

Original article

Environmental education in the natural sciences in pre-university education



La educación ambiental en las ciencias naturales en la educación preuniversitaria

A educação ambiental nas ciências naturais no ensino pré-universitário

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ABSTRACT

Environmental education has become a fundamental pillar for the comprehensive training of future high school graduates, fostering responsibility and commitment to the planet's sustainability; hence its importance and relevance. In Cuba, the Third Educational Improvement Plan proposes new approaches that, combined with the potential of the natural sciences, lay the foundation for contributing to this educational process from a scientific worldview. This research aimed to characterize environmental education from the perspective of the natural sciences in pre-university education, based on the new approaches conceived in the Third Educational Improvement Plan. A descriptive study was conducted using a literature review, and from a theoretical standpoint, the following methods were employed: historical-logical, analysis and synthesis, and inductive-deductive, which allowed for the analysis of conceptions on the topic from different perspectives and

contexts. In addition, empirical instruments were used: document analysis, surveys of teachers and students, interviews with department heads, and classroom observations, which allowed for the identification of strengths and weaknesses. The main results focused on the systematization of representative concepts and the determination of the characteristics of this process within the context described above. In summary, environmental education within the natural sciences at the pre-university level presents shortcomings; it is unsystematic, disjointed, and decontextualized, thus highlighting the need to contribute to environmental education for pre-university students that fosters responsible environmental behavior, fulfilling the requirements of the pre-university graduate profile.

Keywords: environmental education; natural sciences; third educational improvement; new ways of working.

RESUMEN

La educación ambiental se ha convertido en un pilar fundamental para la formación integral de futuros bachilleres, responsables y comprometidos con la sostenibilidad del planeta; de ahí su importancia y pertinencia. En Cuba, el Tercer Perfeccionamiento Educacional propone nuevas formas de trabajo que, unido al potencial de las ciencias naturales, sientan las bases para, desde una concepción científica del mundo, contribuir a este proceso formativo. La investigación tuvo como objetivo caracterizar la educación ambiental desde las ciencias naturales en la educación preuniversitaria, a partir de las nuevas formas de trabajo concebidas en el Tercer Perfeccionamiento Educacional. Se realizó un estudio descriptivo a partir de una revisión bibliográfica y desde el punto de vista teórico se utilizaron como métodos: el histórico-lógico, análisis y síntesis e inductivo-deductivo, los que permitieron analizar concepciones sobre el tema desde diferentes enfoques y contextos. Se utilizaron, además, instrumentos empíricos: análisis de documentos, encuesta a profesores y estudiantes, entrevista a jefes de áreas y observaciones a clases, que permitieron determinar fortalezas y debilidades. Los resultados principales se centraron en la sistematización de conceptos representativos y la determinación de características de este proceso en el contexto descrito anteriormente. En resumen, la educación ambiental desde las ciencias naturales en la educación preuniversitaria presenta insuficiencias, se manifiesta asistémica, desarticulada y descontextualizada, por lo que evidencia la necesidad de contribuir a una educación ambiental en los

estudiantes de preuniversitario que genere un desempeño ambiental responsable, dando cumplimiento a las exigencias del modelo del egresado del preuniversitario.

Palabras claves: educación ambiental; ciencias naturales; tercer perfeccionamiento educacional; nuevas formas de trabajo.

RESUMO

A educação ambiental tornou-se um pilar fundamental para a formação integral de futuros estudantes do ensino pré-universitário, tornando-os responsáveis e comprometidos com a sustentabilidade do planeta; daí a sua importância e pertinência. Em Cuba, o Terceiro Aperfeiçoamento Educacional propõe novas formas de trabalho que, aliadas ao potencial das ciências naturais, lançam as bases para contribuir para esse processo formativo a partir de uma concepção científica de mundo. A pesquisa teve como objetivo caracterizar a educação ambiental no âmbito das ciências naturais no ensino pré-universitário, com base nas novas formas de trabalho concebidas no Terceiro Aperfeiçoamento Educacional. Realizou-se um estudo descritivo fundamentado em uma revisão bibliográfica; do ponto de vista teórico, utilizaram-se os métodos histórico-lógico, análise e síntese, e indutivo-dedutivo, permitindo analisar concepções sobre o tema sob diferentes abordagens e contextos. Além disso, foram utilizados instrumentos empíricos: análise documental, questionários aplicados a professores e estudantes, entrevistas com chefes de área e observação de aulas, o que possibilitou identificar pontos fortes e fragilidades. Os principais resultados concentraram-se na sistematização de conceitos representativos e na determinação das características desse processo no contexto descrito anteriormente. Em suma, a educação ambiental no âmbito das ciências naturais no ensino pré-universitário apresenta insuficiências, manifestando-se de forma assistêmica, desarticulada e descontextualizada; isso evidencia a necessidade de promover uma educação ambiental que gere um desempenho ambiental responsável nos estudantes, atendendo às exigências do perfil de egresso do ensino pré-universitário.

