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Research article

El sendero ecológico: un diálogo entre las ciencias sociales, la ecología y las matemáticas

The ecological path: a dialogue between social sciences, ecology and mathematics

O caminho ecológico: um diálogo entre ßciências sociais, ecologia e matemática

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RESUMEN

La interdisciplinariedad es una apuesta promovida por la educación en todas las áreas del conocimiento siendo múltiples las investigaciones que se han llevado al respecto, sin embargo, la integración entre las ciencias sociales, la biología y las matemáticas en ambientes de modelación con énfasis en la perspectiva socio-crítica es escaso. De esta manera, el Sendero Ecológico se convirtió en un ambiente ideal para posibilitar en 13 años de ejecución, una mirada integradora por parte de los estudiantes quienes al modelar fenómenos socio-ambientales relacionados al cambio climático han reflexionado sobre su papel en la sociedad como promotores de conservación. La investigación que se reporta es de tipo cualitativo y en ella se han beneficiado cerca de 450 estudiantes de los grados octavo a once (13-17 años) de la Institución Educativa El Pedregal, en la ciudad de Medellín. Se han tenido en cuenta observaciones, diarios de aprendizaje y producciones para analizar su accionar frente al proceso y reflexión del modelado. Los resultados permitieron identificar cómo los estudiantes han aprendido de forma integral conceptos relacionados con las tres ciencias y han tenido participación en el proceso de modelado, asumiendo una conciencia frente a la vida en su relación con el otro y con su entorno.

Palabras claves: interdisciplinariedad, modelación matemática, problemas socio-ambientales, conciencia social y ambiental.

ABSTRACT

Interdisciplinarity is a commitment promoted by education in all areas of knowledge, with multiple investigations that have been carried out in this regard, however, the integration between social sciences, biology and mathematics in modeling environments with emphasis on Socio-critical perspective is scarce. In this way, the Ecological Path became an ideal environment to enable, in 13 years of execution, an integrative view by the students who, by modeling socio-environmental phenomena related to climate change, have reflected on their role in society as promoters. of conservation. The research reported is qualitative and nearly 450 students from grades eight to eleven (13-17 years) from the Institución Educativa El Pedregal in the city of Medellín have benefited from it. Observations, learning diaries and productions have been considered to analyze their actions regarding the modeling process and reflection. The results allowed us to identify how students have comprehensively learned concepts related to the three sciences, they have had active participation in the modeling process; They have also assumed an awareness of life in their relationship with others and with their environment.

Keywords: interdisciplinarity, mathematical modeling, socio-environmental problems, social and environmental awareness.

RESUMO

A interdisciplinaridade é um compromisso promovido pela educação em todas as áreas do conhecimento, com múltiplas investigações que têm sido realizadas nesse sentido, porém, a integração entre ciências sociais, biologia e matemática na modelagem de ambientes com ênfase na perspectiva sócio-crítica é escassa. Dessa forma, o Caminho Ecológico tornou-se um ambiente ideal para possibilitar, em 13 anos de execução, uma visão integradora por parte dos alunos que, ao modelarem fenômenos socioambientais relacionados às mudanças climáticas, refletiram sobre seu papel na sociedade como promotores de. conservação. A pesquisa relatada é qualitativa e dela foram beneficiados cerca de 450 alunos do oitavo ao décimo primeiro ano (13-17 anos) da Instituição Educacional El Pedregal, na cidade de Medellín. Observações, diários de aprendizagem e produções foram levados em consideração para analisar suas ações em relação ao processo de modelagem e reflexão. Os resultados permitiram identificar como os alunos aprenderam de forma abrangente os conceitos relacionados às três ciências, tiveram participação ativa no processo de modelagem; Eles também assumiram uma consciência da vida na sua relação com os outros e com o seu ambiente.

Palavras chave: interdisciplinaridade, modelagem matemática, problemas socioambientais, consciência social e ambiental.

