# PROBLEM-BASED LEARNING: TEACHING EXPERIENCE IN THE CONTEXT OF THE WATER CRISIS

# APRENDIZAGEM BASEADA EM PROBLEMAS: EXPERIÊNCIA DE ENSINO NO CONTEXTO DA CRISE HÍDRICA

# APRENDIZAJE BASADO EN PROBLEMAS: EXPERIENCIA DE ENSEÑANZA EN EL CONTEXTO DE LA CRISIS HÍDRICA

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## ABSTRACT

The water crisis represents one of the main contemporary socio-environmental challenges, associated with climate change, environmental degradation, and unsustainable models of water use. In the Brazilian context, despite the country's wide water availability, these processes occur unevenly across the territory, intensified by deforestation, water pollution, and structural deficiencies in basic sanitation. Within this framework, this article analyzes the application of the Problem-Based Learning (PBL) methodology in teaching about the water crisis in the municipality of São José de Ubá, in the state of Rio de Janeiro, with ninth-grade elementary school students. The study adopts a qualitative, exploratory, and descriptive approach, using participant observation and field diary records throughout a pedagogical project developed over six in-person meetings. The results indicate that PBL promotes meaningful learning by articulating scientific knowledge with local experiences, fostering autonomy, collaboration, and critical thinking. A cognitive shift was observed, as students moved from fragmented explanations toward a broader understanding of the water crisis, incorporating structural factors such as deforestation, pollution, and the lack of sanitation. The study concludes that PBL has significant potential for addressing environmental themes in elementary education by integrating school, community, and territory, thus reaffirming the transformative role of education.

**Keywords:** Water. Active Methodologies. Water Crisis. Elementary School.

## RESUMO

A crise hídrica constitui um dos principais desafios socioambientais contemporâneos, associada às mudanças climáticas, à degradação ambiental e aos modelos insustentáveis de uso da água. No contexto brasileiro, apesar da ampla disponibilidade hídrica, esses processos se manifestam de forma desigual, agravados por desmatamento, poluição dos

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corpos d’água e fragilidades no saneamento básico. Diante desse cenário, este artigo analisa a aplicação da metodologia Aprendizagem Baseada em Problemas (ABP) no ensino da temática da crise hídrica no município de São José de Ubá, no estado do Rio de Janeiro, com estudantes do 9º ano do Ensino Fundamental. A pesquisa adota uma abordagem qualitativa, de caráter exploratório e descritivo, utilizando a observação participante e registros em diário de campo ao longo de um projeto pedagógico desenvolvido em seis encontros presenciais. Os resultados indicam que a ABP favorece a aprendizagem significativa ao articular conhecimentos científicos às vivências locais, promovendo autonomia, colaboração e pensamento crítico. Observou-se um deslocamento cognitivo dos estudantes, que passaram de explicações fragmentadas para uma compreensão mais ampla da crise hídrica, incorporando fatores estruturais como desmatamento, poluição e ausência de saneamento. Conclui-se que a ABP apresenta elevado potencial para o ensino de temáticas ambientais na Educação Básica, ao integrar escola, comunidade e território, reafirmando o caráter transformador da educação.

**Palavras-chave:** Água. Metodologias Ativas. Crise Hídrica. Ensino Fundamental.

**RESUMEN**

La crisis hídrica constituye uno de los principales desafíos socioambientales contemporáneos, vinculada al cambio climático, a la degradación ambiental y a modelos insostenibles de uso del agua. En el contexto brasileño, a pesar de la amplia disponibilidad hídrica, estos procesos se manifiestan de forma desigual en el territorio, agravados por la deforestación, la contaminación de los cuerpos de agua y las deficiencias estructurales en el saneamiento básico. En este marco, el presente artículo analiza la aplicación de la metodología de Aprendizaje Basado en Problemas (ABP) en la enseñanza de la crisis hídrica en el municipio de São José de Ubá, en el estado de Río de Janeiro, con estudiantes de noveno grado de la educación primaria. La investigación adopta un enfoque cualitativo, de carácter exploratorio y descriptivo, utilizando la observación participante y registros en un diario de campo a lo largo de un proyecto pedagógico desarrollado en seis encuentros presenciales. Los resultados indican que el ABP favorece el aprendizaje significativo al articular el conocimiento científico con las experiencias locales, promoviendo la autonomía, la colaboración y el pensamiento crítico. Se observó un desplazamiento cognitivo de los estudiantes, quienes pasaron de explicaciones fragmentadas a una comprensión más amplia de la crisis hídrica, incorporando factores estructurales como la deforestación, la contaminación y la ausencia de saneamiento. Se concluye que el ABP presenta un alto potencial para el abordaje de temáticas ambientales en la educación primaria, al integrar escuela, comunidad y territorio, reafirmando el carácter transformador de la educación.

