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# Development and implementation of an investigative teaching sequence on Marajó ecosystems

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## ABSTRACT

This article presents the development, application, and validation of an Educational Product titled "A Mata do Bacurizal só tem bacuri? Sequência de Ensino Investigativa sobre Diversidade de Ecossistemas Marajoaras" (Does the Bacurizal Forest has only bacuri? Investigative Teaching Sequence on the Diversity of Marajoara Ecosystems), developed on the Postgraduate Program in Science Education in the Amazon (PPGEECA/UEPA). This qualitative research is an educational case study conducted at the Professora Oscarina Santos Municipal School , in Salvaterra (PA), with a class of 28 students from the 7th grade of elementary school. The study intended to promote the students' Scientific Literacy using the Inquiry-based Science Education methodology, combined with Environmental Education and the Marajoara sociocultural context. In this context, the study proposes integrating Inquiry-based teaching with the Amazon reality through the Ecological Reserve Mata do Bacurizal and Lago do Caraparú, contextualizing scientific content based on students' experiences. The methodological process included four stages: (1) identification of the research field; (2) development of the Inquiry-based Teaching sequence; (3) application, evaluation, and validation of the proposal; and (4) analysis of the results. The activities included a survey of prior knowledge, interviews, an interpretive trail, reading, text production, and diorama construction, allowing students to actively and participatively understand Amazon ecosystems. The results showed that students developed a variety of perceptions of the environment, classified into three categories: romantic view, sustainable view, and pessimistic view, content analysis. Significant progress was observed in Scientific Literacy Indicators.

**KEYWORDS:** environmental context; learning assessment; teaching and learning process; teaching resources; students.

# Elaboração e aplicação de uma sequência de ensino investigativa sobre ecossistemas marajoaras

**RESUMO**

Este artigo apresenta o desenvolvimento, a aplicação e a validação de um Produto Educacional intitulado “A Mata do Bacurizal só tem bacuri? Sequência de Ensino Investigativa sobre Diversidade de Ecossistemas Marajoaras”, desenvolvido no Programa de Pós-Graduação em Educação em Ciências na Amazônia (PPGEECA/UEPA). Esta pesquisa qualitativa é um estudo de caso educacional realizado na Escola Municipal Professora Oscarina Santos, em Salvaterra (PA), com uma turma de 28 estudantes do 7º ano do ensino fundamental. O estudo teve como objetivo promover a Alfabetização Científica dos estudantes, utilizando a metodologia do Ensino de Ciências por Investigação, em articulação com a Educação Ambiental e o contexto sociocultural marajoara. Nesse contexto, o estudo propõe integrar o ensino por investigação à realidade amazônica por meio da Reserva Ecológica Mata do Bacurizal e Lago do Caraparú, contextualizando os conteúdos científicos com base nas experiências dos alunos. O processo metodológico incluiu quatro etapas: (1) identificação do campo de pesquisa; (2) desenvolvimento da sequência de ensino investigativa; (3) aplicação, avaliação e validação da proposta; e (4) análise dos resultados. As atividades envolveram levantamento de conhecimentos prévios, entrevistas, trilha interpretativa, leitura, produção de textos e construção de dioramas, permitindo aos estudantes compreender ativamente e de forma participativa os ecossistemas amazônicos. Os resultados mostraram que os estudantes desenvolveram uma variedade de percepções sobre o meio ambiente, classificadas em três categorias: visão romântica, visão sustentável e visão pessimista. Foi observado progresso significativo nos Indicadores de Alfabetização Científica.

**PALAVRAS-CHAVE:** contexto ambiental; avaliação da aprendizagem; processo de ensino-aprendizagem; meios de ensino; educandos.

## INTRODUCTION

School represents the space of formal education, whose primary function is to provide high-quality teaching that is engaging, meaningful, and contextualized for the students. According to Gohn (2006), formal education responds to curricular demands established by regulatory frameworks and is developed within the school environment, where teachers play a fundamental role in teaching the content and promoting effective learning.

However, Freire et al. (2010) emphasize that quality education is only possible through commitment, collaboration, and systematic planning embedded in the school life, supported by public educational policies that value educators through continuing development. This recognition enables educators to work more effectively, resulting in teaching practices that better address students' needs.

Within this context, continuing education is essential for teachers to overcome challenges such as insufficient knowledge of subject matter, fragmentation of knowledge, and limitations from initial teacher education, while also fostering pedagogical updating and professional growth (Cunha & Krasilchik, 2000). Weffort (1992) reinforce the importance of reflective practice in the construction of knowledge:

> We learn because we symbolize, experience, research, and engage in our own practice and that of others, whether children or artists. Learning through doing, reading, thinking, expressing, and communicating ideas and feelings. A new form of literacy through different codes, empowering the subject-author. (Weffort, 1992, p. 7)

Seeking for improve classroom practices, teachers have increasingly pursued Professional Master's programs, which encourage reflection on teaching practice and promote the development of Educational Products (EPs).