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Background

The Ecological Trail Project is an environmental and social educational strategy that has been running for thirteen years. The strategy was created with the aim of bringing students at the Institución Educativa El Pedregal (Medellín, Colombia) closer to caring for nature through the transformation, recovery, and promotion of their green space, allowing students to experience spaces other than classrooms. And take ownership of their environment. In addition to creating spaces for reflection, they provide an opportunity to connect the sciences, contribute directly to environmental management, and promote research (Peñaherrera-Romero et al., 2022). In summary, the project seeks to make students aware of life, develop civic skills through caring for the environment, understand and protect their surroundings, and promote social transformation (Farfán et al., 2024).

This article aims to provide information on one of the aspects proposed in the Ecological Trail project: the implementation of a mathematical modeling process from a socio-critical perspective. In this context, students analyzed two models related to two socio-environmental problems: climate change and sustainable development.

The models used are Schlegel's (2001) above-ground biomass and Cairns et al.'s (1997) below-ground biomass. These models were selected because they allow for an interdisciplinary approach to social, environmental, and geometric aspects, such as tree height and diameter, which facilitates the understanding and application of mathematical principles in the analysis of carbon accumulation.

Following this process, students also discuss relevant topics in contemporary society, namely the reflective role of mathematical models within the contexts studied (De Sousa and De Lara, 2023).

To carry out this task, a school research group was formed: the Plantamáticos. This group is made up of 20 high school students from grades 8 to 11, whose goal is to work as a team to protect nature and discover new mathematical concepts associated with plants, thereby inviting the educational community in general to create alternatives that allow us to understand and reduce global environmental problems such as global warming and sustainable development.

Socio-environmental problems are a latent concern that never lets up, which is why they need to be studied comprehensively in school (Massip et al., 2021), so that students not only learn about them, but also take a critical stance that represents a change in consciousness and inspires them to take action to mitigate them.

In this sense, modeling can be an integrating factor that allows for interdisciplinarity, since depending on its approach in the classroom, different perspectives can be adopted. One of these is the socio-critical perspective, which is closely related to the sociocultural aspects of mathematics and its role in society, where the modeling process seeks to generate a critical stance in students towards their environment (Kaiser and Sriraman, 2006; Araujo, 2009)

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> "Socio-environmental problems are a latent concern that never lets up, which is why they need to be studied comprehensively in school (Massip et al., 2021), so that students not only learn about them, but also take a critical stance that represents a change in consciousness and inspires them to take action to mitigate them."

In this regard, research on modeling from a socio-critical perspective, such as the work carried out by Caldeira (2008); Ocampo-Arenas and Parra-Zapata (2022); and Mancera-Ortiz et al. (2022) highlight the importance of considering the environmental, social, cultural, and political reality of teachers and students when carrying out a modeling process, which allows them to understand and reflect on the social and environmental vulnerability of their environment.

On the other hand, Jacobini and Wodwotzki (2006), Ferreira and Wodewotzki (2007), and Da Silva et al. (2021) point out the lack of studies exploring the social and pedagogical elements of modeling, as well as the need for more research on interdisciplinarity in this field. Political growth and the formation of critical students are essential aspects of mathematical literacy that must go beyond the technical learning of mathematics to include social awareness and community participation.

The positions outlined above highlight the importance of including the manipulation of mathematical objects as tools for explaining phenomena that occur in students' environments. In this sense, modeling not only facilitates meaningful learning about mathematical concepts, but also enables interdisciplinary dialogue by showing the interrelationship between different sciences and how they work in coordination to explain the same problem from their different perspectives, arriving at a single solution.

In this regard, Da Silva et al. (2021) reports that modeling promotes interdisciplinary situations, that is, joint work between different disciplines, which facilitates the choice of the topic to be modeled, where students reflect on different aspects unrelated to mathematics but relevant to modeling.

In this regard, Cordero et al. (2019) point out that dialogue between school mathematics and reality should be encouraged, with interdisciplinary projects being one of the components to consider. Another position is that of Huincahue and Gaete-Peralta (2024), who identify in their modeling process that the use of mathematics becomes a methodological basis for the development of interdisciplinary problems. Similarly, Calderón et al. (2020) call for studies on interdisciplinarity in secondary education where ecology, politics, and economics are integrated into the curriculum, and finally, Navarro-Diaz et al. (2020) highlight the need to educate students on socio-environmental problems such as climate change, especially so that they perceive this problem and encourage their participation in the search for solutions.