**Palabras clave:** Agua. Metodologías Activas. Crisis Hídrica. Educación Primaria.

## 1 INTRODUCTION

Water is a universal common good, essential for the maintenance and balance of ecosystems in general and the planet itself (Rhoden *et al.,* 2016). According to the National Water and Basic Sanitation Agency (ANA), it is estimated that of all the vast amount of water that exists in the world, 97.5% is salt and 2.5% is fresh water; However, of this 2.5%, only 1% corresponds to the resource of rivers and lakes, the most accessible form for human consumption[4]. The rest of the fresh water is mostly in the polar caps and on mountains in the form of snow and ice. These quantities focus on other important issues for the balance of the planet and the future of humanity, such as: scarcity, power, food sovereignty, among others. In 2015, data from the Food and Agriculture Organization of the United Nations (FAO) indicated that more than 40% of the world's population already suffered from water shortage, and with the weather forecasts, this percentage would tend to jump to 2/3 of the population in 2050 (FAO, 2015).

Over the years, there has been an increase in the complexity of the various uses of water and, with it, a wide dimension of pollution and degradation (Soares; Souza, 2020). In the last century, "freshwater consumption has increased 6-fold [...] and continues to advance at a rate of 1% per year, as a result of population growth, economic development, and changes in consumption patterns" (UNESCO, 2021). On this argument, the conclusions of Tundisi and Matsumura-Tundisi (2011) and the ANA report (2023) highlight that some of the fundamental factors responsible for the water crisis in the world are associated with population growth. Added to this, there is still the loss of water containment instruments that occur through some situations such as: deforestation, elimination of flooded regions, reduction in the volume of rivers and lakes due to the accumulation of sediments, among others.

In view of this scenario, the scientific literature has widely pointed out the need for improvements in the models of planning and management of water use. In general, studies highlight that the planning and management of water resources aim to promote the sustainable use of this asset, mitigate the impacts associated with changes in land use and occupation, and strengthen conservation practices, in order to reduce waste and inappropriate use of water (Locke, 2024; Wang, 2025). To this end, it is important to preserve water resources, based on the promotion of educational, constructive and awareness-raising activities (Balbinot *et al.*, 2008; Lanes *et al.*, 2022a). In this sense, a notable progress for the management of water resources in Brazil was Law No. 9,433/97, which established the

[4] More information on this topic is available at https://www.gov.br/ana/pt-br/acesso-a-informacao/acoes-e-programas/cooperacao-internacional/agua-no-mundo.

National Water Resources Policy and instituted, in Brazil, the National Water Resources Management System, based on its article 1:

> I - Water is a good in the public domain;
> II - Water is a limited natural resource, endowed with economic value;
> IV - The management of water resources must always provide for the multiple use of water;
> V – The hydrographic basin is the territorial unit for the implementation of the National Water Resources Policy and the performance of the National Water Resources Management System;
> VI – The management of water resources must be decentralized and count on the participation of the Government, users and communities. (Brazil, 1997)

Within the scope of recent international policies and treaties on water, the new political approach of the Sustainable Development Goals (SDGs) comprises the economic, social and environmental spheres, as part of a new sustainable development program, called the 2030 Agenda (UN, 2019). The 2030 Agenda is an action plan that points out the 17 SDGs and, in detail, their 169 goals to end poverty and provide dignity for all within the limitations of the planet. These are objective goals for all countries to integrate water management among their priorities and also to work in universal cooperation to benefit people's lives in the present and future (UN, 2020).

According to the 2030 Agenda, among the 17 SDGs is goal 6 "Drinking Water and Sanitation", which aims to ensure the availability and sustainable management of water and sanitation for all. Based on this objective, this article focuses primarily on target 6.7b: "to support and strengthen the participation of local communities to improve water and sanitation management" (UN, 2019). Therefore, this article places at the center of the discussions some ways to stimulate the participation of students in the management of water resources, based on an environmental demand in the city of São José de Ubá, in the state of Rio de Janeiro.

With this contextualization, this article aims to analyze the application of the Problem-Based Learning (PBL) methodology in the teaching of the water crisis theme, in the municipality of São José de Ubá, with a class of the 9th grade of Elementary School at the Maria Leny Vieira Ferreira Silva State School. The proposition of the use of this methodological approach takes place within a panorama of problematization and obligation to address the environmental themes provided for in the National Policy of Environmental Education, Law No. 9.795 of April 27, 1999 and in the National Common Curricular Base (BNCC), among other normative frameworks of Brazilian education.

In this sense, the educational approach to water resources and other environmental components should be present in school educational curricula and, therefore, in all stages of

school education (Lanes *et al.*, 2022a). Therefore, the relevance of this article is to contribute to the strengthening of active methodologies in Basic Education, expanding the debate on the role of the teacher as a mediator of knowledge. In addition, the article highlights the need for pedagogical practices that integrate cognitive, ethical, and socio-environmental dimensions of school education, in which water can be understood as a central element for the promotion of critical education that allows the articulation of scientific content, social issues, and contemporary challenges related to sustainability. The inclusion of the theme of water in the school daily life favors the development of socio-environmental awareness and the responsible use of this resource (Lanes *et al.*, 2022b).

## 2 PROBLEM-BASED LEARNING (PB): METHODOLOGICAL DESIGN OF THE RESEARCH

Problem-Based Learning (PBL) is a type of active methodology, through which students act in a participatory way in the construction of their own knowledge, with all attention focused on their learning (Glasgow, 2019). According to Moran (2018, p. 4) "active methodologies emphasize the student's leading role, their direct, participatory and reflective involvement in all stages of the process, experimenting, drawing, creating, with the guidance of the teacher". In PBL, students relate collaboratively with a view to the elaboration of knowledge and, therefore, attribute to the teacher the role of mediator who intervenes in their group dialogues. In this process, the focus is on the students' learning independence and not on the practice of teaching, as knowledge is built as a result of this relationship (Maidame, 2018; Alves *et al.*, 2025).