Although these programs represent an important link among academic knowledge and pedagogical practice, Rezende and Osterman (2015) argue that professional master's programs can't solve alone the challenges of education. However, EPs constitute methodological and organizational tools that can significantly enrich pedagogical practices (Rosa & Freitas, 2023).

When associated with innovative teaching approaches, such strategies can foster more dialogical relationships in the classroom, granting greater protagonism to research participants, who may experience and evaluate EPs either directly or indirectly.

In this context, beginning in the second half of the twentieth century, a new didactic approach known as Inquiry-Based Science Education (IBSE) emerged, emphasizing investigative and reflective processes in the classroom (Sasseron, 2018). IBSE is an active learning methodology in which students, starting from themes related to their realities, try to solve problems autonomously under the guidance of the teacher (Carvalho, 2013). This approach not only enhances the meaningfulness and engagement of the school environment but also contributes to the formation of critical, participative citizens.

In this scenario, the development of EPs strengthens teachers' continuing education and increase learning opportunities that are aligned with the realities of the school context.

IBSE is also indirectly addressed in the Brazilian National Common Core Curriculum (BNCC), particularly within some of its general competencies, such as Competency 2, which states:

> To exercise intellectual curiosity and employ scientific approaches, including investigation, reflection, critical analysis, imagination, and creativity, in order to investigate causes, formulate and test hypotheses, solve problems, and devise solutions based on knowledge from different fields. (BNCC, 2018, p. 18)

At the intersection of IBSE and EPs, Inquiry-Based Teaching Sequences (IBTS) stand out as a pedagogical strategy capable of promoting active, reflective, and contextualized learning. Such sequences enable students to critically analyze and apply scientific knowledge to everyday situations. According to Sasseron (2018), IBTS consist of systematically planned lessons designed to address a given theme based on students' prior knowledge, creating opportunities for reflection, discussion, and practical application.

Considering the educational context of a school located in the municipality of Salvaterra, in the state of Pará (PA), within the Marajó Archipelago and in proximity to the Bacurizal Forest Ecological Reserve (RESEC) and Caraparú Lake, it becomes essential to connect these environmental and cultural aspects to everyday school practices. These elements are fundamental for integrating Inquiry-Based Science Education with Environmental Education, aligning them with local specificities and the pedagogical potential of the region in the development of the Educational Product.

So, the present study aimed to elucidate the processes of design, implementation, evaluation, and validation of an IBTS as an educational product entitled "Does the Bacurizal forest Only Have Bacuri? An Inquiry-Based Teaching Sequence on the Diversity of Marajoara Ecosystems."

By developing an educational product, teachers strengthen the relationship between theory and practice, fostering a reflective and critical pedagogical stance (Silva & Castilho, 2022). In addition to being adaptable to diverse teaching contexts, educational products may be revised, be integrated with other educational products, and be reused according to pedagogical needs, thereby enabling the creation of new EPs (Rizzatti et al., 2020).

## METHODOLOGICAL PROCEDURES

The Educational Product (EP) presented in this study is the result of a master's dissertation entitled "Does the Bacurizal forest Only Have Bacuri? An Inquiry-Based Teaching Sequence on the Diversity of Marajoara Ecosystems", developed within the Graduate Program in Science Education in the Amazon (PPGEECA) at the State University of Pará (UEPA), which is on the final editorial processing. The research was conducted between October 2022 and March 2023, during the investigative process.

This study has a qualitative research approach, specifically a case study design, which seeks to understand a whole through the analysis of a part of reality by examining a specific case in depth—such as an individual, a group, an institution, an event, or a phenomenon. According to Lüdke and André (1986), the case study is a qualitative approach aimed at achieving an in-depth understanding of a phenomenon by exploring all relevant aspects of the case. Peres and Santos (2005) emphasize that this qualitative approach considers even minimal information about the case, allowing for comprehensive understanding and the emergence of new insights.

The selected case consists of the implementation of an Inquiry-Based Teaching Sequence (IBTS) in a school where the teacher-researcher has worked for more than seven years. This choice is justified by the researcher's familiarity with the institution's dynamics and structure, which helps the development of investigative teaching sequences. In addition, the school is located next to the Bacurizal Forest Ecological Reserve (RESEC) and Caraparú Lake, an area chosen due to its ecosystem diversity and socio-economic relevance. The region is characterized by the harvesting of bacuri (*Platonia insignis*) and crab (*Ucides cordatus*) as sources of income for many families in the municipality of Salvaterra, as well as by its rich local biodiversity. As it is designed to enhance understanding of educational action, this research is characterized as an educational case study, as defined by Moreira (2011).

As previously stated, the research location and the implementation of the IBTS took place at the Professora Oscarina Santos Municipal Elementary School, located in the municipality of Salvaterra, in the state of Pará (PA). A total of 28 students from a 7th-grade class participated in the study, with ages ranging from 11 to 14 years. Throughout the implementation stages, participation levels varied caused by personal and contextual factors related to the school reality.