The studies reviewed affirm the promotion of an education in which mathematics becomes a tool for ongoing dialogue with other sciences. Consequently, mathematical modeling and interdisciplinarity play a key role in training students to think critically about environmental and social changes. These ideas gave rise to the following research question: What educational strategies can be implemented to promote investigative processes among students and teachers in the Ecological Trail (green area) of the Institución Educativa El Pedregal that promote healthy coexistence, teamwork, and socio-environmental awareness?

In summary, we have seen how the Ecological Trail project relates modeling as a learning environment from a socio-critical perspective that promotes interdisciplinarity. Below, we describe the methodology used and the students' work.

Methodology

This research focused on describing an educational process, analyzing the perceptions and actions of a specific group of students from a qualitative perspective. Participatory action research (PAR) was used as a method to generate knowledge and transform the educational reality with the active collaboration of the participants (Valle et al., 2022; Alonso et al., 2023).

The study was conducted in Medellín, Colombia, at the Institución Educativa El Pedregal, where the Plantamáticos research group was created, linked to the Sendero Ecológico project. With 20 students from different grades, the group worked with teachers once a week for a year. The methodology was divided into three collaborative stages between students and teachers (see Table 1), using surveys, productions, and observations to analyze student interactions and behavior (Valle et al., 2022).

Table 1. Stages of the methodological process under the participatory action research strategy carried out in the project.

Stage	Actions	Evidences	Weekly Meetings	Product
Perception and interests	Tour of the institutional green area	Problems found in the green area. Mind map about the importance of urban trees. Students' topics of interest.	2	Research question to work on with the students
Conceptualization	Videos about climate change and its effects. Workshop on concepts related to climate change. Practice on photosynthesis and the carbon cycle. Quantification of carbon stored in trees of the Ecological Trail.	Mathematical procedures for calculating carbon in trees. Mathematical analysis of the models and validation of results. Carbon calculation presentation.	8	Presentation of the mathematical analysis of the models and the associated socio-environmental concepts.
Reflection	Reflection and actions survey to solve the problem. Review of learning diaries.	Individual open-ended questions for each student with proposals to improve coexistence with nature.	2	Survey to analyze the development of socio-environmental awareness.

Note: Author's elaboration based on the research project..

> "In this regard, Cordero et al. (2019) point out that a dialogue between school mathematics and reality must be encouraged, with interdisciplinary projects being one of the components to consider. Another perspective is that of Huincahue and Gaete-Peralta (2024), who identify in their process..."

Results

First Stage: Perception and Interests

The objective of this stage was for students to identify a common issue related to the care and protection of the environment. To this end, they were asked to take a walk along the Ecological Trail and make observations focused on the impact of humans on nature. The students identified the following issues:

- The ground in the green area is littered with all kinds of objects.
- The lack of cleanliness, care, and responsibility with regard to waste.
- The danger posed by thorns and weeds. In addition to the poor accessibility of the green area.
- The lack of awareness about caring for the environment.
- The lack of research groups.
- Poor maintenance and conservation of institutional flora: trees and shrubs.