To contextualize, it is important to emphasize that PBL was initially implemented by the McMaster University School of Medicine in Canada in 1969, and by the University of Maastricht, in the Netherlands in the 70s (Souza; Dourado, 2015; Pereira Ronn *et al.*, 2019). After that, this methodology underwent modifications to adapt to other teaching contexts, being built as a result of the efforts of professors and coordinators of these institutions to fill some gaps in traditional teaching, especially those related to learning in medical courses and professional medical practice (Souza; Dourado, 2015). In Brazil, the State University of Londrina (UEL) and the Faculty of Medicine of Marilia (FAMEMA) were the first institutions to apply this methodology, and then other institutions also adopted it (Araújo; Arantes, 2009).

For a differentiation between PBL and traditional teaching, the literature indicates that in traditional methodological perspectives the teacher occupies the center of the pedagogical process, transmitting knowledge considered finished and students assimilate it in a passive position and, thus, thinking and taking initiative are not encouraged (Glasgow, 2019).

Regarding passive learning, Ribeiro (2010, p. 9) points out that "there is a consensus that this (traditional) methodology is no longer able to promote the meaningful learning of conceptual knowledge". For this reason, the author adds that such a methodology cannot encourage the development of other types of knowledge and skills, valued and demanded in professional and social life (Ribeiro, 2010).

Based on the theoretical debate presented, the research understands that traditional teaching methods do not favor the confrontation of the problems of our time, especially environmental problems. Thus, school educational processes need to stimulate the strengthening of participatory societies and, with this, develop responsible, scientific, critical and creative thinking, committed to the civilizing process. In the search for these competencies, the National Common Curricular Base (BNCC) emphasizes the importance of exercising intellectual curiosity in Elementary School, using the approach of Science (Brasil, 2017). In other words, to include "inquiry, reflection, critical analysis, imagination, and creativity, to investigate causes, to elaborate and test hypotheses, to formulate and solve problems, and to create solutions [...] based on the knowledge of different areas" (Brasil, 2017, p. 9).

Within this context, PBL has been gaining ground as an active methodology that has shown important results in the process of knowledge production, particularly in higher education (Maidame, 2018; Pereira Ronn *et al*., 2019; Alves *et al*., 2025). However, this methodology is still little known in the context of Basic Education in Brazil and, when known, it continues to be little implemented and explored (Lopes *et al*., 2019). This means a loss of opportunity to address environmental problems of everyday reality, in a contextualized and territorialized way, without losing sight of the central element of the teaching-learning process; that is, the applicability of knowledge in the reality experienced by students.

Research carried out both in Higher Education and in Basic Education – by Sales, Del and Sales (2013), Maidame (2018), Pereira Ronn et al (2019), Alves et al (2025) – positively evaluated the use of PBL. The results of these studies showed that the participants showed acceptance of the methodology, as well as that it enabled the development of problem-solving skills, allowed self-learning and encouraged the search for knowledge. In turn, in the studies of Borochovicius and Tortella (2014) the results highlight that the conquest of knowledge begins with the presentation of a problem-situation, very close to the reality of the students. Therefore, the fact that there is no predetermined resolution leads to the emergence of doubts and questions, which stimulate reflective activity that, at the same time, will direct the student to a probable solution of the proposed problem.

The possibilities of developing the scientific, critical and creative thinking of students

was decisive for the choice of the methodological approach of PBL in this research. Although this methodology has its origin in teaching in the medical field, its foundations are consistent for it to be worked on at other levels of education and areas of knowledge (Ribeiro, 2010; Borochovicius; Tassoni, 2021). In this adaptation, the research that originated this article took place at the Maria Leny Vieira Ferreira Silva State School, located in the city of São José de Ubá, in the Northwest region of the state of Rio de Janeiro. The empirical work was carried out from the execution of a research project entitled "Our daily water: preserving the life of tomorrow",[5] which included 6 face-to-face meetings lasting three hours each, totaling 18 hours of activities.