It is worth reiterating that the process of developing the Educational Product followed the framework proposed by Rizzatti et al. (2020), following the stages of implementation, evaluation, and validation, which are considered the minimum recommended instances for its execution. The analysis, grounded in the theoretical framework, was guided by the principles of Inquiry-Based Science Education (IBSE) and Scientific Literacy (SL) (Sasseron & Carvalho, 2008). So, understanding the EP as a structured educational product composed of stages that ensure contextual comprehension and the application of appropriate methodologies to promote learning, the following methodological phases were defined: (1) recognition of the research field; (2) development of the IBTS; (3) implementation, validation, and evaluation of the IBTS; and (4) analysis of the results of the IBTS implementation.

## RECOGNITION OF THE RESEARCH FIELD

In the initial phase, the recognition of the research field was carried out at the school, beginning with contact with the school management team to present the proposal of the Inquiry-Based Teaching Sequence (IBTS), highlighting its pedagogical potential. After that, the school's Pedagogical Political Project (PPP) was reviewed in order to understand the institution's educational philosophy and

guidelines. Classes observations of the participating group were then conducted to identify the context in which the IBTS would be implemented.

Following this initial stage, the teacher-researcher conducted an interview with a long-term resident of the municipality of Salvaterra, aiming to recover local memories and traditional knowledge related to the Bacurizal forest Ecological Reserve and Caraparú lake. This action aim to value traditional knowledge as a fundamental element for contextualizing the proposal. Such methodological alignment is consistent with the principles of Inquiry-Based Science Education (IBSE), recognizing the diversity of Amazonian ecosystems not only as objects of study but also as integral components of the lived experiences and perceptions of the local community.

So, this initial stage strengthens the connection between the objectives of this study and the development of a contextualized IBTS, capable of dialoguing with students' realities and fostering meaningful learning, as advocated by Gil (2002).

## DESIGN OF THE INQUIRY-BASED TEACHING SEQUENCE (IBTS)

The Inquiry-Based Teaching Sequence (IBTS) focused on Marajoara ecosystems was developed based on theoretical and methodological assumptions of inquiry-based education, with the aim of establishing teaching processes that would enable students to explore the theme, formulate questions, and construct biological, physico-chemical, and sociocultural knowledge about the environment. The structure of the proposal was grounded in participant observation and involved defining the theme of ecosystem diversity, learning objectives, the guiding problem question, and investigative activities (Carvalho, 2013).

From a methodological and structural perspective, the IBTS is intended to provide an environment in which students can express their ideas and engage in dialogical discussions with peers and teacher(s), establishing connections between their current level of knowledge and the potential knowledge developed through the application of the strategy. In this sense, Carvalho (2013) highlights the following stages in the construction of an IBTS: (1) identification of a problem; (2) group activities; (3) search for solutions to the problem; (4) systematization of knowledge; and (5) assessment activities.

It is important to note that inquiry-based sequences do not have a fixed number of lessons, as this depends on the theme, the class profile, and the number of students (Carvalho, 2013). In this study, the IBTS was organized into the following planned and implemented stages: (1) assessment of prior knowledge (drawings of the RESEC); (2) recovery of memories related to the Bacurizal Forest; (3) problem formulation by the teacher-researcher; (4) field lesson along the interpretive trail in the Bacurizal Forest; (5) individual knowledge systematization; (6) group knowledge systematization; and (7) assessment through the production and presentation of dioramas representing the Bacurizal Forest.

Considering the time frame, stages, proposed activities, and learning objectives for each phase, a synthesis of the IBTS is presented in Table 1:

**Table 1**

*Síntese da SEI com todas as etapas, atividades e objetivos das atividades.*

| | IBTS STAGE | PROPOSED ACTIVITIES | OBJECTIVES |
|---|---|---|---|
| 2 lessons – 1h30 | (1) Assessment of prior knowledge | Presentation of a video interview with a former bacuri collector to introduce the theme; students create drawings representing how they imagine the Bacurizal Forest. | To identify students' prior knowledge about the Bacurizal Forest RESEC. |
| 2 lessons – 1h30 | (2) Recovery of memories related to the Bacurizal Forest | Application of a semi-structured questionnaire to collect data and memories related to bacuri collection with family members or acquaintances. | To recover students' memories and experiences related to the Bacurizal Forest. |
| 1 lesson – 45 min | (3) Problem formulation | Presentation of the guiding problem: "Does the Bacurizal Forest only have bacuri?"; guidance regarding the field visit; discussion of questionnaire responses. | To recover students' memories and experiences related to the Bacurizal Forest<br>To promote interaction through the exchange of ideas and improve argumentation using scientific language. |
| 3 lessons – 2h15 | (4) Field lesson in the Bacurizal Forest | Visit to the ecological reserve; observations, notes, interactions, and drawings; dialogical conceptual explanations by the teacher; reading and discussion on environmental education. | To acquire knowledge by relating the reality of the Bacurizal Forestto the BNCC skill (EF07CI07) within the Inquiry-Based Teaching Sequence (IBTS).<br>To develop a critical understanding of the importance of environmental education and of preservation and conservation practices for ecosystems.<br>To promote the practice of the scientific method through observation, analysis, comparison, and experimentation concerning the Bacurizal Forest.<br>To characterize the Bacurizal Forest.<br>To understand scientific concepts through illustrative experiences in the Bacurizal Forest.<br>To associate social and ethical practices with environmental problems present in |