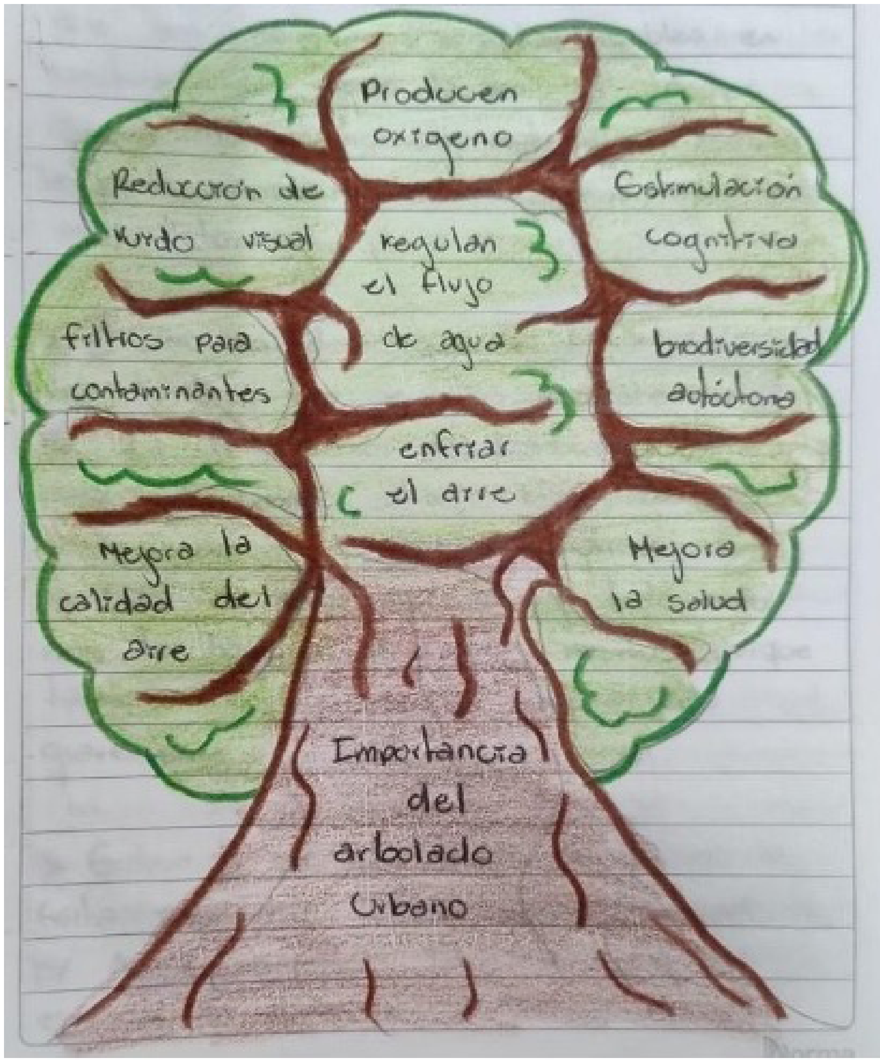
Next, two videos were shown: "La Silla Vacía" (The Empty Chair), 2021, and "Póveda," 2021, which addressed the climate situation in Colombia and around the world in recent years. These videos invited viewers to reflect on how we can contribute to caring for the environment and mitigating the effects of climate change from our homes.

As a result, the students in the seedbed pose the following question: How do the trees in the institutional green area influence the reduction of the impact of climate change in the city? Based on this question and avoiding catastrophic language, a series of climate-related terms are addressed, such as the greenhouse effect, the ozone layer, El Niño and La Niña phenomena, climate change and its causes and effects, as well as the conservation and protection of flora. A comparison was made showing how the climate has varied naturally throughout Earth's history, regardless of human presence. It also explains why there is now talk of an acceleration of current climate change due to anthropogenic factors.

In addition, the possibility of considering other natural processes that also significantly affect the climate, such as cosmic radiation, whose effects still require further research, is left open (Carriazo et al., 2024). The process included an in-depth study of the role of photosynthesis and respiration in the carbon cycle, which was carried out using microscopes to identify stomata as fundamental components in gas exchange in plants.

From this process, students also gained some insights, as shown in Figure 1, where they were asked to create brain-maps about the importance of urban trees. In these maps, students expressed various ideas that promote environmental awareness and conservation. They identified the importance of urban trees for oxygen production, reduction of air pollutants, and lowering of the heat index. In addition, they highlighted their role in feeding and nesting birds and other animals, the water flow regulation, noise reduction, environmental beautification, and cognitive stimulation.

Figure 1. *Production by a group from the seedbed Plantamáticos on their reflections on the importance of urban trees..*



Note: Prepared by students during the research process.

