RAPID ASSESSMENT PROTOCOL AS A PEDAGOGICAL RESOURCE FOR THE SOCIO-ENVIRONMENTAL READING OF URBAN RIVERS: ADAPTATIONS IN THE DEVELOPMENT AND VALIDATION OF A DIDACTIC GUIDE

PROTOCOLO DE AVALIAÇÃO RÁPIDA COMO RECURSO PEDAGÓGICO PARA A LEITURA SOCIOAMBIENTAL DE RIOS URBANOS: ADAPTAÇÕES NO DESENVOLVIMENTO E NA VALIDAÇÃO DE UM GUIA DIDÁTICO

PROTOCOLO DE EVALUACIÓN RÁPIDA COMO RECURSO PEDAGÓGICO PARA LA LECTURA SOCIOAMBIENTAL DE RÍOS URBANOS: ADAPTACIONES EN EL DESARROLLO Y LA VALIDACIÓN DE UNA GUÍA DIDÁCTICA

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ABSTRACT

This article analyzes the development, structure, and validation of a didactic guide constructed through the adaptation of a Rapid Assessment Protocol (RAP) for elementary education, seeking to address the problem of how such an instrument can promote critical environmental learning and assist students in understanding the socio-ecological determinants of urban river degradation. Grounded in a qualitative approach, the study combined documentary analysis, methodological adaptation of the RAP, pedagogical workshops, and field activities conducted with students from a public school in Janiópolis, Paraná (Brazil). The theoretical framework engages with references on urban water resources (Tucci, 2008; Tundisi, 2014; 2020), Rapid Assessment Protocols (Callisto et al., 2002; Guimarães, Rodrigues & Malafaia, 2012), and Critical Environmental Education (Guimarães, 2004; Layrargues & Lima, 2014), as well as the principles of the National Water Resources Policy and Sustainable Development Goal 6 (SDG 6). The results indicate that the guide fostered a critical reading of the Água dos Peões stream, enhanced students' interpretive capacity, strengthened their understanding of anthropogenic pressures, and stimulated argumentative positioning in relation to local environmental conflicts. The product proved to be scientifically and pedagogically robust, with high potential for replication in public schools and practical relevance – particularly in terms of public management – for small municipalities. It is concluded that the guide constitutes a relevant educational technology for improving school-based environmental management, fostering social participation, and supporting formative practices aligned with the National Water Resources Policy, the SDGs, and critical perspectives in Environmental Education, thereby justifying its academic, public, and social significance.

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Keywords: Participatory Diagnosis. Urban Water Resources. Investigative Learning. Socio-Environmental Management. Critical Environmental Education. Rapid River Assessment.

RESUMO

Este artigo analisa o desenvolvimento, a estrutura e a validação de um guia didático construído a partir da adaptação de um Protocolo de Avaliação Rápida (PAR) para o Ensino Fundamental, buscando responder ao problema de como tal instrumento pode promover aprendizagens ambientais críticas e auxiliar estudantes na compreensão dos determinantes socioecológicos da degradação de rios urbanos. Ancorado em uma abordagem qualitativa, o estudo articulou análise documental, adaptação metodológica do PAR, oficinas pedagógicas e atividades de campo junto a estudantes de uma escola pública de Janiópolis (PR). A fundamentação teórica dialoga com referências sobre recursos hídricos urbanos (Tucci, 2008; Tundisi, 2014; 2020), Protocolos de Avaliação Rápida (Callisto et al., 2002; Guimarães; Rodrigues; Malafaia, 2012) e Educação Ambiental Crítica (Guimarães, 2004; Layrargues; Lima, 2014), além dos princípios da Política Nacional de Recursos Hídricos e do ODS 6. Os resultados evidenciam que o guia favoreceu a leitura crítica do córrego Água dos Peões, ampliou a capacidade interpretativa dos estudantes, fortaleceu sua compreensão das pressões antrópicas e estimulou posicionamentos argumentativos diante dos conflitos ambientais locais. O produto mostrou-se robusto do ponto de vista científico e pedagógico, com alto potencial de replicabilidade em escolas públicas e de utilidade – em termos de gestão pública – para municípios de pequeno porte. Conclui-se que o guia constitui uma tecnologia educacional relevante para qualificar a gestão ambiental escolar, fomentar a participação social e subsidiar práticas formativas coerentes com a PNREH, com os ODS e com perspectivas críticas da Educação Ambiental, justificando sua importância acadêmica, pública e social.

Palavras-chave: Avaliação Rápida de Rios. Diagnóstico Participativo. Recursos Hídricos Urbanos. Aprendizagem Investigativa. Gestão Socioambiental. Educação Ambiental Crítica.

RESUMEN

Este artículo analiza el desarrollo, la estructura y la validación de una guía didáctica construida a partir de la adaptación de un Protocolo de Evaluación Rápida (PER) para la Educación Primaria, con el propósito de responder al problema de cómo dicho instrumento puede promover aprendizajes ambientales críticos y ayudar a los estudiantes a comprender los determinantes socioecológicos de la degradación de los ríos urbanos. Basado en un enfoque cualitativo, el estudio articuló análisis documental, adaptación metodológica del PER, talleres pedagógicos y actividades de campo realizadas con estudiantes de una escuela pública del municipio de Janiópolis (PR, Brasil). El marco teórico dialoga con referencias sobre recursos hídricos urbanos (Tucci, 2008; Tundisi, 2014; 2020), Protocolos de Evaluación Rápida (Callisto et al., 2002; Guimarães, Rodrigues y Malafaia, 2012) y Educación Ambiental Crítica (Guimarães, 2004; Layrargues y Lima, 2014), además de los principios de la Política Nacional de Recursos Hídricos y del Objetivo de Desarrollo Sostenible 6 (ODS 6). Los resultados evidencian que la guía favoreció la lectura crítica del arroyo Água dos Peões, amplió la capacidad interpretativa de los estudiantes, fortaleció su comprensión de las presiones antrópicas y estimuló posicionamientos argumentativos frente a los conflictos ambientales locales. El producto se mostró sólido desde el punto de vista científico y pedagógico, con alto potencial de replicabilidad en escuelas públicas y utilidad – en términos de gestión pública – para municipios de pequeño porte. Se concluye que la guía constituye una tecnología educativa relevante para cualificar la gestión ambiental escolar, fomentar la participación social y sustentar prácticas formativas coherentes con la Política Nacional de Recursos Hídricos, los ODS y las perspectivas críticas de la Educación Ambiental, lo que justifica su importancia académica, pública y social.

Palabras clave: Evaluación Rápida de Ríos. Diagnóstico Participativo. Recursos Hídricos Urbanos. Aprendizaje Investigativo. Gestión Socioambiental. Educación Ambiental Crítica.

1 INTRODUCTION

The degradation of Brazilian urban rivers, intensified in recent decades, has evidenced (i) the fragility of aquatic ecosystems in the face of anthropogenic pressures and, above all, (ii) the structural limits of traditional management and education models regarding water resources. The disorderly expansion of cities, the increasing impermeabilization of the soil, the continuous discharge of effluents and solid waste and the suppression of riparian forests configure a picture of degradation that compromises the quality of water, biodiversity and the socio-ecological balance of urban environments[3]. These problems deepen socio-environmental asymmetries, reinforcing historical inequalities that mainly affect vulnerable and/or racialized populations – see environmental racism – whose access to quality water is systematically threatened[4].

This scenario directly confronts the principles of the National Water Resources Policy (PNREH), which recognizes water as a public good and demands integrated, participatory and decentralized management practices (Brasil, 1997). Likewise, it highlights the distance between the global normative projections enshrined in the Sustainable Development Goals (SDGs), especially SDG 6, and the concrete reality experienced in Brazilian urban micro-basins, still marked by *deficits* in planning, monitoring and territorialized environmental education (UN, 2015). In view of this, it is found that the environmental crisis of urban rivers is simultaneously ecological, political, pedagogical and epistemological – and therefore demands strategies that transcend exclusively technical diagnoses, calling for training processes that promote a critical reading of reality and community engagement.

In this sense, Critical Environmental Education (EAC) becomes central by proposing the overcoming of merely informative practices and the defense of emancipatory pedagogical processes capable of questioning productivist rationalities and the logics of degradation of common goods[5]. By incorporating the analysis of power relations, socio-environmental inequalities and the complexity of natural and social systems, EAC positions itself as an essential training field for students to understand their territory, identify local problems, interact with their socio-natural environments and recognize themselves as subjects capable of transforming their realities.

However, school practice still lacks qualified didactic methodologies that bring students closer to environmental research, stimulating intellectual autonomy, ecological sensitivity and ability to read the territory. The absence of pedagogical materials specifically aimed at the participatory diagnosis of urban rivers constitutes one of the gaps that limit the school's

[3] Tucci, 2008; Andrade et al., 2019.
[4] Tundisi, 2014; Brazil, 2021.
[5] Guimarães, 2004; 2013; Layrargues; Lima, 2014.

commitments to scientific, citizen and environmentally critical education. Thus, it is urgent to develop and analyze didactic instruments that articulate ecological, geographical, chemical, social and political knowledge, especially in contexts of public schools located in municipalities that face the direct effects of water degradation.