Palavras-chave: educação ambiental; ciências naturais; terceiro aperfeiçoamento educacional; novas formas de trabalho.

INTRODUCTION

Today's society is marked by globalization, social conflicts, scientific and technological advances, climate change, and a new context of a post-COVID-19 health emergency world that has exacerbated the environmental crisis.

All these causes have the same origin: human activity, which brings ecological, social, and climatic consequences. Therefore, a change is urgently needed through preventive and restorative solutions, using educational processes to promote changes in individual and collective behaviors, based on values-based education that strengthens critical thinking and responsibility to achieve a collective environmental ethic towards sustainable development.

Within the framework of the 70th General Assembly of the United Nations, as part of the 2030 Agenda, the Sustainable Development Goals were adopted, with No. 4 signifying the need to: "Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all" (NU CEPAL, 2019).

In this regard, Santos Abreu *et al.* (2020) points out that: "Education, in its broadest sense, is the most profitable long-term investment to transform this panorama and develop the feelings, attitudes and values necessary to achieve the most intelligent reconciliation between environment and development, and thus raise the quality of life (p. 3).

Sustainable development is understood as a process, resulting from systemic relationships, in which the natural, social, and economic dimensions are dynamically integrated into a single whole, based on principles of equity and social justice for all species on the planet. From this perspective, the anthropocentric vision that has dominated throughout human history is overcome, and progress is made toward an ambiocentric perspective (Márquez Delgado *et al.*, 2021).

Environmental education has emerged as a response to the global ecological crisis and plays a vital role in preparing citizens, enabling them to transform their behavior in order to address environmental problems arising from society's indiscriminate interaction with nature. It also recognizes the urgent duty of educators as a political matter and a public action, with the goal of fostering participation and building environmentally sustainable societies.

In Cuba, the integration of environmental education into the pedagogical process at all educational levels is of great importance and priority. It currently plays a vital role in preparing new generations

for life; this presupposes that they learn to live harmoniously with the environment and possess the necessary tools to understand and address the environmental problems they face in their school and community settings.

To achieve this goal, Cuban education intends to increase the levels of academic rigor, with an interdisciplinary and transdisciplinary approach, in order to improve the quality of student learning and allow them to direct their actions towards the formation of a systemic and comprehensive vision of the environment.

Despite all the efforts made, strengthening environmental education remains an unresolved problem that requires continued solutions and results that contribute to sustainable development; it demands research and the responsibility of everyone. This is an approach that aligns with the criteria and work of authors such as Moré and Valdés (2008); Charbonet (2009); Fragoso *et al.* (2017); Santos Abreu *et al.* (2020); Márquez Delgado *et al.* (2021); Mejías *et al.* (2021); Márquez Delgado *et al.* (2023).

Parada (2008), as cited in Rodríguez León *et al.* (2022) It defends the following criterion: environmental education is a formative and integrative process (...) in which all the subjects involved participate and in which educational influences only acquire true meaning in the individual when they are assumed by him, when they reach an authentic individual meaning and value and are incorporated as traits and/or qualities of his personality, which regulate his behavior and enable him to operate with the knowledge acquired, so that its result is realized in the environmental training of the student.

Henao Castro and Vives Hurtado (2025) believe that it is important in environmental education to raise awareness, to know (to have knowledge), to analyze problems based on diagnoses and to experiment to verify causes and consequences of phenomena.