Second Stage: Conceptualization: Practical Modeling Process

In this stage, an analysis of the models (see Table 1) is carried out to quantify the carbon in the trees of the institutional green area, and the influence of green areas and forests on climate change mitigation and sustainable development through the protection of flora is discussed.

Class guides and readings are used to explain to students the importance of the carbon, oxygen, and carbon dioxide cycles, and how the absorption of carbon dioxide in natural ecosystems and urban green spaces reduces the effects of human-induced climate change.

In addition, a general explanation is provided on how to indirectly quantify the carbon in a tree. Subsequently, trees in the institutional green area are assigned to calculate their height and diameter at breast height, reinforcing basic concepts of trigonometry and circumferences (Figure 2). Based on the work carried out, a carbon accumulation calculator is developed using Excel (Figure 3).

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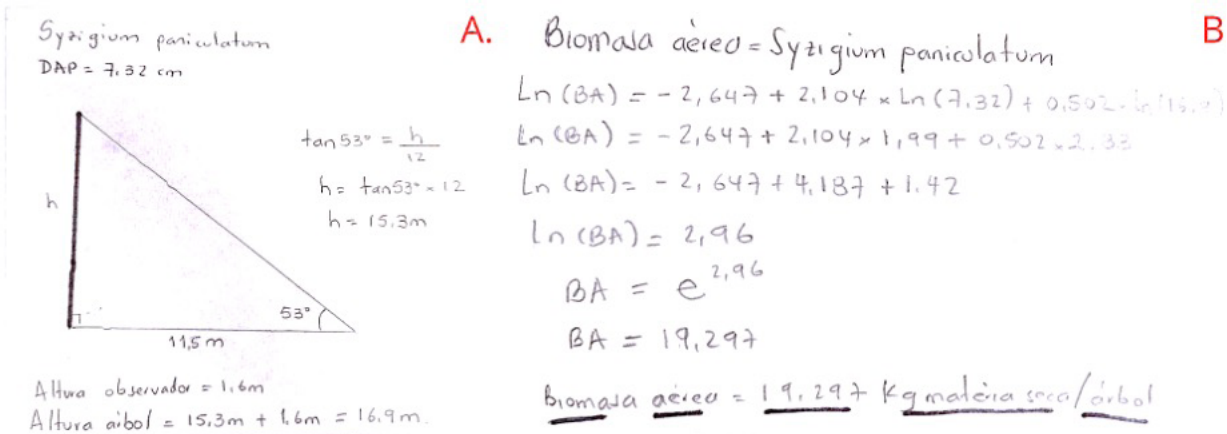
Table 1. Mathematical models by Schlegel (2001) and Cairns et al (1997).

Modelos	Componentes
Ln (BA)= -2,647 + 2,104 * ln (DAP) + 0,502 *LN (B)	BA: above-ground biomass (in kg of dry matter/tree)) DBH: diameter at breast height in centimeters B: tree height in meters
BR = $e^{((-1.085+0.9256)\ \ln (BA))}$	ABM: Above-ground biomass (tons dry matter/hectare) RB: Root biomass (tons dry matter/hectare)

Note: Prepared by the author based on Schlegel (2001) and Cairns et al. (1997

Figure 2. *Student work showing an example of the mathematical procedure used by students to calculate the height of a tree (A) and the above-ground biomass (B).*



Note: students' work during the course of this research.

> "The students' productions, exhibitions, and reflections demonstrate how their perceptions of socio-environmental problems are integrated into the socio-critical modeling perspective adopted in the project. The acquisition of interdisciplinary learning that promotes reflection on climate change and sustainable development, as proposed by Cordero et al. (2019), can be observed."

Tabla 2. Student work on tree classification and calculation of accumulated carbon using Excel software.