It is in this context that this article is inserted, whose main objective is to present, analyze and discuss the development and validation of a didactic guide built from a Rapid Assessment Protocol (PAR) adapted for elementary education. This educational product, derived from research linked to the Professional Master's Degree in the National Network for the Teaching of Environmental Sciences (ProfCiamb), seeks to integrate investigative practices with participatory environmental diagnosis, bringing students closer to the critical analysis of the Água dos Peões stream, in the municipality of Janiópolis (PR). The guide was developed to allow an integrated reading of the physical, biological and anthropic factors that affect the environmental quality of urban rivers, seeking to transform field activity into interdisciplinary and critical formative practice.

The problem that guides this study is summarized as the following question: how can a didactic guide structured from an adapted PAR promote environmental learning and help elementary school students in understanding and diagnosing urban rivers? To answer it, the following objectives were defined: a) to present the conceptual and methodological foundations that support the elaboration of the guide; b) describe its process of construction and adaptation, considering the specificities of the PAR and the challenges of didactic transposition; c) analyze its application and validation with students, identifying learning, limits and potentialities; d) to discuss the contribution of the guide – an interdisciplinary educational product – in the context of ProfCiamb.

Methodologically, the study is based on a qualitative approach[6], involving document analysis, technical adaptation of the PAR, pedagogical workshops, field activities and formative evaluation of students' learning. The construction of the guide emerges from the articulation between (i) theoretical references of the EAC, (ii) technical-ecological foundations of the Rapid Assessment Protocols[7] and (iii) pedagogical demands identified in the school context. In addition, the study contributes to the field of Environmental Science Teaching by offering a replicable, low-cost and theoretically grounded educational technology, aligned with the principles of the PNREH, the commitments of the SDGs and the transformative perspectives of the EAC. In addition, the guide mobilizes the territory as a pedagogical space, stimulates participatory research processes and expands the methodological repertoire

[6] Minayo, 2001; Gil, 2008; Silveira; Córdova, 2009.
[7] Callisto et al., 2002; Guimarães; Rodrigues; Malafaia, 2012; Angels; Vasconcelos; Negreiros, 2021; Bersot, Menezes and Andrade, 2015; Pedroso; Colesanti, 2018.

available to educators and environmental managers. Finally, before presenting the development of the guide and the results of the research, it will be understood below the theoretical contributions that supported its conception – especially those related to water resources, the rapid evaluation of rivers, the critical perspectives of Environmental Education and the role of educational products in professional master's degrees.

2 THEORETICAL BACKGROUND

Understanding the socio-environmental dynamics that structure the relationship between society and water resources requires an interdisciplinary and critical approach, capable of articulating legal frameworks, scientific references and pedagogical perspectives that illuminate the contemporary challenges of water management and environmental education. In a context marked by increasing pressure on aquatic ecosystems, especially in urbanized areas, it is essential to analyze how water degradation is related to historical, economic, and cultural processes that shape the territory (Tucci, 2008; Andrade et al., 2019). At the same time, the literature shows that social participation, applied research and critical school education play a strategic role in promoting qualified readings of these environments and, consequently, in subsidizing public decisions and more sustainable community practices (Guimarães, 2004; Tundisi, 2014; CAPES, 2019). In this scenario, environmental diagnosis methods such as PARs and educational products developed in professional teaching programs emerge as important mediation devices between science, education and territorial management.

The present theoretical framework, therefore, discusses four fundamental axes: (i) the degradation and pollution of water resources and the need for integrated management; (ii) the principles and educational potential of the Rapid Assessment Protocols; (iii) Critical Environmental Education as an epistemological matrix; and (iv) the role of educational products within the scope of professional master's degrees, especially in ProfCiamb.

2.1 WATER RESOURCES: DEGRADATION, POLLUTION AND INTEGRATED MANAGEMENT

Water, constitutionally recognized as a good for the common use of the people and essential to life (Brasil, 1988; 2020a; 2020b), has been subjected to increasing pressures resulting from hegemonic models of urbanization and agro-industrial expansion in Brazil. Such models have produced significant impacts on water systems, expressed, among other aspects, by (i) extensive soil sealing, (ii) irregular occupation of permanent preservation areas, (iii) discharge of domestic and industrial effluents without adequate treatment, and (iv)

diffuse input of contaminants associated with agro-industrial practices, such as fertilizers, pesticides, and sediments, compromising the quality and availability of water in urban and urban environments. peri-urban (Tucci, 2008). The literature shows that such processes intensify the physical, chemical, and biological degradation of water bodies, promoting siltation, eutrophication, contamination, and loss of biodiversity (Montagner; Vidal; Acayaba, 2017; Nova; Tenório, 2019). In addition, studies on the environmental history of Brazilian cities reveal that water pollution is articulated with cultural practices and development patterns that have naturalized the transformation of urban rivers into waste receptors, as demonstrated in the analysis of Lake Guaíba by Andrade et al. (2019).

At the institutional level, the National Environmental Policy (Brasil, 1981) and the National Water Resources Policy (Brasil, 1997) structured a new management paradigm, based on decentralization, social participation and integration between multiple uses of water. The creation of the National Water Agency (Brasil, 2000) reinforced the need to expand the monitoring, framing and regulation of water bodies, recognizing that decision-making must dialogue with continuous territorial diagnoses. Tundisi (2014) reinforces that integrated management is not limited to hydrological or technical aspects; In fact, it requires considering ecological, social and political dimensions that influence the availability and quality of water.

It is not by chance that the 2030 Agenda (UN, 2015) has internationally consolidated the understanding that the protection of aquatic ecosystems is inseparable from education, urban planning, public health, and environmental justice policies. In this sense, schools and communities play a strategic role by engaging in processes of critical reading of the territory, since water degradation represents, above all, an indicator of the ways in which society organizes, distributes and consumes its resources.

2.2 RAPID ASSESSMENT PROTOCOLS: FOUNDATIONS, POTENTIALITIES AND EDUCATIONAL USES

Rapid Assessment Protocols represent environmental diagnostic methodologies widely used to analyze the quality of lotic ecosystems in an agile, integrated and low-cost manner (Callisto et al., 2002). Its synthetic character allows the systematic observation of variables such as (i) vegetation cover of the banks, (ii) bed stability, (iii) presence of sediments, (iv) anthropogenic changes, (v) solid waste and (vi) flow conditions, resulting in an interpretative classification of the integrity of the environment. Based on these variables, the PAR offers not only an overview of ecological conditions, but also subsidies to understand the socio-environmental pressures that structure the territory.

In recent years, applied research has shown that PAR is highly effective in educational

contexts because it favors situated learning, critical thinking, and student engagement with real environmental problems. For example, Guimarães, Rodrigues and Malafaia (2012) showed that elementary school students are able to identify significant environmental changes from the use of the protocol, understanding relationships between human practices and impacts on rivers. Anjos, Vasconcelos, and Negreiros (2021), as well as Oliveira, Veloso, and Rossoni (2021), reaffirm the tool's formative potential, highlighting its contribution to developing observation, argumentation, and scientific interpretation skills.

Other authors reinforce the importance of PAR in field activities to sensitize students about degradation processes, promoting the articulation between ecological theory and territorial experience (Machado, 2019; Amorim, 2021). Pontini and Coelho (2019) and Silva et al. (2019) demonstrate that, even in highly impacted urban contexts, the application of the methodology allows the identification of patterns of erosion, siltation, irregular occupation and waste deposition, qualifying environmental perception and subsidizing discussions on public policies and conservation practices. The literature points out, therefore, that the educational use of the PAR goes beyond the simple physical diagnosis: it is configured as an epistemic device that enables students to understand the complexity of society-nature relations, connecting it to debates on environmental justice, collective rights and democratic water management.

2.3 CRITICAL ENVIRONMENTAL EDUCATION: FORMATION OF A SOCIO-ECOLOGICAL READING OF THE TERRITORY

Critical Environmental Education, according to Guimarães (2004; 2013) and Layrargues and Lima (2014), is a theoretical-political field that interprets the socio-environmental crisis from its historical, social and economic foundations. From this perspective, environmental problems are understood as resulting from structural processes associated with the forms of organization of production, the appropriation of nature and the reproduction of inequalities that characterize capitalist modernity. The centrality of this approach lies in the understanding that the relations between society and nature are mediated by conflicts, interests and social projects, which are expressed in an unequal way in territories and social groups.

By assuming this understanding, the EAC is guided by a political-pedagogical dimension that articulates training, social awareness and collective action, thus establishing an epistemology of environmental complexity[8]. Its commitment is focused on strengthening

[8] The epistemology of environmental complexity, according to Leff (2003) and Riojas (2003), constitutes a framework that understands environmental problems as non-linear phenomena, historically situated and crossed by multiple rationalities, in which ecological, social, economic, cultural and political dimensions are

community participation, problematizing hegemonic socioeconomic practices and building integrated readings of socio-environmental reality. The dialectical analysis of these relations makes it possible to understand environmental phenomena as dynamic and historically situated processes, opening space for educational practices that promote critical reflection, the production of collective meanings and the transformation of the social conditions that sustain environmental degradation.

