understood as a structured and auditable academic version of the review, and not as a statement that 25 eligible studies were found.

Despite this limitation, the synthesis points to a clear research agenda: to expand longitudinal studies on the effects of continuing education; to combine questionnaires, interviews and observation; to investigate differences between state and municipal networks; to analyze working conditions; and to evaluate whether changes in teachers' conceptions translate into lasting changes in Environmental Education practices.

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