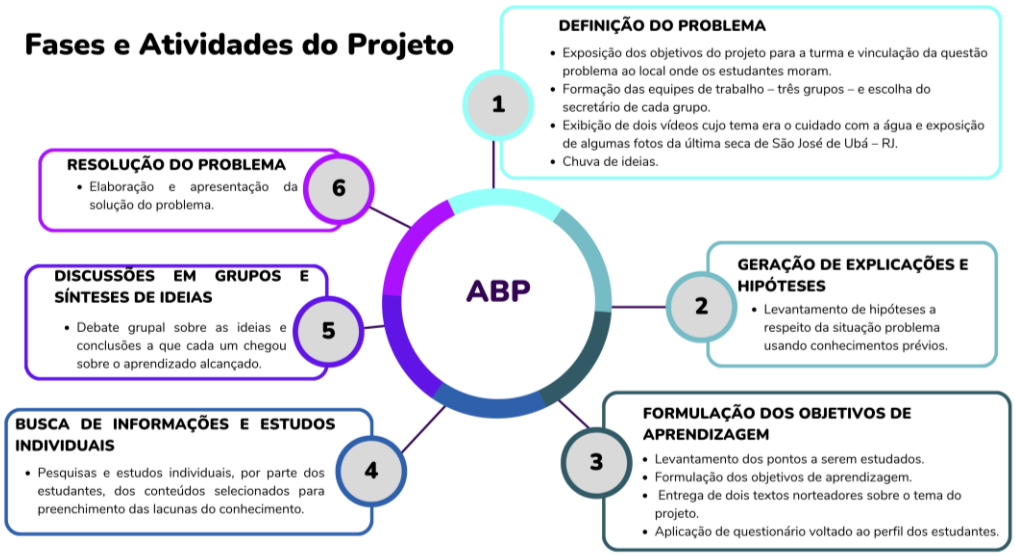
In accordance with the qualitative approach, of an exploratory and descriptive nature, in addition to the objective already presented, this article seeks to explore the understanding of the meanings attributed by students to the learning experience, rather than to quantify its results (Mónico *et al*., 2017). Likewise, this article aims to fill an existing gap regarding the low use of APB in Basic Education and, consequently, the low scientific production on its use in this educational stage (Borochovicius; Tassoni, 2021). For this reason, it assumes the exploratory approach as an empirical horizon, given the low expressiveness of research of this nature (Lopes *et al*., 2019). Additionally, it assumes a detailed description of the actions, procedures, stages and results, in order to provide a broad overview of the process of applying PBL in Elementary School, based on an environmental problem. This description will not only allow the analytical construction of the results, but will also allow the replication of the research in other contexts and with other themes within the scope of Basic Education.

The empirical work of the research had the participation of 21 students from the 9th grade of Elementary School. The criteria for selecting the subjects included: a) voluntary participation in the activity; b) regular attendance in Science classes; c) authorization of those responsible, as determined by Resolution No. 510/2016 of the National Health Council (Brasil, 2016). These 21 students were protagonists in the two stages of the study: a) *theoretical approach* – active construction of knowledge about the water issue of the municipality made possible by the PBL; b) *practical activities* – dissemination of some of the results obtained in the first phase of the project through posters, making of a handmade dripper and distribution of tree seedlings for reforestation. The first stage of the research was structured based on two main questions, which constitute the main results of this article. The organization overview of this step can be seen in Figure 1.

[5] This research meets all ethical protocols for research involving human beings, being registered under CAAE 38937320.8.0000.5288 and with project approval by opinion 4.323.811.

**Figure 1**

*Problem-Based Learning: phases and activities carried out*




Source: Elaboration by the authors (Research data, 2025).

The six phases of the first stage of the research, as described in Figure 1, were planned and executed according to the literature that studies the applicability of APB (Borochovicius; Tortella, 2014; Conrado *et al.*, 2014; Silva *et al.*, 2015). Methodologically, the research was built based on the descriptive qualitative approach, precisely: on the observation, description and interpretation of the phenomenon studied (Mónico *et al.*, 2017). For this, we used the field diary as an instrument for data production, complemented by a record of the students' speeches and observations of the researchers recorded at each stage of the development of the research. For the organization and interpretation of the material, the methodological approach of Thematic Analysis was used, since it allows the identification of relevant patterns and themes from the textual data, that is, it enables the identification of deep meanings in the descriptions of the phenomena (Braun; Clarke, 2006). Therefore, the Thematic Analysis allowed the organization of the thematic categories related to the perception and response of students about the water crisis, group work and interdisciplinary learning.

In order to ensure the reliability and validity of the data, the triangulation of the information was adopted, taking as reference: observations, statements, written records and results achieved with the application of PBL. Such triangulation met the functionality of seeking convergences and divergences in the meanings expressed by the research participants (Flick, 2018). In this sense, following the steps indicated by the theoretical framework adopted in the article, the process of applying PBL was guided by the following problem questions: What are the possible reasons for the lack of water in the municipality of

São José de Ubá? And what are the possible ways to solve these problems?

Both questions subsidized the development of the research, whose scientific relevance is inscribed in the scope of environmental studies and active methodologies. In a broader perspective, the results were organized into three emerging thematic categories, based on thematic analysis: *understanding the environmental problem*; *autonomy* and *collaboration in learning*. Each of these categories reflects the way students experienced PBL and articulated knowledge with their daily experiences.

## 3 RESULTS AND DISCUSSIONS

In PBL, the presentation of the problem, associated with the students' reality, is essential for the success of the later stages (Silva *et al*., 2015; Borochovicius; Tassoni, 2021). With this, the students who led the research discussed the problem in small groups – in this case, in 3 groups of 7 students – where they raised hypotheses to explain the problem, and such assumptions were based on the use of previous knowledge. After these two stages, presentation of the problem and formation of the working groups, a survey was carried out of the gaps that still needed to be studied, as well as the formulation of the new learning objectives, which will be detailed in Figure 1.