In this theoretical matrix, the environment is conceived as a socio-historical totality, and the school becomes a privileged space to promote critical readings of the territory, articulating scientific, cultural and popular knowledge. Applied studies in the field of water education and conservation (Maciel; Sousa, 2022; Raupp; Fransciscato; Lima, 2019) highlight that field activities, when planned from this approach, contribute to the formation of subjects capable of problematizing environmental degradation, questioning inequalities and understanding water as a common good.

The PAR, in this context, works as a methodology congruent with the EAC, after all, it offers subsidies for students to understand environmental impacts as products of human decisions, public policies, economic practices and environmental conflicts. By interpreting the conditions of an urban river, they identify environmental indicators and develop, at the same time, socio-environmental awareness, engagement and argumentative capacity – essential subsidies for current socio-ecological citizenship.

2.4 EDUCATIONAL PRODUCTS: RELEVANCE TO ENVIRONMENTAL EDUCATION

The professional master's degrees in Teaching, according to CAPES guidelines (2019), presuppose the articulation between research, teaching practice and development of educational products. Such products – such as didactic guides, didactic sequences, adapted protocols, and field materials – constitute educational technologies that dialogue with real problems in schools and promote the transposition of academic knowledge into concrete pedagogical practices (Gonçalves et al., 2019; Rosa; Batista, 2021).

Within the scope of ProfCiamb, this conception is intensified, since the program is

intertwined. This perspective questions the disciplinary fragmentation inherited from modern rationality and proposes integrative approaches capable of dealing with the indeterminacy, uncertainty, and plurality of knowledge implied in the understanding of socio-environmental systems. This foundation sustains the interdisciplinary approach mobilized in the dissertation that gave rise to this research, offering the conceptual framework to interpret the watershed as a "living fabric", in which natural and social processes are articulated. However, the development of this debate would imply resuming ontological and epistemological discussions of greater scope, involving the critique of instrumental rationality, transdisciplinarity and the multiplicity of analytical perspectives, which goes beyond the methodological and didactic objectives of this article. In view of this, a more pragmatic approach is chosen, centered on the development and validation of the didactic guide, without prejudice to the recognition of the epistemology of environmental complexity as one of its structuring theoretical foundations.

based on the dialogue between environmental sciences, education and territorial management. The development of educational products aimed at understanding water resources thus simultaneously promotes continuing teacher training, pedagogical innovation and approximation of the school with the territory. In this sense, a didactic guide based on a Rapid Assessment Protocol is an instrument consistent with the guidelines of Critical Environmental Education (Brasil, 1999; Brasil, 2012a), dialoguing with the need to strengthen socio-environmental reading, student participation and interdisciplinary analysis of urban rivers. In this way, the educational product presented/analyzed here is, in addition to a didactic resource, a scientific-pedagogical artifact that integrates certain theoretical foundations, a participatory methodology and critical socio-environmental training.

3 METHODOLOGY

The methodology of this study is articulated with three interdependent dimensions: (i) the methodological logic that guides the elaboration of this article, based on a qualitative, analytical and documentary approach; (ii) the methodology of the empirical research that gave rise to the educational product and the set of data and analyses used here; and (iii) the specific methodological path of adaptation of the Rapid Assessment Protocol (PAR) and the subsequent elaboration of the didactic guide. This structure, in a triple complementary layer, simultaneously comprises the scientific, pedagogical and technical process that sustains the development of the educational program presented in this work.

3.1 METHODOLOGICAL DIMENSION OF THE ARTICLE

Epistemologically, this article uses a qualitative and interpretative approach, appropriate to the analysis of complex socio-environmental and educational phenomena that involve meanings, practices and cultural mediations (Minayo, 2001). The theoretical-analytical approach favors the articulation between water resources management, critical environmental education and environmental diagnosis methodologies, allowing the interpretation of the production of the didactic guide as a pedagogical, scientific and technological artifact.

The analytical corpus used stems from the dissertation developed within the scope of the Graduate Program in the National Network for the Teaching of Environmental Sciences (ProfCiamb-Associada UEM) – by Helaine de Oliveira Menezes entitled "Use of Didactic Guide with Rapid Assessment Protocol in the Diagnosis of Urban Water Systems" (2023) –, including: field records, photographs, files of the protocol applied by the students, workshop transcripts and questionnaires, in addition to the educational product itself. The analysis of

this material was guided by the principles of content analysis (Bardin, 2016; Silva; Fossá, 2015), especially to identify categories that emerge from the students' perception of the investigated river and the use of the PAR. By structuring the article under this logic, this methodology allowed us to reconstruct the process of elaboration of the guide, to discuss its theoretical-pedagogical robustness, and to situate it in the context of river evaluation methodologies and Critical Environmental Education.

3.2 METHODOLOGICAL DIMENSION OF THE ORIGIN RESEARCH

The empirical research that underlies this article adopts a qualitative and investigative approach, articulating field procedures, didactic activities and data analysis instruments of a descriptive and interpretative nature (Gil, 2008; Kauark; Mornings; Medeiros, 2010). The study was developed with elementary school students from a state school, involving three main stages: (1) introductory workshop and environmental awareness; (2) application of the Rapid Assessment Protocol in the analyzed stream; and (3) systematization and discussion of the results obtained.

Different instruments were used, ensuring triangulation and analytical depth (Fontana, 2018; Fontana and Rosa, 2021): (i) diagnostic questionnaire, aimed at capturing students' previous conceptions about water resources and environmental impacts; (ii) direct observation during fieldwork; (iii) structured PAR forms, filled out by the students; (iv) photographic records for visual validation of the observed environmental conditions. From these materials, a database was organized that later subsidized the construction and validation of the didactic guide.

The data from the questionnaires and workshops were analyzed through Content Analysis (Gaspi; Maron; Magalhães Júnior, 2021; Bardin, 2016), allowing the identification of categories such as perception of the environment, understanding of impacts, relationship with the territory and learning resulting from the application of the PAR. The protocol data were systematized according to criteria previously defined in the technical-scientific literature on rapid assessment (Callisto et al., 2002; Guimarães; Rodrigues; Malafaia, 2012), applying environmental scores and classifications that make up the final diagnosis. This process generated the empirical bases that guided both the theoretical discussion and the elaboration of the educational product.

3.3 METHODOLOGICAL DIMENSION OF THE ADAPTATION OF THE RAPID ASSESSMENT PROTOCOL (PAR)

The adaptation of the PAR was a central methodological step in the research and development of the didactic guide. The starting point was the protocol proposed by Callisto et al. (2002), widely used in teaching research and river monitoring because it integrates agility, rigor and applicability. However, the school use of this tool requires methodological adjustments, as demonstrated by authors who have worked with similar adaptations for teaching (Guimarães; Rodrigues; Malafaia, 2012; Pontini; Coelho, 2019; Machado, 2019; Amorim, 2021). Thus, the process followed four stages: (a) review of the parameters; (b) adequacy of the scoring scale; (c) field testing and photographic record; and (d) pedagogical validation.

In view of this, a critical analysis of the parameters of the existing protocols was carried out, including those applied in different urban and peri-urban basins (Anjos; Vasconcelos; Negreiros, 2021; Oliveira; Veloso; Rossoni, 2021; Lima et al., 2017; Rangel; Botelho, 2017), with the objective of reorganizing the criteria into observation categories understandable to students, preserving scientific rigor and, simultaneously, adopting a pedagogical language compatible with the school context (a). Considering that the literature points out that excessively complex scales tend to compromise student comprehension and the didactic functionality of the instruments (Machado, 2019), we proceeded to simplify the descriptors and reorganize the score levels, seeking greater intuitiveness without breaking the methodological coherence with consolidated studies in the area (b). The experimental application of the protocol in the Água dos Peões stream was a fundamental step in the process, as it made it possible to identify ambiguities, overlaps, and interpretative gaps in the parameters, in line with methodological approaches that advocate the testing of protocols in real field conditions as an instrumental refinement strategy (Silva et al., 2019; Pontini; Coelho, 2019; Rodrigues, 2017) (c). In this context, the students carried out the full application of the protocol and participated in a workshop oriented to discuss the results, a procedure aligned with the formative experiences described by Machado (2019) and Amorim (2021), which allowed them to confront the perceptions built in the educational process with the technical data obtained (d). From this integrated analysis, a version adapted to the school context was consolidated, characterized by scientific consistency, visual clarity and accessible language, constituting the central methodological basis of the didactic guide developed.

3.4 METHODOLOGY FOR THE CONSTRUCTION OF THE DIDACTIC GUIDE

The preparation of the didactic guide was guided by principles that prioritize clarity, replicability, and pedagogical coherence (Gonçalves et al., 2019; Rosa; Batista, 2021), involving the integrated organization of its conceptual, visual, and methodological contents. In this process, the selection and articulation of central concepts related to water resources, environmental impacts, relevant legislation and EAC was carried out, in order to dialogue with the adapted PAR. The structuring of the material sought to ensure its self-sufficiency, allowing teachers to use it autonomously, without the need for prior external training. At the same time, the parameters of the PAR were translated pedagogically through contextualized explanations, photographic records, practical examples, and accessible descriptors, in line with studies that highlight the relevance of visual resources and teaching materials in the mediation of complex ecological processes (Machado, 2019; Amorim, 2021).