Furthermore, it is essential to generate training dynamics that stimulate collective participation, social cooperation and, at the same time, promote in individuals the ability to identify their own contradictions, transcend individualistic positions and move towards community practices that are harmonious and sustainable in time and space.

In this sense, the need emerges to strengthen the responsibility and capacity of citizens to act in solving environmental problems that affect local development (Márquez Delgado *et al.*, 2023, p. 24).

It is worth noting that several authors have defined environmental education: McPherson (2004); Sauvé (2005); González-Escobar (2017); Llopiz *et al.* (2020), among others, who agree on the interdisciplinary and systemic approach to environmental education, its close link with sustainability, and with the problems of the natural and social environment. The participation and responsibility of different social sectors is evident, based on joint action aimed at strengthening values that are essential to reversing the existing environmental situation in a given context.

For their part, Márquez Delgado *et al.* (2021) define it as:

a continuous and permanent learning process that is directed towards enabling individuals and communities to understand the complexity of environmental problems and to act in their solution, based on the appropriation of new knowledge, skills, values and attitudes, different from those that make up the current social rationality (p. 304).

This definition is particularly relevant to the object of study of this research for several reasons. First, its procedural, continuous, and permanent nature corresponds to the conception of environmental education as a formative dynamic that permeates the entire pre-university curriculum, not as a one-off or isolated action.

Secondly, by emphasizing the understanding of the complexity of environmental problems, it justifies the interdisciplinary approach required in the natural sciences (Biology, Chemistry and Geography) to address phenomena that cannot be explained from a single discipline.

Third, the action orientation it advocates ("act in your solution") aligns with the purpose of training students with transformative modes of action, capable of influencing their environment.

Fourth, the acquisition of knowledge, skills, values, and attitudes comprehensively encompasses the dimensions of educational achievement that are pursued: not only knowing, but also knowing how to do, knowing how to be, and knowing how to live together. Finally, the aspiration to transform the dominant social rationality gives environmental education a critical and ethical dimension, consistent with the principles of curricular sustainability and contextualization that guide the proposed pedagogical model.

This definition highlights the need for sustainable development from an instructional, educational and developmental perspective, and the role of science in the formation of the individual and of the individual in relation to the community.

The natural sciences (Biology, Chemistry, and Geography) are fundamental to understanding the complexity of environmental systems. Their potential as a vehicle for strengthening environmental education is considerable, given that they provide the basic scientific knowledge for understanding the interrelationships within natural systems, the impact of human activities, and the foundation for finding sustainable solutions.

Integrating environmental education into this field allows students to develop a holistic, critical, and ethical view of the environment, linking theory with practice and fostering school research as a way to solve local and global problems; contributing in turn to a scientific education and active student participation.

According to Alcívar Cedeño and Alcívar Chávez (2022), the area of natural sciences is designed to foster critical and creative thinking, for the analysis and positioning of sociocultural and natural problems, to stimulate the development of scientific skills, which includes the use of technology for information search, research and the ability to solve environmental problems (p. 174).

These premises addressed by these authors are important considerations of the Third Improvement of the National Education System implemented by the Ministry of Education (MINED) from 2014 onwards, with the objective of raising the quality of education, fulfilling the goals and objectives of the 2030 Agenda and the Guidelines of the Economic and Social Policy of the Party for the period 2021-2026.

This process, as a scientific response, is of great importance because it allows for a level of updating of the teaching and learning process that is linked to the country's socioeconomic development. Educational institutions must fulfill their social responsibility at each historical moment, and to do so, they must integrate themselves into and transform their educational reality.

Therefore, in response to the demands of current Cuban society, providing answers in the natural sciences to strengthen Environmental Education in pre-university education becomes a challenge and must be internalized as a formative need that contributes to the comprehensive training of graduates

at this educational level, in accordance with the objectives pursued by the Third Improvement of the National Education System.

To this end, the goal of Pre-University Education is projected as: "The achievement of the development and integral formation of the personality of the students with a cultural base, in correspondence with the patriotic, civic and humanist ideals of Cuban socialist society in its prosperous and sustainable development. Ideals expressed, moreover, in the ways of feeling, thinking and acting, according to their particularities and individual interests, in correlation with social needs, which allows them to assume a scientific conception of the world and prepare for life" (Ramos Cuza & Jardinot Mustelier, 2023).