Subsequently, the students followed the following steps: *a)* they sought different sources of information; *(b)* they made individual studies on the selected themes; *(c)* discussed these contents in groups; and, *d)* established a consensus regarding the resolution of the problem. During the development of all stages, periodic evaluations were carried out through observation about the development of the methodology, since "in PBL, evaluation is part of the learning process and the production of individual and group knowledge" (Souza; Dourado, 2015, p. 196). Likewise, the role of tutor teachers in all stages of PBL was maintained; that is, the role of mediator and facilitator, guiding the students' activities and valuing the cooperative elaboration of knowledge, where each student contributes to the construction of learning processes on the topic studied (Maidame, 2018).

### 3.1 BRAINSTORMING: UNDERSTANDING THE ENVIRONMENTAL PROBLEM

In PBL, the *Brainstorming stage* – in this article, showers of ideals – is presented as an essential element to encourage divergent thinking and cognitive collaboration about the problem to be solved. The term brainstorming refers to one of the stages of the PBL methodology where students must expose their flow of ideas in relation to the exposed theme, and this flow is based on previous knowledge and common sense (Conrado *et al.,* 2014). In this stage of the empirical work, we showed two videos, whose theme was the care of water:

the episode of Chaves in cartoon and Juca Pingo D'água. In the mediation process, we presented the objectives of the project to the class and associated the problem issue with the city where the adolescents live. After that, we exhibit some photos of the region of São José de Ubá demonstrating the last drought that the municipality and region went through. Afterwards, the students were encouraged to debate about the central issues related to the videos and photos, and received a sheet to write down their ideas while debating as a group. Based on the information obtained, we prepared a word cloud graph, the results of which can be seen in Figure 2.

**Figure 2**

*Brainstorming: students' perceptions of the lack of water*


Source: Elaborated by the authors. Research Data (2025).

The data shown in Figure 2 represent the words most cited by the students in the brainstorm and, therefore, these themes began to guide the development of the project, namely: drought and lack of water; pollution and springs. Regarding the first, drought and lack of water, it is worth mentioning that the municipality of São José de Ubá has a dry tropical climatic type, presenting a negative annual water balance. In the period from February to October, evapotranspiration is greater than precipitation, causing water shortage for most of the year, in addition to the occurrence of dry spells with a notable frequency (Lumbreras *et al*., 2011). The average annual rainfall in the municipality is 1172 mm (Gonçalves *et al*., 2006; Noronha *et al*., 2016).

In addition to the significant dry season, the region still has vast areas predominantly occupied by pastures, few forest remnants and a high degree of soil degradation, which characterizes environmental problems (Lumbreras *et al*., 2011). Historically, the practice of deforestation in recharge regions, as well as in soil areas with low agricultural propensity and

in riparian forest regions, causes relevant losses of soil, nutrients, organic material and, especially, water, which is closely related to the drought of numerous springs in the municipality (Freitas *et al*., 2001). Vegetation destruction in the region is worrying, since in the period between 2013 and 2014 only 5% of the extension of the municipality of São José de Ubá was covered by Atlantic Forest, which is equivalent to 1,205 hectares (TCE-RJ, 2016).

With regard to water pollution in the city of São José de Ubá, a theme often evoked in the students' brainstorming, as it is a mostly agricultural area, there are diffuse sources of water contamination in the municipality. Conventional tomato cultivation is significant in this city, associated with the use of pesticides that, in most cases, are applied inappropriately, contaminating rivers and springs (Carneiro *et al.,* 2015). Remnants of these products are retained in the soil and, with rain, they can reach the groundwater and/or be carried to surface waters, thus causing their pollution and degradation (Soares; Souza, 2020). These elements reveal that the students were able to associate everyday issues with the study problem in the first stage of PBL – *brainstorming*.

The research data reveal that the central themes of the environmental problems of São José de Ubá were evoked by the students, which demonstrates that these situations are part of their realities and that they were contextualized in the development of the methodology. Still on the pollution of water, rivers and springs, the ABRASCO dossier released in 2015 warns about the impacts of pesticides on health and the environment (Carneiro *et al*., 2015). Despite the warnings, between 2019 and 2022, Brazil experienced the highest number of registrations of new pesticides for a presidential administration, since 2003; that is, the release of 2,182 new pesticides (Firmino *et al.,* 2024).

Additionally, among the various forms of water pollution and contamination listed by the students, in the municipality of São José de Ubá sewage treatment is not carried out in urban and rural spaces. Therefore, the waste is dumped *in natura in the* floodplains and water bodies of the municipality, and can even affect the water located in the wells, especially in the rural area, with a view to the domestic supply of residents (Rio de Janeiro, 2015). Thus, the data presented in this article, obtained through the brainstorming, reveal that the students are not oblivious to the environmental problems of the municipality, since pollution appears at the center of their concerns.

The main results in this stage indicate that the students, initially, presented a fragmented understanding of the water crisis, attributing it to the lack of rain or domestic waste. However, throughout the process, the broader structuring dimensions of the problem were integrated, such as: deforestation, contamination of rivers and inequality in access to water. This cognitive displacement demonstrates the power of PBL as a mediator of

meaningful learning, since the students reformulated their hypotheses based on dialogue and collaborative research. This corroborates the idea that learning occurs when new information is integrated, in a non-arbitrary way, into the pre-existing cognitive structure (Silva *et al.,* 2015). During the group discussions, one of the students said: "*we always think that there is a lack of water because the people spend a lot, but now I understand that the problem is bigger, it comes from the companies and the forests that have been cut down*." This statement translates the conceptual advance provided by the method, revealing the transition from common sense to a critical reading of reality.