| | IBTS STAGE | PROPOSED ACTIVITIES | OBJECTIVES |
|---|---|---|---|
| | | | the RESEC. |
| 2 lessons – 1h30 | (5) Individual knowledge systematization | Reading of instructional materials; production of a written synthesis of learning. | To verify students' understanding and conclusions derived from the IBTS. |
| 2 lessons – 1h30 | (6) Group knowledge systematization | Comparison of observations from the interpretive trail and instructional materials. | To produce a comparative framework highlighting ecosystem differences. |
| 3 lessons – 2h15 | (7) Assessment – Diorama production | Construction and presentation of dioramas representing the Bacurizal Forest. | To assess students' understanding of scientific concepts through explanation and representation. |

Source: Authors' own elaboration (2024).

## APPLICATION AND EVALUATION OF THE IBTS

The application and evaluation of the IBTS happened at the Professora Oscarina Santos School, with 7th-grade students from the morning shift. Investigative activities were carried out both in the classroom and on an interpretative trail in the Bacurizal Forest and Caraparú Lake.

During the application of the IBTS, students participated in various activities such as creating drawings and texts, joining the interpretative trail and dioramas construction. For the evaluation of the IBTS, a qualitative approach was adopted, based on observations made during the application, analysis of the materials produced during the process, and feedback from the students.

## ANALYSIS OF THE IBTS APPLICATION RESULTS

The qualitative analysis of the research data was carried out through participant observation, involving the interpretation of drawings about the RESEC, field notebooks, texts produced by the students, and the dioramas created.

For the analysis of the drawings, Content Analysis proposed by Bardin (2016) was used, as it is a methodology that allows for the examination of communicative data such as texts, images, and other records, to identify data beyond a simple reading. Through Content Analysis, it is possible to identify patterns, categories, and meanings. In the present study, Content Analysis was used to explore the environmental concepts and perceptions expressed in the students' drawings.

According to Santos et al. (2017), drawings symbolically convey messages about students' perceptions and knowledge of the environment. Therefore, their analysis provides an interpretive path to understand how these students perceive the RESEC Bacurizal Forest and Caraparú Lake.

The data collected were in their raw form, with explicit content. To reveal their implicit and contextual meanings, it was necessary to analyze them systematically and objectively (Cardoso et al., 2021).

The students' drawings were an implicit way of demonstrating their perceptions of the RESEC. In creating the categories for analysis, the focus was on the domain of nature and the degree of human intervention in the depicted space. Thus, the following categories of perception were defined: romantic view, sustainable view, and pessimistic view.

For the analysis of field notebooks, systematization texts, and dioramas, the Scientific Literacy Indicators (SLI) proposed by Sasseron and Carvalho (2008) were adopted, as shown in the following table:

**Table 2**

*Scientific Literacy Indicators*

| | Indicator | Description |
|---|---|---|
| **FIRST** | Information seriation | Related to the establishment of bases for investigative action. |
| | Organization of information | Occurs when preparing the existing data on the investigated problem. |
| | Classification of information | Appears when establishing characteristics for the obtained data. |
| **SECOND** | Logical reasoning | Refers to the way ideas are developed and presented. |
| | Proportional reasoning | Similar to logical reasoning, this shows how thought is structured. |
| **THIRD** | Hypothesis formulation | Occurs when assumptions are made about a given topic. |
| | Hypothesis testing | Occurs when previously formulated assumptions are tested. |
| | Justification | Appears when a claim is supported by a rationale for what is proposed. |
| | Prediction | Explicit when an action or phenomenon is stated to follow certain events. |
| | Explanation | Emerges when trying to relate information and hypotheses already raised. |

Source: Sasseron, Carvalho (2008)

## ETHICAL ASPECTS

The study respected all the ethical and safety criteria established for research involving human subjects. Participants were informed about the development of the research and expressed their agreement through the signing of the Data Use and Handling Commitment Term and the Free and Informed Consent Form (ICF). All participants received a copy of the signed documents prior to the beginning of the study.

Confidentiality was ensured for all participants, safeguarding their privacy. They were also guaranteed the right to refuse or withdraw from any stage of the

study without any negative consequences, as well as the right to access the information related to the research. In case of any doubts, participants could directly contact the responsible researchers.

Students participating in the IBTS were identified by fictitious names inspired by cities from the Marajó Archipelago and communities from the municipality of Salvaterra, strengthening the thematic connection with the research context. According to Monteiro et al. (2019), constructing fictitious names does not lower the importance of the participants but serves as an ethical and symbolic strategy that protects their identities while increasing the representation of the study.