Based on the above criteria, the need is seen to train young people committed to sustainable development, who are able to identify the environmental problems of the school and community context, integrate the system of knowledge acquired in their training process, taking advantage of the various means and existing technologies, giving rise to a practice that genuinely guarantees a way of acting in accordance with the values of sustainable development, with a high sense of individual and social responsibility.

Pre-university education is immersed in these transformations. Among them are modifications to the general curriculum, based on proposed changes to the study plan programs; the integration of environmental education as one of the nine content components in the different subjects; and the design of an institutional curriculum that, due to its flexibility, allows the incorporation of actions deemed necessary by the school according to its needs and potential. These include complementary activities, projects, scientific societies, and others.

The institutional curriculum, by its very nature, allows the school to design and incorporate educational activities that respond to its specific needs and contexts. It fosters the essential integration of educational and instructional processes, taking advantage of the opportunities offered by the content of the natural science subjects, the learning process itself, and the natural connection with the family and community environment.

Its implementation and contextualization are achieved through the institutional educational project, taking into account the particular educational conditions and the potential of the community in which the institution is located; based on consultation with all the factors of the center itself and the environment that influence the education of the students.

According to Alcolea Parra (2024), the construction of the institutional curriculum requires the participation of various stakeholders, as well as consideration of students' interests and motivations. Likewise, efforts should continue to maximize the potential of the curriculum to complement the general curriculum.

The institutional curriculum, as a complement to the general curriculum, incorporates the so-called projects (social, cultural and technical), which constitute a component that strengthens the scientific knowledge that the student receives and the formation of search and research skills, while addressing global problems of society and nature, community action projects, and others, according to the possibilities of the territory and the interests of the students.

Therefore, the objective of this article is defined as: to characterize environmental education in the natural sciences in pre-university education, based on the new forms of work conceived in the Third Educational Improvement.

MATERIALS AND METHODS

A descriptive study was conducted based on a literature review. From a theoretical standpoint, the following methods were used: historical-logical, analysis-synthesis, and inductive-deductive. These methods allowed for the analysis of conceptions on the topic from diverse approaches and contexts. At the empirical level, documentary analysis was used to gather information from a group of guiding documents for Pre-University Education, syllabi for natural science subjects, and methodological guidelines for the natural sciences area and its constituent subjects.

To fulfill the objective of this article, a series of instruments were applied to diagnose the initial state of the environmental education process from the natural sciences in pre-university education.

The research was developed at the Pre-University Vocational Institute of Exact Sciences Federico Engels in Pinar del Río, between October 2024 and July 2025. It was carried out with three sample groups, composed of 274 students, (90 students from 10th grade, 93 from 11th grade and 91 from 12th grade), 18 teachers (seven teachers from 10th grade, seven from 11th grade and four from 12th grade) representing the area of natural sciences and 24 heads of areas and subjects.

The theoretical systematization made it possible to arrive at an operational definition of the variable under study.

In turn, it has two inherent dimensions, which are clearly expressed in the distinctive features that make up its conceptualization and which, when deployed through indicators, allowed the evaluation of the process being studied.

RESULTS

The application of the instruments and methods described above allowed us to obtain the following results.

A group of trends were identified in the environmental education process in the international and national context, namely:

- Recognition of the urgency of environmental education, considering it a key element for development and for the integral formation of the individual.
- Strengthening environmental policies towards sustainable development, highlighting the importance given to this process as a core aspect to transform the environmental reality of communities through the educational process.
- institutional links, in order to develop cooperation actions to strengthen the environmental education process.
- Priority of the work carried out in educational institutions as entities integrating actions for environmental education, in favor of sustainable development and the training of social actors that allow them to become agents of change in the communities and promote local development.
- Increased use of new information and communication technologies, based on the environmental education process.

Environmental education in the natural sciences at the pre-university level has been recognized as a priority for the comprehensive development of students. But pre-university education It has not recognized a pedagogical tool that guides teachers on how to conceive the process of environmental education in the natural sciences based on the potential of the Third Educational Improvement that results in this integral formation in the student, which is expressed in their actions towards the environment.