Tree number	Family	Scientific name	Common name	Above-ground biomass (Kg dry matter/tree)
1	Myrtaceae	*Psidium guajaba*	Guava	1332,4399
2	Myrtaceae	*Syzygium paniculatum*	Eugenio	16,3436
3	Myrtaceae	*Syzygium paniculatum*	Eugenio	278,748
4	Fabaceae	*Leucaena leucocephala*	Leucaena	9,4983
5	Asparagaceae	*Dracaena fragrans*	Dracaena	24,4241
6	Asparagaceae	*Dracaena fragrans*	Dracaena	3,3835
7	Myrtaceae	*Syzygium paniculatum*	Eugenio	36,3437
8	Myrtaceae	*Syzygium paniculatum*	Eugenio	25,0612
9	Myrtaceae	*Syzygium paniculatum*	Eugenio	23,1411
10	Myrtaceae	*Syzygium paniculatum*	Eugenio	68,9398
11	Myrtaceae	*Syzygium paniculatum*	Eugenio	21,1764
12	Myrtaceae	*Syzygium paniculatum*	Eugenio	38,8997
13	Myrtaceae	*Syzygium paniculatum*	Eugenio	19,3374
14	Malpighiaceae	*Malpighia glabra*	Huesito	9,5707
15	Arecaceae	*Dypsis lutescens*	Areca palm	1,9328
16	Araliaceae	*Heptapleurum arboricola*	Dwarf cheflera	4,9205
17	Myrtaceae	*Syzygium paniculatum*	Eugenio	27,2145
18	Myrtaceae	*Syzygium paniculatum*	Eugenio	12,5574
19	Myrtaceae	*Syzygium paniculatum*	Eugenio	814,0245
20	Myrtaceae	*Syzygium paniculatum*	Eugenio	13,1973
21	Myrtaceae	*Syzygium paniculatum*	Eugenio	203,8373
22	Oleaceae	*Fraxinus uhdei*	Urapán	151,7739
23	Moraceae	*Ficus benjamina*	False laurel	4426,9104
24	Euphorbiaceae	*Codiaeum variegatum*	Croto	71,8567
25	Euphorbiaceae	*Codiaeum variegatum*	Croto	24,2675
26	Myrtaceae	*Syzygium paniculatum*	Eugenio	22,6596
27	Fabaceae	*Leucaena leucocephala*	Leucaena	12,7563
28	Araucariaceae	*Araucaria heterophylla*	Araucaria	889,5936
29	Moraceae	*Ficus benjamina*	False laurel	7042,4865
30	Arecaceae	*Archaentophoenix cunninghamia*	Payanese palm	96,127
31	Rutaceae	*Citrus sp.*	Lemon	2,4625
32	Arecaceae	*Archontophoenix cunninghamian*	Payanese palm	125,8583
33	Arecaceae	*Archontophoenix cunninghamian*	Payanese palm	70,1215
34	Araucariaceae	*Araucaria heterophylla*	Araucaria	680,2173
35	Oleaceae	*Fraxinus uhdei*	Urapán	1,2134
36	Fabaceae	*Calliandra haematocephala*	Carbonero	1149,4081
37	Oleaceae	*Fraxinus uhdei*	Urapan	1,522
38	Bignoniaceae	*Pink Tabebuia*	Pink guayacan	100,4907
		Total above-ground biomass (BA)		17854,7173

Note: prepared by students during this research.

As for the results obtained by the students, 38 trees were found in the institutional green area (see Table 2). The most representative family is Myrtaceae, with the species Syzygium paniculatum, which has 16 individuals. To estimate the carbon content in trees conceptually with the students, an estimate of 45% of biomass as carbon content was used (Rodríguez, 2022), without distinguishing between trees and palm trees. A total of 7,498.98 kg of carbon accumulated in the trees was obtained. Considering the area of the institutional green space of

609.26 square meters, a cumulative total of 161.08 t C/ha of carbon was calculated. Of this total, 131.88 t C/ha corresponds to above-ground biomass and 29.20 t C/ha to roots.

At the end of this stage, students evaluated what they had learned through group presentations explaining the creation of a carbon calculator and other academic concepts related to fundamental ecological issues such as climate change, the greenhouse effect, and the role of vegetation in reducing the environmental impact of deforestation.

In addition, there was an equitable distribution of tasks within the groups, and an understanding of the trigonometric concepts needed to calculate tree height. They also showed the results of applying mathematical models to estimate the carbon retained in the institution's green areas (see Figure 2).