The construction of the guide was organized in three articulated movements – theoretical awareness, field activity and reflective analysis –, a structure that favors the integration between knowledge, empirical experience and critical problematization, according to the assumptions of the EAC (Guimarães, 2013; Layrargues; Lima, 2014). The validation of the guide occurred from the analysis of the results of the pedagogical workshops and the questionnaires applied, ensuring coherence between the proposed objectives, the methodological procedures adopted and the formative potential of the educational product. This stage gave consistency to the material and was aligned with the guiding principles of professional master's degrees, especially with regard to the articulation between academic production, pedagogical applicability, and social relevance (CAPES, 2019).

3.5 SUMMARY OF THE METHODOLOGICAL APPROACH

The methodology adopted articulates empirical investigation, critical literature review, methodological adaptation and technical-pedagogical development. The integration of these dimensions ensures that the didactic guide presented in this article is simultaneously: (i) scientifically based; (ii) validated in a real teaching context; (iii) conformed within an interdisciplinary perspective[9]; (iv) consistent with contemporary methodologies for river

[9] The relationship between interdisciplinarity and the adaptation of the PAR is treated in a synthetic way in this article, since its deepening would require recovering, with greater amplitude, the epistemological discussion developed in the dissertation that gave rise to the research. Even so, it is important to highlight that the adaptation of the PAR itself constituted an interdisciplinary exercise, by articulating contributions from river ecology, physical geography, school cartography and Critical Environmental Education, mobilized in the reconstruction of the parameters and in the redefinition of its pedagogical uses. This process implied sensitive methodological decisions, involving the didactic transposition of indicators originally conceived for specialists (Callisto et al., 2002), the problematization of the limits and potentialities of simplified assessments in educational contexts (Guimarães; Rodrigues; Malafaia, 2012) and the need to make them intelligible to students through adequate pedagogical translations (Pontini; Coelho, 2019). The detailed inclusion of this debate would

diagnosis; and (v) aligned with the principles of Critical Environmental Education and the guidelines of professional master's degrees in teaching.

4 THE ORIGIN RESEARCH

The research on which this article is based was developed within the scope of ProfCiamb-Associada UEM (Menezes, 2023) and was structured as a qualitative investigation, of a formative and participatory nature, oriented both (i) to the construction of a socio-environmental diagnosis of an urban water body and (ii) to the elaboration of a didactic guide aimed at Basic Education. Since its conception, the study has adopted an integrated perspective between education, territory and water resources, understanding the investigative process as a space for the production of knowledge and training of the subjects involved. This orientation implied the development of methodological instruments capable of articulating technical rigor, student participation and pedagogical applicability, in line with references that defend integrated approaches in the field of water management and EE (Brasil, 1997; Callisto et al., 2002; Guimarães, 2013).

4.1 OBJECTIVES AND LOCUS OF THE RESEARCH

The study aimed to understand how the pedagogical application of a PAR – adapted for educational purposes – could foster critical learning about the degradation of urban water resources and contribute to the construction of a replicable and grounded educational product. As specific objectives, it was sought: (i) to analyze the students' initial perception of rivers, environmental impacts and water management; (ii) develop and test a PAR adapted to the school context; (iii) to assess the students' understanding after fieldwork; and (iv) systematize the process in a didactic guide consistent with the EAC guidelines (Menezes, 2023).

The research was carried out in a state school in Janiópolis/PR (PPP, 2022), [10]a small city located in a territory marked by disorderly urban expansion, waterproofing processes,

shift the focus of the article, centered on the educational product and its validation, to a broader discussion on the epistemology of participatory environmental assessment. This elaboration is extensively developed in the dissertation – see (Menezes, 2023) –, in which it is demonstrated how the PAR adaptation methodology, by integrating different fields of knowledge around the socio-environmental reading of urban rivers, constituted itself as an interdisciplinary practice in itself.

[10] The role of the school as a territorial institution – understood as a structuring agent of the relations between subjects, territory, culture and public policies – is addressed in this article in a synthetic way. However, in the theoretical perspective that underlies the dissertation (Menezes, 2023), the school is understood as a social actor inserted in the processes of production of the territory, capable of mediating local and institutional knowledge, articulating scales of action and bringing communities, public management and environmental policies closer together. In this condition, the school participates in the construction of collective practices of reading and socio-environmental intervention, contributing to the formation of critical subjects and to the strengthening of participatory dynamics at the local level (Tucci, 2005; 2008; Cirilo, 2019). The in-depth

and diffuse pressures on watercourses (Dangui, 2022; IBGE, 2022; Ipardes, 2025). The environment selected for the application/testing of the PAR was the Água dos Peões stream[11], an urban water body that expresses the tensions between human occupation, territorial planning and environmental quality – characteristics that make it particularly significant for didactic-analytical purposes (Tucci, 2008; Nova; Tenório, 2019).

4.2 METHODOLOGICAL PATH OF THE RESEARCH

The research was organized in three articulated movements, conceived as dialogical stages between theory, practice and critical reflection: (a) initial diagnosis and environmental awareness; (b) application of the adapted pair in the field; (c) systematization and collective analysis. Thus, the students participated in an introductory workshop in which fundamental concepts of water resources, anthropic impacts and integrated water management were discussed (Brasil, 2000; Tundisi, 2014). The activity sought to identify previous perceptions and stimulate the investigative look, favoring the understanding of water as a common good and structuring element of the territory.

Then, the students carried out fieldwork in the Água dos Peões stream, applying the PAR in its preliminary version. This stage was crucial to observe (i) the environmental conditions of the river and (ii) the way in which the students interpreted the parameters, understood the environment and articulated evidence – a process widely discussed in research that evaluates the educational use of environmental protocols (Guimarães; Rodrigues; Malafaia, 2012; Pontini; Coelho, 2019; Machado, 2019; Amorim, 2021). Finally, the data produced in the field were analyzed in a subsequent workshop, in which the students compared observations, discussed interpretative divergences, and related visual, ecological, and social evidence. This dialogical dimension consolidated the critical understanding of the

development of this argument would imply analyzing the school as a socio-political space, with emphasis on its interfaces with public management and territorial planning instruments, which goes beyond the focus of this article, centered on the didactic guide. The option adopted, therefore, stems from an editorial and analytical choice, without prejudice to the recognition of the centrality of the school as a territorial institution in the broader approach to research.

[11] The articulation between the results produced by the students and municipal management, especially with regard to the Janiópolis Master Plan (2022), is little addressed in this article. In general, the socio-environmental diagnosis elaborated from the application of the PAR subsidized reflections on the use and occupation of the soil, the preservation of permanent protection areas and the environmental conditions of the Água dos Peões stream, aspects related to urban planning instruments and the management of water resources at the local level. The systematization of this information in a technical-pedagogical report made it possible to establish a channel of dialogue between the school and the public authorities, by making visible, in an organized way, empirical evidence on the environmental state of the watercourse. However, the deepening of this articulation, involving the analysis of decision-making processes, planning instruments and related public policies, goes beyond the objectives of this article, which privileges the pedagogical-methodological dimension of the didactic guide. For broader discussions on watershed management, urban planning, and water resources policies, see Brasil (1997), Tucci (2005; 2008), and Prado, Johnsson, and Marques (2017).

territory and revealed the pedagogical power of the PAR as an instrument that produces socio-environmental reading.

4.3 CONSTRUCTION AND TESTING OF THE ADAPTED PAIR

The adapted PAR emerged as an essential intermediate product of the research, having been developed from an analytical process that articulated specialized literature, experimentation and pedagogical validation. Although the previous methodological section described the technical procedures for adaptation, here we highlight the academic foundations that justified this movement and the empirical evidence produced during its testing. The initial version was built based on the protocol of Callisto et al. (2002), a consolidated reference in the evaluation of lotic ecosystems. In addition, adaptations employed in school and urban contexts by authors such as: (a) Guimarães, Rodrigues and Malafaia (2012), in studies focused on elementary education; (b) Anjos, Vasconcelos, and Negreiros (2021) and Oliveira, Veloso, and Rossoni (2021), which analyze heavily anthropized rivers; (c) Pontini and Coelho (2019) and Machado (2019), who highlight elements of morphological and anthropic interpretation; (d) Silva et al. (2019) and Rangel and Botelho (2017), who discuss sensitive parameters for urban environments; (e) Amorim (2021), who emphasizes pedagogical aspects of environmental protocols. It is not by chance that the convergence of these studies allowed the definition of a set of parameters accessible to students, but scientifically valid, ensuring the dual pedagogical and technical function of the instrument.