3.2 GENERATION OF HYPOTHESES AND OBJECTIVES: AUTONOMY AND COLLABORATION IN THE ABP

In *the second* and *third* phases of the research, the students were invited to develop hypotheses for the problem questions, create learning objectives and, thus, achieve these objectives through research. After the brainstorming, the students began to debate, in their respective working groups, the two central issues to be solved. At this stage of the research, students were invited to answer the problem questions only using their previous knowledge, without using any means of research, as adopted in the studies by Borochovicius and Tortella (2014), Silva *et al*. (2015), Maidame (2018). During this phase, one of the students in group 2 asked if she could write something that she believed "did not make much sense", showing insecurity in relation to her previous knowledge. Such an occurrence is possibly associated with the absence of protagonism in learning itself, as one of the striking characteristics of traditional teaching. Figure 1 shows the hypotheses raised by the students in each group, as well as the other research questions.

**Figure 1**

*Hypotheses and learning objectives: group responses*

| Groups | Hypotheses | Questions | Group responses |
|---|---|---|---|
| **Group 1** | One of the first reasons for the lack of water is the lack of rain and intense heat; the pollution of rivers; lack of basic sanitation; the rise in deforestation, etc. The ways to solve it would be to make more (artificial) rivers; new management to capture rainwater; nets at the mouths of the manholes; turn off the tap at bath time (soaping); turn off the tap when brushing our teeth and when washing the car (or any other car). In 2017 there was one of the biggest droughts in São José de Ubá, many animals died, with the devaluation of the government. | 1) Why do they still throw garbage in rivers, lakes and beaches? | 1) Because it is not the people who throw the garbage, it is the government that does not know how to provide the preparations where they are going to dump so much material that can be reused. |
| | | 2) Why is there no more basic sanitation in São José de Ubá? | 2) The government says it does not have the money for quality basic sanitation for the city. |
| | | 3) Why don't they still wash the | 3) Because they think it is easier and more practical to wash with a |

| | | | |
|---|---|---|---|
| | | cars with the buckets? | hose, but they do not know that they use liters of water just in washing a car. |
| **Group 2** | Irresponsibility; pollution; deforestation; waste; lack of rain; fires; throwing garbage on the streets and in the seas; Do not use disposable straws and cups. The ways to solve it would be to have responsibility (save water); do not throw oil into the sink drain; do not throw garbage on the ground; do not cut down trees; not to set fire to the forest and to make people aware of the lack of water on the planet; use reusable straws and cups; stop polluting the rivers in order to be able to continue with the life of the beings that live on planet Earth. | 4) Why doesn't it rain as often as before in my city? | 4) The region's rainfall regime is characterized by long periods of drought, low rainfall and maximum peak rainfall. |
| | | 5) Why are there places that rain more than others? | 5) Because there are places close to the sea or with a lot of exposed water and in others they are drier. |
| **Group 3** | Lack of rain; the waste of water; the pollution of rivers with sewage. The ways to solve it would be: reuse the waters of the river; we try to avoid waste in the gardens; try to avoid the use of pesticides that pollute the water table; when brushing the tooth, turn off the tap; reduce shower time; improve sanitation, trying to take their path to the rivers. | 6) Why doesn't it rain like it did in Ubá? | 6) Due to global warming, climate change, deforestation, among other factors. |
| | | 7) Does the weather interfere? | 7) Yes, climate change interferes with everything in our lives. |
| | | 8) Are we far from sea level, so are we without rain? | 8) Not only for that, but for other reasons as well. |

Source: Elaborated by the authors. Survey data (2025).

The process of generating hypotheses within the PBL methodology is of great importance, given that through this process it is possible to awaken creativity and increase the motivation of students, since the hypotheses of resolution are problems linked to everyday life (Souza; Dourado, 2015; Silva *et al*., 2015). In addition, because it involves students' previous knowledge, the generation of hypotheses expands the critical capacity for analyzing problems and developing solutions. In addition, the joint construction of hypotheses leads to interaction between students and the acquisition of interpersonal skills, such as respect and cooperation. Such abilities were also verified in the studies carried out by Souza and Dourado (2015), Silva *et al.* (2015), Borochovicius and Tassoni, (2021), Alves *et al.* (2025) as well as in the behavior of students during the development of this research. During the elaboration of the hypotheses, it was possible to perceive a collaborative and friendly relationship between the students, so that they were motivated to solve the questions, demonstrating autonomy and curiosity in relation to the resolution of the problem.

The research data indicate that two, out of a total of three groups, were more successful in generating hypotheses. Regarding the applicability of PBL, Ribeiro (2010, p. 89) mentions that this transition requires time, understanding and adaptation from students,

in the "passage from passive to active learning". The author also points out that "it is necessary to take into account the effects of the adoption of PBL in view of the years of schooling of students in conventional teaching environments" (Ribeiro, 2010, p. 76). In turn, the results obtained with the majority of students corroborate that the structuring of questions, during the dynamics of problem discussion, collaborates positively for the development of autonomy, critical and reflective capacity of students (Silva *et al*., 2015).