The access to the collected results and data was granted to the participants, enabling them to review their statements, positions, and experiences recorded during the study. Participants were free to request modifications or deletions if they wanted, for any reason.

## RESULTS AND DISCUSSION

The IBTS consisted of seven stages, designed based on Carvalho (2013), totaling 15 classes of 45 minutes each, distributed across five meetings during Science classes. Investigative activities, interviews, semi-structured questionnaires, drawings, readings, reports, and both individual and group work were utilized. The central theme, "diversity of ecosystems," was chosen because it is included in the Brazilian National Common Core Curriculum (BNCC) and requires discussions from the perspective of Environmental Education (EE).

From the first stage of the IBTS, it became evident, through questions made by the teacher to the students, that they initially perceived the Bacurizal Forest and Caraparú Lake as having only economic importance. However, it was necessary to ajust their understanding, highlighting its natural, social, and historical relevance. According to Souza and Lucena (2022), perception is shaped by how individuals read and assign meaning to the environment they inhabit. It can be either positive or negative and is likely to evolve as new knowledge is acquired.

Through Content Analysis (CA), as proposed by Bardin (2016), applied to the drawings produced during the students' knowledge survey, three categories of environmental perception emerged: romantic view, sustainable view, and pessimistic view. A total of 27 drawings were analyzed, produced in class and categorized according to the students' environmental perceptions of the Bacurizal Forest. It was found that twenty-three of the drawings expressed a romantic view, three displayed a sustainable view, and one illustrated a pessimistic view.

As noted by Zanini et al. (2021), individual pessimistic perception is linked to how one captures, read, selects, and organizes the sensory information received. Through perception, individuals attribute meaning to their surrounding environment, making studies on environmental perception essential for understanding the relationship between people and nature, and fostering critical reflection on environmental issues.

The categories revealed that the romantic view was the most common, where the physical presence of nature predominated. This finding is consistent with works by Santos et al. (2017), Layrargues and Lima (2014), and Malafaia and Rodrigues (2009). The prevalence of the romantic nature perception in most drawings can be attributed to the students' direct contact with the region's natural environment.

The sustainable view was the second most frequent perception, characterized by preserved and balanced environments, which allow for a harmonious coexistence between humans and the environment. According to Meridieu (2017), drawings reflect the subconscious, expressing the individual's perceptions and feelings toward the environment (Figure 1).

**Figure 1**

*Figure 1 presents drawings produced by the students participating in the research, illustrating their perceptions of the RESEC. Figure 2 represents a romantic perception of nature, Figure 3 illustrates a sustainable perception, and Figure 4 depicts a pessimistic perception.*


Source: Participants of the research (2024).

According to Reigada and Tozoni-Reis (2004), it is essential for Environmental Education (EE) to enhance students' critical awareness of the environment in the classroom, highlighting that humans are part of the natural environment and engage in activities that modify nature. Students must understand that environmental degradation results primarily from human actions and is not exclusively a natural process.

During the interpretive trail, observations, dialogues, and field notebook entries were made, which were later analyzed using the Scientific Literacy Indicators (SLI) proposed by Sasseron and Carvalho (2008). From these notes, it was observed that students achieved the first and second axes of scientific literacy.

The first axis relates to understanding basic concepts and terms; the second axis involves ethical and political reflection, with students recognizing themselves as active participants in the scientific process. The third axis, which concerns the relationship between science, technology, society, and the environment, was not observed in the analyzed productions.

The following notes from the student "Chaves" are provided to illustrate the analysis of records in light of the SLIs:

1- The path at the beginning is very open.

2. A very quiet place.

3. Lots of mosquitoes.

4. Many fallen trees.

5. Two bacuri trees, about 10 to 15 meters tall.

6. There was a lot of straw.

7. A large clearing.

8. The trees sweat and hydrate.

9. Two crooked bacuri trees full of branches.

10. The soil is very soft and damp, with a strong smell of rotting fruit and rotten branches.

11. Pneumatophore roots.

The analysis of Chaves' field notebook demonstrates the presence of several Scientific Literacy Indicators (SLI). Initially, Seriation of Information (SI) can be observed when the student describes specific features of the trail, such as the open path, mosquitoes, tall trees, clearings, and the characteristics of the mangrove soil. Organization of Information (OI) is also evident, as the observations are numbered and presented sequentially, showing a logical structure in the data presentation. Although less apparent, Classification of Information (CI) is present, as the student points the difference between vegetation, soil, and scents in the environment, avoiding a singular category of description.