The application of the protocol in the Água dos Peões stream revealed central environmental aspects – such as the presence of residues, changes in the flow, erosion of banks, reduced riparian vegetation and signs of siltation – which are in line with the literature on water degradation in urban areas (Tucci, 2008; Montagner; Vidal; Acayaba, 2017). From a pedagogical point of view, the testing showed that the students were able to: (i) distinguish physical, biological and anthropic parameters; (ii) relate observed impacts to social practices; (iii) and interpret the river as part of a larger system of urban management and planning. These results confirmed the adequacy of the adapted PAR and provided direct support for the elaboration of the didactic guide[12].

[12] In addition to the pedagogical results resulting from the application of the PAR – fundamental for the construction and validation of the didactic guide –, the research produced material results that enabled the elaboration of a socio-environmental diagnosis of the Água dos Peões stream which, in turn, was able to evidence the spatial heterogeneity of the ecological conditions along the urban stretch analyzed. The evaluation carried out at six sampling points, distributed from upstream to downstream, revealed a gradient of environmental conservation directly associated with the forms of use and occupation of the banks, anthropogenic interventions in the bed and the presence of degradative processes. The points located at the ends of the urban stretch, especially P1 and P6, presented the highest overall scores, being classified as

4.4 FIELD PROCESS AND PEDAGOGICAL WORKSHOPS

The construction of the educational product was influenced by the field process and the workshops, which functioned as moments of experimentation, reflection and collective validation. The fieldwork was constituted as an experience of "incarnate reading of the territory", in which the environment, in addition to being an object of analysis, became a living space of interaction between subjects, society and nature – a perspective consistent with the EAC (Guimarães, 2013; Leff, 2003; Roos; Becker, 2012). During the workshops, it was observed that there was a significant development of argumentation skills, ecological perception and interpretation of evidence. The collective discussion of the PAR forms[13] allowed the students to confront their analyses, identify contradictions and construct explanations anchored in environmental indicators. This dynamic reproduces what the literature calls "ecological pedagogical mediation", in which field activity acts as a catalyst for processes of awareness and critical reading (Maciel; Sousa, 2022; Raupp; Fransciscato; Lima, 2019). These experiences formed the epistemological and pedagogical core of the

"natural", due to the greater vegetation cover, lower intensity of anthropogenic changes, absence of odors and oiliness and better visual conditions of the water. On the other hand, the intermediate points (P2, P3, P4 and P5) were classified as "altered", reflecting the intensification of urbanization, the reduction of riparian vegetation, the occurrence of erosive processes and siltation, the recurrent presence of solid waste, changes in the channel of the watercourse and less diversity of visible organisms. The integrated analysis of the macroscopic parameters also showed that, although the direct presence of domestic or industrial sewage discharge at all points was not found, the signs of anthropogenic pressure are expressed in a diffuse way, especially through the occupation of the banks, the channeling of stretches, inadequate soil management and the degradation of the Permanent Preservation Area. In this sense, the PAR proved to be effective in characterizing the Água dos Peões stream as an urban water system subjected to processes of progressive environmental degradation, while at the same time it made it possible to identify segments with greater potential for conservation and recovery. These results allowed us to characterize the stream as an urban water system subjected to diffuse and progressive anthropogenic pressures, while indicating segments with greater potential for conservation and environmental recovery. The set of this information was condensed into a technical-pedagogical report prepared collectively by the student participating in the research, in which the data obtained in the field, photographic records, schematic maps, interpretations of the evaluated parameters and recommendations of an educational and environmental nature were systematized. This report was formally forwarded to the municipal government, configuring itself as another product of the research and as an instrument of dialogue between school, community and public management, by materializing the results of the diagnosis and increasing the visibility of the socio-environmental conditions of the Água dos Peões stream at the local level.

[13] The Rapid Assessment Protocol, after the adaptation process developed in this research, became a socio-environmental diagnostic instrument with a dual purpose – pedagogical and technical – organized in such a way as to allow its application in school contexts without prejudice to scientific rigor. The adapted PAR was structured based on a set of macroscopic parameters related to the physical conditions of the watercourse, the use and occupation of the banks, the integrity of the riparian vegetation, the presence of solid waste, signs of erosive processes and siltation, as well as visual and olfactory signs associated with water quality. Each parameter was accompanied by objective descriptors, illustrative examples, and reference photographic records, organized into simplified and progressive scoring scales, which enable the identification of different levels of environmental change. The reorganization of the categories and the redefinition of the scales aimed to favor the readability of the instrument for students, maintaining methodological coherence with protocols consolidated in the literature. The adapted PAR provides for application at previously defined sampling points, systematic recording of observations in standardized forms and subsequent integrated analysis of the results, allowing the general classification of the evaluated stretch and the comparison between different segments of the watercourse. By articulating direct observation, data systematization, and collective interpretation, the protocol assumes a mediating role in the educational process, operating as a support for the critical reading of the territory and the understanding of the relationships between socio-spatial dynamics and the degradation of urban water systems – see the PAR in its final version in Menezes, 2023.

didactic guide, ensuring that its elaboration represents an organic movement based on educational praxis and the materiality of the territory.

5 DEVELOPMENT OF THE DIDACTIC GUIDE

The didactic guide was the main product of this investigation, the result of an elaboration process related to the articulation between theory, field, participatory observation and critical reflection. Its development expresses the understanding that EAC demands instruments that promote rigorous socio-environmental readings of the territory, sensitive and politically situated (Guimarães, 2013; Layrargues; Lima, 2014). In this way, the guide sought to overcome traditional prescriptive approaches, offering material that invites students and teachers to understand the complexity of urban rivers, recognizing them as living expressions of historical, political and ecological processes.

The elaboration of the guide, therefore, ended an investigative path that involved methodological adaptation, practical experimentation, collective analysis and theoretical support. Its form and content respond to what the research itself revealed about the potentialities and limits of teaching about water resources in the school context, dialoguing with the empirical findings recorded in the dissertation (Menezes, 2023) and with the literature that discusses both PARs[14] and field methodologies in EAC[15].

5.1 PRINCIPLES OF CONSTRUCTION OF THE GUIDE: LANGUAGE, REPLICABILITY AND VISUALITY

The construction of the guide was guided by three complementary didactic and epistemological principles, defined based on the requirements of the public school, the characteristics of the students involved and the theoretical assumptions of the EAC: (a) dialogical and accessible language without loss of conceptual density; (b) replicability as a public commitment; and (c) visuality as cognitive and affective mediation. In view of this, it is noted that the language of the guide was conceived in such a way as to balance communicative clarity and analytical rigor. The central concern was to avoid both hermetic technicality and excessive simplification – common vices in teaching materials on environmental topics. This methodological choice stemmed from the understanding that forming critical readers of their territory requires that concepts such as *water resources*, *anthropic impacts*, *integrated management*, and *socio-environmental justice* be presented with precision, but mediated by examples, images, and analyses connected to the students'

[14] Callisto et al., 2002; Pontini; Coelho, 2019; Angels; Vasconcelos; Negreiros, 2021.
[15] Machado, 2019; Amorim, 2021; Maciel; Sousa, 2022.

daily lives (Brasil, 1997; Tundisi, 2014). Language, therefore, informs, tensions, provokes and instigates.

The guide was planned to be replicable in different schools, preserving its methodological coherence independently of the original researcher. This characteristic meets the guidelines of professional master's degrees, which demand educational products capable of having an expanded impact on the reality of basic education (CAPES, 2019). Replicability, in addition to the possibility of use, also involved teacher autonomy, procedural clarity and contextual flexibility, allowing the PAR to be applied in urban and peri-urban rivers or even in rural micro-basins.

The use of photographs, schemes, and visual records – many of them produced by the students themselves during fieldwork – derives from the conception that learning in EE is strengthened when observation is guided, structured, and contextualized (Machado, 2019; Amorim, 2021). Images of siltation, erosion, the presence of residues, changes in the flow and degradation of the riparian forest functioned, in the guide, as perceptual anchors that allowed us to understand abstract phenomena through the materiality of the territory. Visuality, in this sense, rather than a simply illustrative resource, becomes a pedagogical device for critical reading.

5.2 INTERNAL STRUCTURE OF THE DIDACTIC GUIDE

The organization of the guide established a pedagogical flow aligned with the logic of the Teaching of Environmental Sciences and with the EAC. The structure is simultaneously progressive and circular: each section prepares the next and all return to the central idea that to understand a river is to understand a territory, a society and its contradictions; Thus, the guide was divided into: (1) Conceptual introduction; (2) field orientations; (3) the adapted PAR; and (4) synthesis and reflection activities

The first section translates into didactic language the theoretical basis of the dissertation: ecological functions of rivers, impacts of urbanization, anthropogenic pressures and principles of the National Water Resources Policy (Brasil, 1997; Brasil, 2000). The narrative seeks to show that the process of degradation is not natural; in fact, it is historically produced, in line with the reflections of Tucci (2008) and Nova and Tenório (2019).

In the field orientations, methodological, ethical and operational care are presented, articulating geographical, ecological and safety procedures. This section values the investigative dimension of the field trip, reinforcing that to observe is to see/see and, above all, to interpret and situate (Raupp; Fransciscato; Lima, 2019).