According to the data shown in Figure 1, in relation to the hypotheses, the data indicate that the students used daily issues observed in their daily experiences, as a way to justify the environmental problems of São José de Ubá, linking the responsibility that society should have in relation to environmental degradation. After this phase of the research, the groups of students wrote down the points that they believed still needed to be studied. Then, they took these to their homes to be researched and studied individually, with a period of one week for this research. With regard to the points to be studied, we observed, in part of the participants, a certain restlessness and desire to understand the following issues: *a)* society's contemptuous behavior towards water; *(b)* the climatic phenomena that govern rainfall in the municipality.

At this stage of the PBL methodology, we advise you to read two texts: "Water: without it we will be the planet Mars of tomorrow", by the author Marco Antônio Ferreira Gomes (2011); a news article[6] in which he states that the Chamber of Deputies created a commission to evaluate a project that intends to classify the North and Northwest of the state of Rio de Janeiro as a semi-arid area. Such texts had the purpose of subsidizing students in the search for information. Remembering that the main points that the groups mentioned in the elaboration of hypotheses are related to: public policies; climate issues; habits and behaviors of society.

Regarding public policies, the students accessed information about the Municipal Basic Sanitation Plan (2015 – 2034) of the city of São José de Ubá, whose actions were designed to generate short, medium and long-term impacts. Such actions are mainly linked to the municipality's water supply, and some of the objectives of this plan consist of the "protection of springs used for public supply [...]; recomposition of riparian forest at the source [...]; preparation of periodic campaigns and activities with the participation of the community related to the rational use of water" (Rio de Janeiro, 2015, p. 79). Although the students did not mention this plan in their written answers, they pointed out the main issues linked to it, such as the fight against waste, the protection of water bodies and the need for sanitation.

[6] Available at: <https://g1.globo.com/rj/norte-fluminense/noticia/2019/08/07/camara-cria-comissao-para-avaliar-projeto-que-quer-classificar-norte-e-noroeste-do-rj-como-area-de-semiarido.ghtml>. Accessed on: September 22, 2020.

In turn, on climate issues, the participants mentioned various aspects related to climate and its relationship with water resources. This aspect is relevant considering that the climate changes that have been occurring and intensifying in recent years can cause very significant consequences for the global supply of drinking water (UNESCO, 2015; FAO, 2015). Climate change can influence the natural water cycle, since phenomena such as unusual temperature and precipitation patterns, increased frequency of disastrous meteorological episodes involving water resources such as cyclones, and long periods of drought, have an impactful influence on freshwater systems (Tundisi; Matsumura-Tundisi, 2011).

In relation to the changes in habits and behaviors on the part of the population, mentioned by the students, the literature indicates that the way water is treated by society in general is closely linked to a crisis triggered by a worldview centered on the utilitarianism of natural goods and on the form of development defined by society (Soares, 2022). This crisis is a consequence of an extensive process of appropriation and exploitation of nature, which has been accentuated with the evolution of industrial capitalism, generating a socio-environmental crisis (Andrade 2020; Lanes *et al.,* 2022b).

After the elaboration of the hypotheses, studies of the suggested texts and autonomous research carried out by the students, the three groups met again, exchanged ideas about the individual study in their homes and their conclusions were noted, as shown in Figure 1. Before the elaboration of the final solution of the problem questions, we held a debate with the students, aiming to make some considerations about the discussions of some groups. The purpose of this debate was, as Maidame (2018) points out, to avoid misunderstandings in relation to the central issues to be solved. Some examples of these misconceptions were: "*it is not the people who throw the garbage in the water bodies, but the government that does not know how to take the necessary measures regarding the disposal of the waste*" (G1-R1[7]). Often, public agencies are omissions, but this does not exempt society and companies from the duty to seek the appropriate way to dispose of waste, so that water bodies would be an unjustifiable alternative.

One of the mistakes made by the students refers to the rainfall characteristics of the region, without mentioning the changes that these patterns have been undergoing (G2-R4); as well as, "*because there are places close to the sea or with a lot of exposed water and in others they are drier*" (G2-R5). In this case, the influence of maritimity and continentality on the rainfall regime was cited, as claimed by Armond (2015) and Diniz et al (2014), however, São José de Ubá is not close to the sea. Following misconceptions we have: "*we are far from sea level, so we are without rain*" (G3-R8), which indicates that we would be at high altitudes

[7] Code used to identify the workgroup and response number.

and, consequently, in conditions of low atmospheric pressure most of the time. As low atmospheric pressure conditions favor precipitation, according to the National Institute for Space Research (INPE, 2020), we should not suffer, therefore, from the scarcity of rainfall.