Third Stage: Reflection on the Interdisciplinary Modeling Process.

At this stage, the aim is to identify students' reflections based on a survey with questions designed to encourage connections between the importance of the lessons learned, awareness of caring for nature, and individual actions that can be taken at home to mitigate the impact of climate change. The responses obtained in the surveys were categorized by content into common themes, which made it possible to identify the frequency and relevance of the different topics addressed by the participants. The questions and analysis of their results are presented in Table .

Table 3. *Reflection questions and results of interdisciplinary work between ecology, geometry, and social sciences.*

Question	Analysis of results
How important is the conservation of green areas for the institution and the neighborhood?	The responses were organized into two categories: those who showed interest in preserving green spaces and those who did not. According to the results, 100% of the students expressed interest in this topic. Among the responses highlighted by the students, the importance of plants in feeding animals, especially birds, was emphasized, as well as their role in reducing air pollution and mitigating the effects of climate change.
How do trees help to mitigate the effects of climate change?	The responses were organized into several categories, each with a frequency of 100% among all students surveyed. These categories were based on the frequency of mentions of the following aspects: 1. Regulation of carbon dioxide in the atmosphere. 2. Decrease in wind chill. 3. Regulation of stream channels and reduction of flood risk. 4. The role of photosynthesis. In general, respondents mentioned at least some relationship to these aspects. For each of the categories formed, similarities were found in the responses as follows: In relation to the first category, 90% of students mentioned the importance of trees in reducing atmospheric carbon dioxide. Regarding the second category, 75% referred to the role of trees in reducing ambient temperature, which contributes to improving people's thermal comfort. Only 25% mentioned the importance of trees in regulating water flow in streams and reducing the risk of flooding. Of the total number of students, 10% m ntioned the crucial role of photosynthesis in this process.

Question	Analysis of results
What actions do you propose to care for and preserve the institutional ecological trail?	Based on the responses generated, the following categories were created: 1. Institutional educational activities 2. Planting or caring for trees Among the actions proposed by the students, 95% suggested implementing educational activities for their classmates, with the aim of preventing them from littering on the trail. These activities include creating posters, giving presentations in classrooms, and producing videos for social media. Ten percent of the students proposed placing barriers on the windows to prevent waste from being thrown into the green area. However, during the reflective process with the group, it was concluded that it is more important to educate and raise awareness among classmates. In addition, 40% of the students highlighted the importance of caring for the condition of urban trees and proposed planting new plants in the green area and other spaces in the neighborhood.
How can we contribute to caring for the environment from our homes?	At this point, most students, 95%, highlighted the importance of not wasting water. Suggested actions included reducing shower and toothbrushing time in order to conserve this vital resource. In addition, 80% of students emphasized the importance of promoting recycling as an essential measure to prevent the deterioration of nature. On the other hand, 30% of students mentioned the importance of educating about behaviors at home that contribute to environmental conservation.

Note: Prepared by the author based on research.

Discussion

When comparing the values obtained in the institutional green area of 7,498.98 kg of carbon accumulated in trees and 131.88 t C/ha of biomass, aerial with similar studies carried out at the University of Antioquia, where a total of 757,976.5 kg of carbon accumulated in the biomass of the trees on the university campus was recorded, with an average of 42.58 t C/ha of above-ground biomass (Rodríguez, 2022), as well as at the Technological University of Antioquia, where average values of above-ground biomass between 123.36 and 121.18 t C/ha were recorded for its urban trees (Escudero, 2019), students recognized the importance of the institutional green area for carbon capture and climate change mitigation; They found that this higher carbon value per hectare could be due to the proximity of tree growth in the institutional green area, a concept associated with population density. With the help of their teachers, they concluded that other factors such as the species present, the specific conditions of each area, and the use of different mathematical models could also influence these results. This process corresponds to a model analysis, with a hybrid approach to mathematical modeling proposed by De Sousa and De Lara (2023).