The core of the guide is the PAR adapted, reorganized and explained step by step. The arrangement of the parameters on clear cards and accompanied by images facilitated the autonomy of the students, allowing the interpretation of substrate, flow, oiliness, establishment of margins and residues based on criteria inspired by the specialized literature (Callisto et al., 2002; Pontini; Coelho, 2019). Finally, the last section proposes exercises that stimulate critical and analytical thinking and the articulation of empirical evidence with public policies and social practices. In this part of the guide, Freire's logic of critical reading of the world finds its materiality in the analysis of an urban river, bringing the theory closer to praxis (Guimarães, 2013).

5.3 PARAMETERS ADAPTED FROM THE PAIR: SUBSTRATE, OILINESS, MARGINS, RESIDUES AND FLOW

The adaptation of the PAR parameters was a central stage of the research, as it enabled the conversion of a technical-scientific instrument into an accessible pedagogical resource, preserving its analytical and interpretative capacity. This process was guided by the theoretical contributions mobilized in the dissertation, as well as by the empirical data produced in the Água dos Peões stream, resulting in the reformulation of the following parameters: (a) substrate; (b) oiliness and superficial films; (c) margins and riparian vegetation; (d) solid waste; and (e) flow and obstructions. The redefinition of these categories sought to ensure legibility to the instrument in the school context, articulating scientific concepts, direct observation and critical interpretation of the socio-environmental reality.

The parameter referring to the type of bottom – sandy, muddy, rocky or mixed – was maintained as a structuring element of the evaluation, due to its ecological relevance for the understanding of erosion processes, siltation and dynamics of the benthic community (Callisto et al., 2002). Its adaptation involved the conceptual translation of the technical descriptors and the incorporation of comparative images, facilitating visual identification in the field. In an articulated way, the analysis of the presence of oiliness and superficial films began to be mediated by examples from everyday life and by photographic records of the stream itself, favoring the understanding of the relationships between urban runoff, effluent discharge and anthropogenic pressures, as indicated in the specialized literature (Montagner; Vidal; Acayaba, 2017).

The parameters related to the margins and riparian vegetation were expanded to include aspects such as stability, slope, occurrence of erosive processes and degree of vegetation cover, recognizing the sensitivity of these variables in the characterization of environmental degradation in urban areas (Rangel; Botelho, 2017; Pontini; Coelho, 2019).

With regard to solid waste, the classification adopted began to distinguish between floating materials, deposition in the bed, and accumulation on the banks, enabling the identification of spatial patterns and the inference of probable origins, in line with approaches proposed by Anjos, Vasconcelos, and Negreiros (2021). The interpretation of the flow incorporated the observation of visible changes in water velocity, the presence of physical barriers and interventions associated with urbanization, fundamental elements for understanding the local water dynamics and their links with soil sealing processes (Oliveira; Veloso; Rossoni, 2021). Together, the adapted parameters were anchored in empirical evidence produced in the field and later discussed with the students, strengthening the articulation between systematic observation, critical interpretation and socio-environmental learning.

5.4 VALIDATION THE DIDACTIC GUIDE WITH STUDENTS

The validation of the guide was configured as a process of shared critical reading, developed in the context of the analysis workshops, in which the students used the material to interpret the observations made in the field, review records produced and problematize divergences identified throughout the application of the PAR. This dynamic favored the construction of a dialogical space in which the guide operated as a mediator of the training process, in line with the assumptions of the EAC.

During this process, the following were observed: (a) the progressive appropriation of the technical language associated with environmental assessment, articulated with the capacity for contextual analysis of the observed phenomena; (b) the establishment of consistent relationships between the parameters evaluated and the social practices that affect the watercourse, indicating a broader socio-environmental understanding; (c) the strengthening of the investigative protagonism of the students, who began to recognize themselves as subjects who produced knowledge about the territory in which they are inserted; and (d) the coherence between the structure of the instrument and its application in the field, showing that the guide sustains consistent investigative practices that can be replicated in other school contexts. The validation of the guide, understood in this way, dialogues with analyses by Maciel and Sousa (2022) and Raupp, Franciscato and Lima (2019), when they indicate that educational products built from situated practices tend to constitute powerful and formative devices for the promotion of critical reflection and socio-environmental learning.

6 RESULTS AND DISCUSSIONS

The results of this research process show the formative potential of the didactic guide developed, as well as its effectiveness as an instrument of participatory environmental diagnosis. Such findings should be interpreted in the light of Critical Environmental Education, which understands the educational process as a social practice of producing meanings about the territory and the relationships that are established in it (Guimarães, 2013; Layrargues; Lima, 2014). In this context, the results indicate qualitative transformations in the ways in which students began to read, interpret and critically position themselves in the face of the socio-environmental conditions of the Água dos Peões stream, expanding their capacity for understanding and symbolic intervention in the local reality.

6.1 LEARNING: CRITICAL READING OF THE TERRITORY AND ECOLOGICAL UNDERSTANDING

In terms of learning, students have developed more refined analytical skills on the degradation processes of urban rivers. Initially, many participants had diffuse perceptions about water quality and the factors that contribute to its deterioration – a perception similar to that recorded in studies such as those by Maciel and Sousa (2022) and Santos and Corrêa (2020). However, after the application of the didactic guide and the completion of the field activities, a set of specific learnings emerged. First, students began to identify phenomena such as siltation, erosion of the banks, presence of solid waste, alteration of the flow and signs of contamination with greater precision, articulating these elements with urban dynamics and sanitation policies (Brasil, 2020b; Tucci, 2008). In addition, they recognized the importance of Permanent Preservation Areas (PPAs) and the ecosystem services provided by riparian vegetation, bringing their reading of the territory closer to the analyses found in Pontini and Coelho (2019) and Miranda, Botezelli, and Pamplin (2021).

Another significant learning refers to socio-environmental awareness[16]. The students' reports and records indicate that they understood environmental degradation as a consequence of human and political choices, management failures and historically

[16] The field narratives produced throughout the research – which include students' speeches, interpretative conflicts that emerged during the application of the PAR, episodes that tensioned initial readings of the stream and records built in the observation process itself – are not developed in detail here, in view of the need for objectivity and conciseness that guides the article. Even so, it is important to note that such narratives constituted a central element of the research, as it revealed how the empirical experience in the watershed of the Água dos Peões stream mobilized disputes of meaning, revisions of perception and interpretative reconfigurations about the territory. The dissertation deepens these experiences, demonstrating how direct contact with the environment, mediated by the guide and the adapted PAR, expanded the students' analytical repertoire and favored the construction of meaningful learning, as indicated by Santos and Corrêa (2020) and Amorim (2021). In this text, the identification of general interpretative trends and consolidated results is privileged, to the detriment of the reproduction of specific narratives, in order to preserve the analytical focus on the educational product and its validation.

consolidated social practices – a perspective emphasized by Tucci (2005) and Tundisi (2014). In summary, the guide mediated learning about river ecology and, at the same time, contributed to a critical reading of the relationship between society and nature.

6.2 EFFECTIVENESS OF THE GUIDE IN ENVIRONMENTAL DIAGNOSIS: ACCURACY, AUTONOMY AND INTERPRETATION

The application of the guide was effective as a didactic-scientific tool. The students demonstrated the ability to correctly fill in the parameters of the adapted PAR, evaluating substrate, margins, flow, oiliness and presence of residues with coherence and precision. The comparison between the evaluations made by the participants and those recorded by the researcher indicates significant convergence, which reveals that the material was able to properly translate technical concepts without compromising their analytical quality, as recommended by Callisto et al. (2002), Anjos, Vasconcelos, and Negreiros (2021), and Oliveira, Veloso, and Rossoni (2021).

The autonomy of the students during the diagnosis is another indicator of the effectiveness of the guide. Unlike excessively technical protocols, whose application requires specialized training, the adapted material made it possible for groups of students to carry out direct observations, debates and internal deliberations on the scoring of the parameters. This autonomy is consistent with the logic of educational products proposed in the professional master's degrees (CAPES, 2019) and reinforces the importance of pedagogical instruments that democratize access to ecological knowledge. In addition, the results also indicate that the guide favored complex discussions on the causes and consequences of degradation, articulating the empirical diagnosis with broader socio-environmental interpretations, as suggested by the studies consulted in our "theoretical framework" – section two –, and certain documents that currently discipline/regulate Environmental Education in Brazil and Paraná[17].

[17] The articulation of Menezes' (2023) research with the National Common Curricular Base (Brasil, 2018), with the Curriculum of the State Network of Paraná – CREP (2018; 2021) and with the guiding documents of EE in Brazil is not developed extensively in this article, since these curricular and normative references constitute a broad set of documents, whose analysis would require a specific section. However, it should be noted that the conception, structure, and application of the didactic guide dialogue with the principles and competencies provided for in these milestones, especially with regard to argumentation, scientific investigation, socio-environmental responsibility, and the critical reading of the territory (BNCC, 2018). In the dissertation, it is demonstrated how such competencies are materialized in pedagogical practice through the diagnosis of urban rivers, articulating contents of Natural Sciences, Geography and Critical Environmental Education in an interdisciplinary perspective. In this article, we choose to privilege the presentation of the guide as an educational product and the description of its methodological dynamics.