Another mistake discussed in this phase of application of the PBL methodology is related to the altitude of São José de Ubá itself, in this case, low altitude – 120m (Gonçalves; Nobleman; Bastos, 2006). Thus, since atmospheric pressure is inversely proportional to altitude, high pressure conditions disfavor the formation of clouds, and, consequently, precipitation in the region (INPE, 2020). After these elucidations and discussions, the students jointly reached the solution of the questions. In this way, they realized that the possible reasons for the lack of water in the municipality of São José de Ubá are:

> ✓ R1 – Rampant deforestation with a view to agriculture. Such practice has seriously harmed the water infiltration process, due to the significant lack of vegetation and soil exposure. Therefore, the limited amount of rainfall that falls on the region cannot be stored for later use during the months with no precipitation.
> ✓ R2 – The pollution caused by numerous factors, such as pesticides, sewage, garbage, among others.
> ✓ R3 – The waste practiced by the inhabitants, who are often unaware of the water situation in which the municipality has found itself in recent years and treat water as an infinite resource. (Survey data, 2025)

Regarding the possible ways to solve these problems, the students mentioned: *a)* the reforestation of devastated areas, especially regions close to the springs, aiming to increase the process of recharging the groundwater in an attempt to revitalize water bodies that have been drying up; *(b)* the need to sensitize the community as a whole so that everyone is aware of the situation in which the city of São José de Ubá finds itself, with regard to its water resources. With these answers, it is evident the importance of the school developing educational practices about water beyond its walls, involving the community and seeking the possibilities of solving the problem (Lanes *et al.*, 2022a). In this sense, the data obtained in this research are significant in view of the reality of the city, since significant learning is also characterized by the interaction between knowledge in the transitory and non-asymmetric evolutionary relationship.

The research data highlight that through PBL it was possible to stimulate reflective and critical thinking, considering previous knowledge and the reality that constitutes the daily life of students. The development of the PBL methodology, associated with the water crisis in the city, promoted an interrelationship between the school and the community and, therefore, should be encouraged through pedagogical activities that portray the needs of society. The use of PBL makes it evident that the theoretical knowledge formulated by students can be

applied in their contexts and, in this way, allow the occurrence of meaningful learning. Possibly, the pedagogical gains obtained through PBL will help in the construction of a new vision of the socio-environmental reality of students.

In this context, the students' considerations and notes highlight: *a)* the need for efficient public policies, aimed at environmental and water management in the municipality; *(b)* effective reforestation policies and actions aimed at the protection of riparian forests; *(c)* an operating basic sanitation program; *(d)* permanent partnerships with school units, aiming at new project proposals, with regard to environmental issues. These data reinforce the idea that intellectual autonomy and cooperation are fundamental principles of PBL (Borochovicius; Tortella, 2014; Conrado *et al*., 2014). This is because, by being invited to build hypotheses, test ideas and discuss solutions, the students exercised investigative thinking and collective argumentation. In other words, they collectively built precise strategies that enabled self-education processes.

## 4 CONCLUSION

The research aimed to analyze the application of the Problem-Based Learning (PBL) methodology to address the water problem in the municipality of São José de Ubá, with an Elementary School class. The main results of the research indicate that in the brainstorming phase, the participants mostly mentioned the lack and pollution of water in the municipality, exemplifying such problems from the experiences of daily life. These findings corroborate the literature used in this article, with regard to the understanding of the problem situation, from the perspective of the students' reality. In other words, these results highlight that PBL favors the construction of meanings based on the concrete experience of students, that is, they validate the theoretical assumption that knowledge is an active, social and contextual process.

With regard to autonomy and collaboration among the members of the groups, the results indicate that the pedagogical experiences built by two groups, out of a total of three, were more expressive based on the essence of PBL. The students in these groups were more open to PBL, showed greater commitment and curiosity in relation to the development of the methodology. In turn, one group had lower adherence to the research, since some of its members had difficulties adapting to PBL, especially during the second phase – generation of hypotheses. In all three groups, some students received the methodology, at first, with trepidation. However, during the course of the project, most of them did not present any difficulty in adapting. On the contrary, a significant part of the students seemed enthusiastic about their own evolution in the construction of knowledge about their reality. This can be

explained by the autonomy and collaboration they experienced during the process; Something that, until then, in the words of the students, was not part of the pedagogical processes adopted by the school.

On the one hand, these results highlight the central role of the teacher as a mediator and facilitator of learning, within the scope of PBL. On the other hand, the findings reveal the structural limits of public schools, such as: lack of pedagogical time and scarcity of didactic resources, elements that restrict the full application of active methodologies such as PBL. Even in the face of these situations, the most expressive results of the research indicate that the PBL methodology is appropriate and efficient to work on environmental issues with elementary school students, including water resources, in its multiple approaches. This is because the students were able to transport this acquired learning capacity to their daily lives, transcending the school environment. In addition, the students developed other skills essential to the exercise of citizenship, especially those necessary for an active participation in the spaces and debates that involve current environmental problems.

For this reason, the analyses highlight the contribution of PBL to the debate on the role of the school in the formation of subjects concerned with current environmental problems, capable of recognizing the links and dimensions that associate environment, politics and citizenship. In addition, the results show that practices based on autonomy, investigation and cooperation can awaken in students a sense of belonging and socio-environmental responsibility. However, the research indicates some limitations observed, among them: the short period of application of the methodology, organized in six meetings, which suggests the need for long-term studies that can explore the permanence of the effects of PBL over time. Even so, the article highlights that PBL integrates scientific knowledge with local experiences and, therefore, reaffirms the transformative potential of education.

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