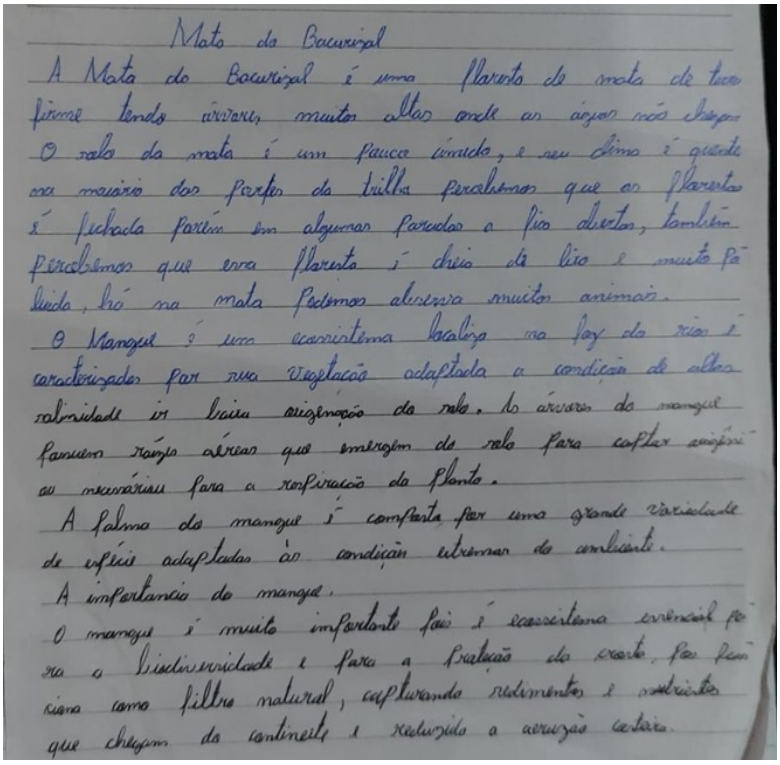
Logical Reasoning (LR) is also evident, as the student maintains coherence in describing the environmental features, relating their observations throughout the trail. However, Hypothesis Formulation (HF) was not identified, despite the student implicitly making inferences about potential causes of the observed characteristics, such as the presence of mosquitoes, the height of the trees, and the strong odor typical of mangroves.

According to Sasseron and Carvalho (2008), the first axis of Scientific Literacy corresponds to basic knowledge that students can apply in their daily lives. The second axis involves understanding scientific methods, procedures, and analyses, including the ethical dimension and the recognition that scientific knowledge is influenced by political and social decisions.

The analysis of the texts and records produced in the other stages of the IBTS and in supplementary materials shows, according to Carvalho (2013), that moments of group interaction—marked by dialogue and idea exchange—are essential for collective knowledge construction. On the other hand, individual writing emerges as a critical strategy for consolidating and expressing learning. This dynamic can be observed in the selected excerpts from the stratified sample, shown below (Figure 2).

**Figure 2**

*Systematization by student Jubim.*



Mata do Bacurizal

A Mata do Bacurizal é uma floresta de mata de terra firme tendo árvores muito altas onde as águas não chegam. O solo da mata é um pouco úmido, e seu clima é quente na maioria das partes da trilha percebemos que as florestas é fechada porém em algumas partes a luz direta, também percebemos que essa floresta é cheia de lixo e muito poluída, há na mata podemos observar muitos animais.

O Manguezal é um ecossistema localizado na foz de rios é caracterizados por sua vegetação adaptada a condições de alta salinidade e baixa oxigenação do solo. As árvores do mangue possuem raízes aéreas que emergem do solo para captar oxigênio necessário para a respiração da planta.

A fauna do mangue é composta por uma grande variedade de espécies adaptadas às condições extremas do ambiente.

A importância do mangue.

O mangue é muito importante pois é ecossistema essencial para a biodiversidade e para a proteção da costa pois eles atuam como filtro natural, capturando sedimentos e nutrientes que chegam do continente e reduzindo a erosão costeira.

Source: Jubim (2024).

The Bacurizal Forest an upland (terra firme) forest, characterized by very tall trees that are not reached by floodwaters. The forest soil is slightly moist, and the climate is hot. Along most of the trail, the forest is dense, although some sections are more open. One of the main problems observed is that this forest area contains a significant amount of waste and is highly polluted. Within the forest, it is possible to observe a wide variety of animal species. Mangroves are ecosystems located at river mouths and are characterized by vegetation adapted to conditions of high salinity and low soil oxygenation. Mangrove trees possess aerial roots that emerge from the soil to capture the oxygen necessary for respiration. Mangrove fauna consists of a wide diversity of species adapted to the extreme environmental conditions. Mangroves are of great importance, as they are essential ecosystems for biodiversity conservation and coastal protection, functioning as natural barriers that trap sediments and nutrients arriving from the continent, thereby reducing coastal erosion.

Based on this text, an analysis was conducted using the Scientific Literacy Indicators (SLI), as presented in Table 3 below.