6.3 COMPARISON WITH OTHER MATERIALS AND APPROACHES FOUND IN THE LITERATURE

The comparative analysis allows us to observe that the guide constructed presents singularities that differentiate it from other didactic materials and protocols presented in the literature. First, materials such as those by Machado (2019) and Amorim (2021) emphasize the didactic dimension of adapted PARs; however, they maintain structures closer to the original technical models. The guide produced by this research, in turn, presents greater integration between concept, visuality and socio-environmental contextualization, which enhances its critical function.

In addition, while traditional protocols – such as those applied in Pontini and Coelho (2019), Lima et al. (2017) and Silva et al. (2019) – use parameters that are difficult to translate into the school environment, the guide of this research simplifies, without impoverishing, the language and evaluation criteria. This dialogical simplification is a relevant innovation for teaching practice, especially in public schools. Another significant difference lies in the reflective character of the guide: instead of being a solely evaluative instrument, it incorporates activities of synthesis, discussion and articulation with public policies, which do not exist in conventional environmental protocols. This characteristic brings it closer to what Guimarães (2013) identifies as the transformative praxis of EAC.

6.4 POTENTIAL FOR REPLICATION IN OTHER SCHOOLS AND MUNICIPALITIES

The analysis of the results allows us to affirm that the guide has high potential for replication and scalability. Its modular structure, accessible language, detailed visuality and methodological coherence allow it to be applied in different territorial realities – whether urban, peri-urban or rural – as long as there is a viable water body for observation. From an institutional point of view, the guide converges with the National Common Curricular Base (Brasil, 2018) and with the state Curricular Frameworks (Paraná, 2018), which emphasize competencies related to scientific research, understanding the territory, and sustainability. This curricular convergence strengthens its applicability in public school systems.

In the context of environmental management, the guide can serve as a complementary tool for participatory monitoring, expanding democratic mechanisms for monitoring water quality, as proposed by Tundisi (2014), Cirilo (2019) and the National Water Resources Policy (Brasil, 1997). Thus, in addition to its pedagogical value, the instrument has social and institutional utility. Finally, the engagement of the students and the autonomy demonstrated throughout the application of the protocol constitute evidence that the guide can foster continuous educational processes, not restricted to the punctual intervention of the research.

Replicability, therefore, is not only technical, but also political, as it stimulates the formation of critical subjects capable of acting and intervening in their communities.

7 INTERDISCIPLINARY CONTRIBUTIONS

The construction and application of the didactic guide show its interdisciplinary character and its ability to integrate knowledge from Education, Ecology, Geography and Environmental Policies. This interdisciplinarity, far from being a mere conceptual adornment, constitutes a structuring element of the educational product and constitutes one of the main scientific contributions of this research to the field of Teaching and Environmental Sciences.

7.1 INTERSECTIONS BETWEEN EDUCATION, ECOLOGY AND GEOGRAPHY: THE CRITICAL READING OF THE TERRITORY

The first interdisciplinary contribution is manifested in the way the guide articulates principles of Critical Environmental Education (Guimarães, 2013; Layrargues; Lima, 2014) with ecological and geographical foundations on the functioning of urban rivers. Such articulation allows students to recognize the environment as (i) a natural scenario and, above all, (ii) a geographical scenario historically produced and marked by socio-environmental conflicts – a perspective that dialogues with Tucci (2008) and Tundisi (2014).

In the field of ecology, the guide translates processes such as siltation, substrate quality, flow dynamics, and integrity of riparian zones into observable and measurable parameters. However, this translation is not reductionist: it incorporates historical, social and cultural dimensions associated with human occupation of the margins, approaching studies that understand water degradation as a synthesis of multiple urban pressures (Montagner; Vidal; Acayaba, 2017; Nova; Tenório, 2019).

From a geographical point of view, the analysis of the stream as part of a larger hydrographic basin – influenced by land use patterns, urban infrastructure and socio-spatial relations – allowed the students to operate with different scales, understanding the river as a key element of territorial organization, which is also mathematically relevant. This approach strengthens skills in landscape reading, cartographic interpretation, and recognition of geomorphological processes (Paraná, 2006/2013/2020; IAT, 2011), reaffirming the interdisciplinary character of the activity. In this way, the guide highlights what the literature points out as the foundation of environmental interdisciplinarity: the understanding of the territory as a unit of analysis in which natural and social processes are inextricably intertwined.

7.2 PUBLIC POLICIES FOR THE ENVIRONMENT AND EDUCATION: TRANSVERSALITY AND CRITICALITY

Interdisciplinarity is also materialized in the relationship between the content of the guide and the legal frameworks of Brazilian public policies. The National Policy on Water Resources (Brazil, 1997), the National Policy on Environmental Education (Brazil, 1999), Conama Resolution No. 357 (Brazil, 2005) and the National Common Curriculum Base (Brazil, 2018) converge in demanding educational processes that integrate technical knowledge, social participation, and research on local realities (Brazil, 2007). In view of this, the guide responds to these demands by proposing an investigative practice in which students carry out environmental diagnosis in a contextualized way.

At the interface between education and politics, the material favors the understanding that water management is a shared responsibility between the State, society, and the school – a view present in Cirilo (2019) and reaffirmed by studies on water governance (Tucci, 2005; Prado; Johnsson; Marques, 2017). It is not by chance that this articulation reinforces that the analysis of an urban river is, in addition to an ecological exercise, a practice of environmental citizenship that exposes inequalities, management omissions, and possibilities for social intervention. It is an interdisciplinary contribution useful for the critical training of students and potentially relevant for the dialogue between schools and environmental agencies.

From this perspective, the transversal aspects of the research that is the basis of this article can be understood as formative dimensions that cross the different curricular components and fields of knowledge, conferring pedagogical, evaluative and social unity to the practices developed, without depending exclusively on processes of epistemological integration between disciplines. Within this approach, EE assumes the role of a structuring transversal axis, by guiding the critical reading of the territory, the problematization of the relations between society and nature, and the formation of ethical dispositions aimed at socio-environmental responsibility. This dimension permeates field activities, the application of the PAR, the production of reports and the discussions held in the classroom, manifesting itself recurrently in the Sciences and Geography, as well as in the Portuguese Language, Mathematics, Art and Human Sciences, without being limited to a specific curricular component. The environment operates, in this way, as a cross-cutting theme capable of articulating values, educational purposes and formative meanings, in line with the guiding documents of EE in Brazil.

Another relevant cross-cutting aspect concerns citizenship education and social participation, since the research mobilizes reflections on the right to water, the public function of water bodies, municipal management and the production of diagnoses that dialogue with

the public power. These elements cross the different stages of the work, promoting the development of skills related to argumentation, collective responsibility and ethical positioning in the face of socio-environmental problems, regardless of the disciplinary area from which they are approached.

The scientific and institutional language also assumes a transversal character, as it permeates the production of field records, the organization of data, the preparation of the technical report and the socialization of the results. The use of formal language, the appropriation of textual genres typical of science and public management, and the construction of argumentative narratives cross the entire pedagogical process, articulating reading, writing, and communication practices in different areas.

Finally, the valorization of the lived territory is configured as a transversal dimension by promoting the recognition of the local space as a legitimate object of knowledge, reflection and intervention. This perspective crosses the curriculum by connecting school content to students' daily experiences, favoring the feeling of belonging, the critical reading of the place and the understanding of socio-environmental inequalities as historical and social constructions. In this way, the transversality of the research is expressed by the continuous circulation of values, problems and educational purposes – especially those related to the environment, citizenship, language and territory – that cross the different areas of knowledge.

7.3 THE DIDACTIC GUIDE AS AN INSTRUMENT OF ACTIVE INTERDISCIPLINARITY

The guide, in addition to being interdisciplinary in its foundation, operates as an instrument of active interdisciplinarity, allowing different areas to interpenetrate each other in pedagogical practice. This characteristic reflects a movement of rupture with the curricular fragmentation typical of basic education and with merely ecological, depoliticized or decontextualized approaches to the reality of urban rivers. In this sense, the material invites teachers of Science, Geography, Mathematics, Art and even Portuguese Language to work together, articulating empirical investigation, environmental interpretation and argumentative expression[18]. Interdisciplinarity emerges, in this way, as a concrete practice: students

[18] The study on which this article is based has the potential for broad interdisciplinary articulation, since the socio-environmental diagnosis of urban rivers, mediated by adapted PAR, mobilizes knowledge and practices from different fields of knowledge in an integrated and situated way. In the field of Natural Sciences, the protocol favors the understanding of ecological processes related to fluvial dynamics, environmental quality, biodiversity and anthropogenic impacts on aquatic ecosystems. In dialogue with Geography, the reading of the stream as a structuring element of the territory makes it possible to analyze the hydrographic basin as a spatial unit, articulating relief, land use and occupation, urbanization, water flows and scales of analysis. Critical Environmental Education operates as an integrating axis of this process, by guiding the interpretation of data beyond the technical description, incorporating ethical, political and formative dimensions that connect nature, society and social practices. The interface with Sociology and Political Science emerges in the analysis of socio-environmental inequalities, the relations between the State, community and public policies, as well as in the problematization of water governance, urban planning and social participation. Anthropology contributes by

observe ecological phenomena, situate them geographically, critically analyze them in the light of public policies and communicate their conclusions in a structured way – a process that echoes the reflections of Guimarães (2013) on a critical reading of the world. In addition, the guide fosters competencies that go beyond traditional disciplinary boundaries, such as systems thinking, multi-scale analysis, and integration of empirical evidence with theoretical frameworks. This approach is in line with the conception of interdisciplinarity as a "cognitive and political strategy" present in the studies of Riojas (2003), reaffirming that complex socio-environmental problems require equally complex instruments.