In the pre-university education of the Pinar del Río municipality, the phenomenological manifestations of observable reality, revealed in educational practice, continue to present inappropriate behaviors in students. Among these, the following stand out:

- Improper waste disposal, inadequate procedures, and lack of interest in solving environmental problems.
- They fail to integrate the system of knowledge received in the subjects of the natural sciences area in relation to the topics of the integrative seminar.
- Little motivation to conduct environmental research from a local perspective.
- Lack of commitment and responsibility in their modes of action when interacting with environmental resources in the context of the institution and community.
- Lack of interest, sensitivity and concern for taking care of the environment that surrounds them.

The presence of inappropriate behaviors in pre-university students in the municipality of Pinar del Río towards the care and conservation of the environment was identified as a social problem, as well as the need to develop a critical and innovative environmental education that allows them to identify and transform the problems existing in their school and community context.

In order to determine the possible causes that generate the existence of the identified social problem, an exploratory study was carried out, obtaining the following results:

- Predominates in the area of natural sciences when addressing environmental education.
- Little use of the potential offered by the new forms of work of the Third Educational Improvement for the strengthening of the environmental education process.
- Insufficient implementation of scientific-investigative activity from the natural sciences to strengthen environmental education.
- Deficiencies in teacher preparation to implement an environmental education process that is both scientific (based on the rigor of the natural sciences) and complex (addressing ecological, socioeconomic and cultural interrelationships).
- Limited projection of environmental education from the curricular and extracurricular, for the solution of environmental problems of the school and the community, in link with the agencies and agents that intervene in the educational process.
- Insufficient student participation in environmental activities from the area of natural sciences.

The causes identified during this study contribute to the existence of the social problem. They also reveal inconsistencies in the environmental education process within the natural sciences at the pre-university level in the municipality of Pinar del Río.

It was defined the process of environmental education from the natural sciences in pre-university education in the following terms:

A formative dynamic, transversal, systemic, interdisciplinary and contextualized, which, through the integration of the scientific content of the natural sciences with local environmental problems, through school action research, leads students to appropriate knowledge, develop investigative and axiological skills and deploy transformative modes of action towards the sustainability of their environment.

The dimensions of the process being studied were determined within the defined variable, namely:

- Dimension 1. Formative dynamics (Environmental education from the natural sciences as a process).
- Dimension 2. Formative achievement (Environmental education from the natural sciences as a result.)

The identified dimensions were evaluated through the following indicators:

Dimension 1. Formative dynamics

- 1.1 Teacher's theoretical environmental knowledge to address environmental education from the natural sciences.
- 1.2 Direction of the didactic process of environmental education from the subjects of the natural sciences area.
- 1.3 Joint planning and execution from the area of natural sciences and subject of activities that integrate scientific content with local environmental problems.
- 1.4 Application of participatory methodologies (laboratory work, excursions, environmental projects, debates, integrative workshops).

- 1.5 Recognition of the importance of integrating the content of natural sciences with local environmental problems for student training.
- 1.6 Promotion of school research linked to local and community environmental problems.
- 1.7 Active participation of students in environmental activities generated from the training process.

Dimension 2. Formative achievement

- 2.1 Appropriation of scientific knowledge applied to the environment.
- 2.2 Development of research skills (problem formulation, data handling, critical analysis).
- 2.3 Manifestation of values oriented towards sustainability (responsibility, cooperation, respect for nature).
- 2.4 Evidence of transformative modes of action (solution proposals, community projects, changes in habits).
- 2.5 Ability to relate integrative learning to local environmental problems.

The analysis revealed that the observed educational process fails to consolidate meaningful or transformative learning, demonstrating the scientific relevance of the ongoing research and the need for change stemming from the field of pedagogy. The points of agreement and disagreement regarding the object of study were identified.

Coincidences

Dimension 1. Formative dynamics

- Lack of knowledge and skills to strengthen the environmental education process from the natural sciences.
- Deficiencies in curricular integration.
- Lack of participatory and transformative methodologies.
- Weak link with school research.
- Limited focus on sustainability.