**Table 3**

Systematization of Jubim's Data

| Indicator | Excerpts from the text systematization |
|---|---|
| Information Seriation (IS) | Several sequential pieces of information about the Bacurizal Forest can be identified, such as its classification as an upland forest, soil characteristics, climate, and vegetation description. Example: "The Bacurizal Forest is an upland forest, characterized by very tall trees that are not reached by floodwaters." |
| Information Organization (IO) | The information is clearly organized, beginning with a general description of the Bacurizal Forest , followed by details about the mangrove ecosystem and its importance. Example: "Mangroves are ecosystems located at river mouths and are characterized by vegetation adapted to high salinity and low soil oxygenation. Mangrove trees have aerial roots that emerge from the soil to capture oxygen necessary for respiration. Mangrove fauna consists of a wide variety of species adapted to extreme environmental conditions." |
| Information Classification (IC) | The information can be classified into distinct categories, such as characteristics of the Bacurizal Forest, description of the mangrove ecosystem, and its environmental importance. Example: "The Bacurizal Forest is an upland forest with tall trees, slightly moist soil, a hot climate, and predominantly dense vegetation, although some trail sections are more open." |
| Logical Reasoning (LR) | The text presents logical sequencing, beginning with a general description of the Bacurizal Forest, followed by explanations of the mangrove ecosystem and its environmental benefits. Example: "Mangroves are very important because they are essential ecosystems for biodiversity conservation and coastal protection, functioning as natural systems that retain sediments and nutrients from the continent, reducing coastal erosion." |
| Hypothesis Formulation (HF) | From the text, hypotheses could be formulated regarding how pollution affects biodiversity in the Bacurizal Forest and the mangrove ecosystem. |

Source: Research authors (2024).

From the stage involving the construction of dioramas, five groups were formed and six dioramas were produced, with two created by the same group during the evaluation phase of the Educational Product (EP). According to Santos (2022), dioramas can be integrated into students' educational formation, contributing to the development of critical citizens who are sensitive to

environmental issues, while also providing more playful and dynamic teaching resources (Figure 3).

**Figure 3**

*Dioramas produced by students participating in the research as part of the Inquiry-Based Teaching Sequence (IBTS).*

Source: Research data.

These materials can be produced using recyclable and low-cost elements, allowing reflections on the pedagogical approaches of Environmental Education (EE) and Inquiry-Based Science Education (IBSE). In this study, the dioramas were used to represent, on a reduced scale, the ecosystem observed in the RESEC Bacurizal Forest and Caraparú Lake.

Although the teacher-researcher had planned to present the dioramas in a trail-like format for the school community, the schedule had to be modified due to the inclusion of other school activities.

A qualitative assessment was conducted to examine students' understanding of scientific concepts, their characterization of the environments, and their conclusions regarding environmental issues, considering the structuring axes of Scientific Literacy (SL) proposed by Sasseron and Carvalho (2011): (1) basic understanding of fundamental scientific terms, knowledge, and concepts; (2) understanding of the nature of science and the ethical and political factors surrounding its practice; and (3) understanding of the relationships among science, technology, society, and the environment.

In the classroom, contextualization and guidance were provided for the construction of the dioramas, which represented the ecosystems observed in the RESEC on a reduced scale. The proposal employed the IBSE and EE approaches to explore the upland forest and mangrove ecosystems characteristic of the area. The objective of using dioramas in this IBTS was not merely students' artistic representation, but the use of these models as tools for scientific investigation, capable of promoting students' immersion in the complexities and interactions of the ecosystems of the Bacurizal Forest. So, based on the concept of Scientific Literacy proposed by Sasseron and Carvalho (2008), students assumed the role of scientists, observing, collecting data, and making inferences about the elements that compose these environments in order to build their dioramas.

The analysis of the dioramas revealed that, based on observations, field notebook notes, drawings, and photographic records, students were able to properly represent the upland ecosystem, highlighting trees, fauna, biodiversity, and environmental fragility. They identified vegetation structure, different plant and animal species, and discussed the importance of conserving these environments for maintaining biodiversity and ecosystem services, such as temperature regulation, habitat provision, water supply, and the harvesting of fruits and crustaceans.

In the dioramas representing the mangrove ecosystem, a strong visual exploration was observed. The representations of aerial roots and aquatic fauna highlighted the role of mangroves as natural nurseries and barriers against coastal erosion. Students investigated biodiversity, identified key organisms, and discussed the challenges faced by these environments due to anthropic actions, especially during the closed fishing season (defeso). Although the restinga ecosystem was not explored during the interpretive trail, it was included in some dioramas, as students observed, at the end of the trail, the transition between the mangrove and São João beach, near Pousada dos Guarás, as described by Silva (2007) and Ferreira and Carvalho (2008).

Beyond exploring the ecosystems of the Bacurizal Forest, students were encouraged to adopt a critical perspective on local and global environmental issues. They were stimulated to question the causes and consequences of environmental problems, identify the actors and interests involved, and propose sustainable and socially just solutions.

So, the dioramas produced by the students were not merely an assessment activity but concrete records of a process of discovery, learning, and reflection. Through inquiry-based teaching and Environmental Education, these young learners became agents of transformation, committed to the care and preservation of the ecosystems that sustain life.