7.4 INTERDISCIPLINARITY AND POTENTIAL FOR SOCIAL TRANSFORMATION

Finally, the interdisciplinary character of the guide is also manifested in its potential for social transformation[19]. By promoting the critical analysis of the watershed and by bringing the school closer to the issues of municipal water management, the educational product contributes to the construction of subjects capable of understanding and intervening in their

allowing the understanding of perceptions, narratives, cultural practices and forms of symbolic appropriation of the river by the subjects, recognizing the watercourse as a lived and socially signified space. Mathematics is mobilized in the reading of scales, in the organization of data, in the comparison of scores and in the construction of quantitative syntheses that help environmental interpretation, without losing sight of its insertion in broader qualitative contexts. Art is integrated into the process through the photographic record of the points evaluated, the choice of framing, the visual composition and the aesthetic reading of the landscape, contributing to the development of the sensitive look and to the construction of visual narratives about the territory. The Portuguese language crosses the entire investigative path by structuring the production of technical reports, the argumentative organization of the results, the use of formal language and the appropriation of textual typologies typical of the scientific field and public management. Other areas, such as History, by contextualizing the processes of occupation and transformation of the territory, and Information Technology, in the treatment and organization of records, can also be incorporated in a transversal way. This articulation does not occur through the juxtaposition of contents: it is made effective through an organic correlation between knowledge, practices and languages, making the environmental diagnosis an interdisciplinary pedagogical device capable of integrating scientific reading, social analysis, cultural expression and critical training.

[19] The experiential dimension of interdisciplinarity, central to the research on which this article is based, is addressed here in a synthetic way, since its analytical development would require mobilizing theoretical references related to corporeality, environmental perception, the pedagogies of the sensible and the processes of subjectivation, which would significantly expand the scope between didactic methodology and critical training. In the dissertation, this dimension is expressed in the direct experience of students on the banks of the Água dos Peões stream, in episodes of estrangement, discomfort and recognition of the dynamics of degradation, as well as in the situated production of meanings about the territory, configuring an intrinsic interdisciplinary exercise that articulates ecology, geography, critical environmental education and sociopolitical reading of space. Such experiences constitute fundamental socio-environmental mediations of the educational process, as discussed by Guimarães (2013) and Layrargues and Lima (2014), as they favor the construction of interpretations that link empirical observation, critical reflection and ethical-political positioning. In an articulated way, the socio-environmental critique that structures the dissertation – oriented to the understanding of water inequalities, the social production of river degradation and the tensions between State, territory and community – is dealt with in this article only indirectly, in order to avoid shifting the discussion to a broader socio-political analysis. Its deepening would imply examining issues such as environmental injustice, poor sanitation, territorial vulnerabilities and conflicts over the use of water (Montagner; Vidal; Acayaba, 2017; Nova; Tenório, 2019), constitutive themes of the basic research that, however, exceed the purpose of this text, centered on the elaboration, adaptation and validation of the didactic guide as an educational product. In this way, the option adopted corresponds to an analytical delimitation without prejudice to the recognition that experiential interdisciplinarity and socio-environmental criticism constitute structuring foundations of research and its formative developments.

socio-environmental reality. This perspective breaks with the myth of neutrality of environmental content and positions the guide as a tool for strengthening democracy. If, as Guimarães (2013) argues, EAC is an emancipatory educational practice, then interdisciplinarity is a methodological option and, above all, a condition for the formation of situated, analytically and politically active/critical environmental awareness.

8 CONCLUSION

The present study sought to understand to what extent a didactic guide, developed from an adapted PAR, could contribute to the critical education of elementary school students and to the participatory diagnosis of urban rivers, taking the Água dos Peões stream as its locus, in the municipality of Janiópolis (PR). The question that guided the entire process – **how can a didactic guide based on an adapted PAR promote critical environmental learning and assist in reading the socio-ecological reality of urban rivers?** – was faced in an articulated way between theory, methodology and pedagogical practice, allowing for consistent responses, although necessarily provisional and situated.

When returning to the objectives outlined at the beginning of the investigation, it is observed that they were met/answered as the process of research and pedagogical intervention itself complexified the initial understanding of the problem. The first objective – to present the theoretical and methodological foundations that supported the elaboration of the guide – was contemplated through the critical integration between literature on urban water resources, Rapid Assessment Protocols and Critical Environmental Education. This articulation demonstrated that the guide is a didactic material and, together, an **epistemological artifact** built from conceptual choices that reaffirm the centrality of the critical reading of the territory and the active participation of students.

The second objective – to describe the process of construction and adaptation of the PAR – was achieved, revealing that the didactic transposition of the traditional parameters of the protocols required technical adjustments and pedagogical decisions based on principles of conceptual clarity, accessibility, ecological relevance and adequacy to the material conditions of the school. In this sense, the guide was consolidated as a **product** whose consistency derived from (i) the literature that supports it and (ii) the adherence between its parameters and the ecological and socio-territorial reality of the analyzed stream.

The third objective – to analyze the application and validation of the guide with the students – was met through the investigation of the learning mobilized during the workshops and fieldwork. The results showed that the guide expanded the students' ability to identify anthropogenic pressures, understand ecological dynamics, interpret environmental

evidence, and relate forms of urban occupation to patterns of water degradation. More than that, it stimulated critical questioning about the role of the community, the public power and the school itself in the conservation of urban rivers, evidencing its potential as an instrument of critical education aligned with the principles of EAC.

The fourth objective – to discuss the potential of the guide as an interdisciplinary educational product – was fully met. The structure of the material demonstrated articulations between knowledge from ecology, geography, chemistry, environmental policies and social sciences, bringing students closer to a more integrated and complex understanding of the phenomena analyzed. In addition, the guide proved to be able to promote the transition between reading the environment, critical analysis and reasoned argumentation, essential aspects for a citizen education committed to the democratic management of the commons, as recommended by the PNREH (Brazil, 1997) and SDG 6 (UN, 2015).

The results show, therefore, that the research problem was answered: **the didactic guide, when used as a structured methodological mediation, enabled students to carry out coherent environmental diagnoses, develop analytical and interpretative skills and recognize the socio-environmental conflicts that cross urban** rivers. In addition, it allowed students to approach the territory in a critical way, providing elements for them to understand the political, ecological and social character of water management in their municipality.

Regarding the relevance of the study, its potential for educational and public impact is highlighted. In small municipalities, such as Janiópolis (PR), where environmental monitoring structures are scarce and community participation is historically limited, pedagogical tools such as this guide can represent important catalysts for training processes and social mobilization. The guide offers a tool that is **simple to use, low cost, highly replicable and scientifically based**, making it able to subsidize schools, educators, community projects and even municipal initiatives for the diagnosis and management of watersheds. However, like any applied study, this one has limits that must be recognized.

The use of the guide was tested in a specific context, with a limited number of students, in a short time frame and concentrated in a single microbasin. Although consistent, the results do not allow automatic generalizations, and the pedagogical nature of the adapted protocol does not replace deeper physicochemical analyses. In addition, the students' understanding, although significant, could be expanded through longitudinal monitoring processes, recurrence of activities over different school years, comparisons between schools and effective integration with given public policies. These limits, however, constitute **future potentialities**. Subsequent research may investigate: (a) the application of the guide in

different municipalities/socio-environmental realities; (b) impacts of the activity on citizenship education in the long term; (c) its integration with municipal environmental councils; (d) its use in conjunction with the Master Plan and other territorial planning instruments; (e) or the expansion of the protocol with simplified physicochemical indicators for school use.

The contributions of this work are simultaneously aligned with the educational field and the sphere of local environmental management. The didactic guide emerges as an educational technology with the potential to strengthen student protagonism, qualify the critical reading of the territory, democratize access to scientific knowledge and stimulate social participation in water management. In municipalities such as Janiópolis/PR, which live with continuous impacts of water degradation and have limited institutional structures, instruments of this nature are, in addition to pedagogical materials, **devices of environmental citizenship**, capable of bringing together school, territory and community around the defense of water resources as common goods. In view of this, this study reaffirms that educational practices grounded, contextualized and guided by EAC can play decisive roles in the formation of subjects capable of understanding and transforming the socio-environmental reality in which they live. The guide developed and analyzed constitutes a contribution in this sense and opens promising paths for new research, policies and pedagogical actions committed to sustainability, environmental justice and the democratic management of water resources.

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