- Decontextualization of the environmental education process with respect to the local socio-ecological reality.

Dimension 2. Formative achievement

Students have difficulty integrating knowledge, research skills, values, and ways of acting in order to solve the environmental problems of the school and the locality.

Discrepancies

Regarding the process of environmental education from the natural sciences in pre-university education, there are discrepancies between the requirements and objectives projected by the Model and Study Plan of the pre-university and the results derived from the applied instruments.

The study carried out allowed to corroborate the presence of strengths and weaknesses in the process of environmental education from the Natural Sciences in pre-university education.

Strengths

- Environmental education is recognized as a formative need for pre-university students in their comprehensive training as high school graduates.
- Solid curricular foundation in natural sciences to develop integrative learning.
- Recognition of the importance of linking the content of natural sciences with local problems through community action projects.
- Sensitivity to the main environmental problems affecting the school and the locality.

Weaknesses

- Environmental education from the natural sciences in pre-university education in the municipality of Pinar del Río suffers from a systemic, sustainable, contextualized, and participatory approach.
- Limitations in the pedagogical and methodological preparation of teachers to address environmental education from the natural sciences.
- Inadequate conception from the group's educational project and the institutional curriculum of actions aimed at the development of environmental education.
- Limited use of school and community environmental projects as an integrating means of scientific research and educational action.

DISCUSSION

Literature has explored how to incorporate the environmental education process from the natural sciences in pre-university education. These are fundamentally aimed at providing environmental training to the student, preparing them for life, in their family and civic activities, and with an orientation towards sustainable development.

This process has been taken up in the MINED by the Branch Program 11 Environmental education for sustainable development from educational institutions (2009-2012), which continues today in the Project Improvement of Environmental Education for Sustainable Development in the National Education System, associated with the Program coordinated by the Central Institute of Pedagogical Sciences (ICCP) of the MINED (Santos Abreu, 2020).

It is about advancing in the search and construction of a culture of sustainability, which implies the application of various methods and forms that favor the modification of the relationships with the biophysical environment, as well as changes in the cultural, social and economic patterns that have conditioned the current problem (Márquez Delgado *et al.*, 2021).

The new working methods of the Third Educational Improvement, in the opinion of Maturell Aguilera *et al.* (2021) are a set of processes through which the work of the institutions is directed, in which participatory, democratic and flexible management methods are applied, aimed at achieving the purpose and objectives of education and the level, improving the school climate and greater participation of the educational community (agents and agencies) in the integral formation of the students.

Changes in the working methods of educational institutions and modalities cannot be framed within a rigid scheme for all centers, as they are influenced and determined by the conditions of each place and the possibilities of the groups.

In the initial stages of awareness and preparation, an environment conducive to change must be created, mobilizing individuals towards the agreement of transformative actions, based on the establishment of a new management style for all processes: flexible, comprehensive, democratic and participatory, the distribution of tasks and the organization of work groups.

The institutional curriculum is the one that offers the possibility of taking into consideration what needs to be done in each school in order to fulfill what the general curriculum establishes (ICCP, as cited in Bello Martínez, 2022).

In working with the institutional curriculum and the educational project, the essential thing is that all groups of subjects that participate in the work of the institution (teachers, service workers, students, family members and community representatives) get involved and assume responsibilities in the Institutional and group Educational Project.

In the authors' opinion, the incorporation of environmental education into pre-university education It demonstrates a lack of intentionality and personalized treatment from the natural sciences in a way that can be enhanced in an interdisciplinary manner, and promote a culture of sustainability, with the school being, in the opinion of López (2014, as cited in Mateo Rodríguez & García Rodríguez, 2024) the environmental promoter of the locality for sustainable development.

The diagnostic study presents evidence of the deficiencies that exist during the pedagogical process to achieve an adequate incorporation of environmental education in the natural sciences in pre-university teaching, even though all the social actors involved in the process (teachers, students, family and community agents) recognize that it is transcendental for the environmental training of the future high school graduate.

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Conflict of interest

Authors declare no conflict of interests.

Authors' contribution

The authors participated in the design and writing of the article, in the search and analysis of the information contained in the consulted bibliography.



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