The students' productions, exhibitions, and reflections demonstrate how their perceptions of socio-environmental problems are integrated into the socio-critical modeling perspective adopted in the project. The acquisition of interdisciplinary learning that promotes reflection on climate change and sustainable development is observed, as proposed by Cordero et al. (2019), Calderón et al. (2020), Da Silva et al. (2021), and Huincahue and Gaete-Peralta (2024). Students applied concepts related to climate, trigonometric functions, logarithms, photosynthesis, ecosystem goods and services, and food webs. In addition, the analysis of urban trees promoted awareness of the importance of conserving urban green spaces, in line with the approaches of Araújo (2009) and Caldeira (2008) on socio-critical modeling in the design of learning environments.

It has been demonstrated that implementing playful and participatory strategies in the natural environment has a greater impact on the formation of meaningful commitments to sustainability and the adoption of ecological practices. This, in turn, contributes to a growing awareness of the need to protect nature (Garzón, 2023; Domínguez et al., 2023; Caldeira, 2008). Promoting strategies for the restoration and care of green spaces allows people to form bonds with nature, generating physical, social, and emotional benefits. This development of harmonious relationships with the environment is essential for reflecting on, reconstructing, and reframing human interactions with the natural environment (Peñaherrera-Romero et al., 2022; Sander-Regier and Etowa, 2014; Caldeira, 2008).

Teaching climate change and raising environmental awareness must be approached using a coherent and didactic methodology that includes conceptual and attitudinal content, as well as strategies that promote meaningful learning in students (Hache et al., 2023; Meira-Cartea and Arto-Blanco, 2014). This ecological awareness was evident in students' reflective work on their role in mitigating climate change and caring for nature, in which they highlighted the importance of urban trees for conservation, their contribution to reducing the effects of climate change, proposals for education on the care of institutional green areas with other students, the promotion of recycling from homes to prevent further deterioration of nature, and proposals for restoration strategies in green areas, such as tree planting.

"The results of this study show that modeling environments in secondary education designed from a socio-critical perspective facilitates discussions about human relationships with the environment and the importance of conservation processes, enabling individuals and educational communities to understand the importance of the complex relationships that exist between living beings and their environment."

Conclusions

The results of this study show that modeling environments in secondary education designed from a socio-critical perspective facilitate discussions about the relationship between humans and their environment and the importance of conservation processes, so that individuals and educational communities understand the importance of the complex relationships between living beings and their environment, and how humans affect ecosystems through the overexploitation of natural resources, thus promoting spaces for dialogue, reflection, and active participation by students.

Knowledge of the natural environment, its benefits, and the consequences of its overexploitation contribute to developing a sense of responsibility for human actions on the environment and a sustainable vision for the exploitation of renewable and non-renewable resources, so that they can be maintained over time for future generations (Montoya-Osorio, 2014; Navarro-Diaz et al., 2020). Environmental education and the concept of a sustainable world are deeply intertwined. There will be no sustainable future without proper environmental education (Vilches and Gil, 2009; Calero et al., 2019; Navarro-Diaz et al., 2020).

For this reason, the ecological trail at Institución Educativa El Pedregal becomes an alternative for students to progressively approach scientific knowledge, increasing their environmental awareness and sense of belonging to the space around them, in addition to training, observation, and the transformation of a habitable ecological space.

Below are the pedagogical contributions that enable a learning environment such as the ecological trail at the school from an interdisciplinary modeling perspective:

- Instill in students the ability to reflect on their own environment, promoting self-learning and learning to learn by combining theory with practice.
- The ability to serve and respect others, their surroundings, and the environment, preserving the integrity of their natural world.
- The acquisition of skills through the development of dimensions: knowledge, know-how, and interpersonal skills, through the identification of socio-environmental problems, the ability to transform and adapt spaces, the ability to work in teams, and finally, an appreciation and respect for nature.
- Collaborative work between academic peers to generate disciplinary relationships.

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Origin. This work is derived from a school research project, part of a line of research on environment and culture and is a partial product.

Funding. The authors declare that the project received no funding.

Ethical aspects. During the study, participants were informed of the process through a written consent form.

Conflict of interest. The authors declare that there is no conflict of interest.

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