Overall, the exhibition of the dioramas made it possible to observe that most students achieved the first and second axes of Scientific Literacy. They demonstrated an understanding of the differences between the upland forest and the mangrove ecosystem, recognizing the characteristics of their fauna and flora. Among the six dioramas presented, only one showed environmental problems affecting the forest; the others portrayed the environment in a harmonious and optimistic way, suggesting sustainable attitudes as preservation alternatives (Reigada & Tozoni-Reis, 2004).

In the drawing activity, students expressed a perception of a preserved environment, emphasizing the balanced coexistence between humans and nature. During the interpretive trail, the objectives of characterizing the environment were achieved through the understanding of concepts, reflections, arguments, hypotheses, and the proposal of solutions to the identified problems (Sasseron & Carvalho, 2008).

The use of dioramas as an assessment instrument not only enabled the teacher-researcher to assign grades but also to evaluate students' creativity, their understanding of how the ecosystems of the Bacurizal Forest function, and their recognition of the benefits and potential of the area.

It is evident that the relationship between humans and nature has caused negative environmental impacts, reinforcing the urgency of measures to promote a more balanced coexistence. In this sense, Environmental Education constitutes an essential tool for raising awareness about the importance of preservation and fostering a more ethical and sustainable relationship between humans and the environment (Reigada & Tozoni-Reis, 2004).

Finally, the Educational Product (EP) was validated by the examination board, which considered it applicable, adaptable, and appropriate to the Amazonian context, as well as transferable to other ecosystems (Figure 4).

**Figure 4**

*Cover of the EP "Does the Bacurizal Forest only have Bacuri? An Inquiry-Based Teaching Sequence on the Diversity of Marajoara Ecosystems."*


Source: Research authors (2024).

## FINAL CONSIDERATIONS

The educational product “Does the Bacurizal Forest only have Bacuri? An Inquiry-Based Teaching Sequence on the Diversity of Marajoara Ecosystems” was developed with the aim of supporting teachers in the teaching of content related to ecosystem diversity in a practical and investigative manner.

The implementation of the Inquiry-Based Teaching Sequence (IBTS) demonstrated the students’ active engagement throughout all stages of the investigative process. From the identification of the problem situation to the proposal of solutions, students stood out for their protagonism and the practical application of the concepts learned. The IBTS provided an immersive and sensory experience, allowing students to concretely explore the biotic and abiotic elements of the Bacurizal Forest.

In addition, the proposal contributed to the development of attitudinal and procedural aspects, such as interest, cooperation, curiosity, motivation, creativity, organization, and responsibility. Students recognized the importance of investigative activities in understanding their local environmental reality and in developing a critical and sustainable awareness.

The investigative activity—especially the interpretive trail—provided a transformative experience, raising students’ awareness of the need to conserve Marajoara ecosystems.

As a result of this work, the educational product entitled “Does the Bacurizal Forest Only Have Bacuri? An Inquiry-Based Teaching Sequence on the Diversity of Marajoara Ecosystems” was developed to support teachers in the practical and investigative teaching of ecosystem diversity. The material promotes a more dynamic and participatory approach to the teaching of Science and Environmental Education in the school context, contributing to the formation of environmentally conscious and engaged citizens.

Based on the analysis conducted, it can be stated that the IBTS presents significant pedagogical potential for addressing the diversity of Marajoara ecosystems from the perspective of Inquiry-Based Teaching and Environmental Education, using the RESEC Bacurizal Forest and Lake Caraparú as objects of study. This work enhanced teaching and learning processes, encouraging active student participation and the development of investigative attitudes and skills

It is important to emphasize that characterizing an ecosystem only through content exposition or memorization of concepts is a misconception. Although concepts are fundamental, it is the teacher’s role to mediate processes that enable students to construct and reconstruct knowledge in a meaningful way.

The IBTS proved to be essential for students’ development, as they acted as protagonists at all stages—from solving the problem situation, researching and discussing texts about the studied environment, to formulating hypotheses and experiencing the biotic and abiotic elements of the natural environment represented by the Bacurizal Forest. This experience facilitated the understanding of the observed socio-environmental reality and the proposal of solutions.

Students carried out actions typical of scientific practice, contributing to the development of Scientific Literacy. The IBTS proved to be both enjoyable and effective in forming participatory, critical individuals capable of proposing solutions to environmental demands. The investigative activity also enabled students to better understand their local environmental reality, raising awareness of the importance of conserving the RESEC. Most students achieved the first two axes of Scientific Literacy throughout the stages of the IBTS.

Participants reported a high level of satisfaction with the practical and investigative classes, highlighting the teacher's mediating role and the student protagonism promoted by the active, practical, and sensory methodology.

Regarding the relationship between Environmental Education and Inquiry-Based Teaching, it was found that the IBTS allows environmental issues to be addressed in a holistic manner, breaking away from reductionism and integrating social, ecological, and cultural dimensions. Thus, it was possible to work in an integrated way on themes such as ecosystems, water, fauna, flora, and other relevant aspects of the RESEC in local, state, and global contexts.

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