

Basic Sanitation and conscious communities: the construction and validation of a CTS-Freire teaching sequence

ABSTRACT

This study results from a formative experience within the Pedagogical Residency Programme (PRP), as part of an interdisciplinary subproject in Physics and Biological Sciences at a federal public university. The objective was to construct and validate a teaching sequence (TS) on basic sanitation, grounded in the articulation between the assumptions of Science-Technology-Society (STS) Education and Paulo Freire's pedagogical principles. The research, qualitative in nature and designed as a pedagogical intervention, was conducted in a public lower secondary school located in Vitória, Espírito Santo, with a Year 7 class. The development and validation process of the teaching sequence considered the stages of Elaboration, Application, Analysis, and Re-elaboration (EAAR), and the research instruments used were the field diary and the conversation circle. Data analysis was based on the assumptions of Science-Technology-Society Education. The results revealed that the TS enabled the problematisation of the relationships between science, society, and the environment, broadening students' participation and promoting critical reflections on basic sanitation as a social right. During the re-elaboration phase, changes were included in the sequence of lessons, an increase in the number of sessions, and the incorporation of activities focused on citizenship, such as the writing of letters demanding local improvements. It is concluded that CTS-Freire Education represents an important approach for the formation of critical individuals engaged with social, cultural, and scientific issues.

KEYWORDS: Science Education; CTS-Freire Education; Socio-scientific Theme; Educational Product; Pedagogical Residency.

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Saneamento básico e comunidades conscientes: a construção e validação de uma sequência didática CTS-Freire

RESUMO

O presente estudo resulta de uma experiência formativa no Programa Residência Pedagógica (PRP), no âmbito de um subprojeto interdisciplinar de Física e Ciências Biológicas em uma universidade pública federal. O objetivo foi construir e validar uma sequência didática (SD) sobre saneamento básico, fundamentada na articulação entre os pressupostos da Educação Ciência-Tecnologia-Sociedade (CTS) e os princípios pedagógicos de Paulo Freire. A pesquisa, de abordagem qualitativa e do tipo intervenção pedagógica, desenvolveu-se em uma escola pública de ensino fundamental localizada em Vitória-ES, com uma turma de 7º ano. O processo de desenvolvimento e validação da sequência didática considerou as etapas de Elaboração, Aplicação, Análise e Reelaboração (EAAR) e os instrumentos da pesquisa foram o diário de campo e a roda de conversa. A análise de dados foi pautada nos pressupostos da Educação Ciência-Tecnologia-Sociedade. Os resultados evidenciaram que a SD possibilitou a problematização das relações entre ciência, sociedade e ambiente, ampliando a participação dos estudantes e promovendo reflexões críticas sobre o saneamento básico como direito social. Na reelaboração, foram incluídas mudanças na ordem das aulas, ampliação do número de encontros e inserção de atividades voltadas à cidadania, como a elaboração de cartas reivindicando melhorias locais. Conclui-se que a Educação CTS-Freire é uma aposta importante para formação de sujeitos críticos e engajados com questões sociais, culturais e científicas.

PALAVRAS-CHAVE: Ensino de Ciências; Educação CTS-Freire; Tema sociocientífico; Produto educacional; Residência Pedagógica.

INTRODUCTION

The Pedagogical Residency Programme (PRP) was an initiative of the Coordination for the Improvement of Higher Education Personnel (CAPES), aimed at promoting the articulation between theory and practice, contributing to the initial (and continuing) training of basic education teachers connected to undergraduate teacher education courses in Higher Education Institutions. In this context, the PRP provided pre-service teachers with their first teaching experiences in school settings, while also enabling the supervising teachers to reflect on their own teaching practices, thus constituting a possibility for continuing professional development.

The present study stems from a formative experience within the PRP, specifically in an interdisciplinary subproject in Physics and Biological Sciences at a Federal Public University. The main objective of the research is to validate a teaching sequence (TS) on the theme of basic sanitation, establishing a dialogue between the assumptions of Science-Technology-Society (STS) Education and the pedagogical principles of Paulo Freire. We have adopted interdisciplinarity and problem-posing approaches (for instance, CTS-Freire Education) as central axes in addressing the complexities inherent to the education and professional practice of science teachers, particularly in relation to emerging themes that highlight the social contradictions intrinsic to our national reality (Nascimento & Von Linsingen, 2006; Kobata, 2024).

Different studies in the field of Science Education discuss the process of constructing and validating teaching sequences. Verdério and Souza (2024) and Pavani (2023) undertake this process by adopting problem-posing perspectives, addressing, respectively, the theme of “wildfires” under the guidance of CTS Education, and the digestive system articulated with the assumptions of the Three Pedagogical Moments. Silva, Sá, and Batinga (2019) validated a didactic proposal on the theme of water based on the assumptions of inquiry-based science teaching, while Kazmierczak et al. (2018) worked within the perspective of the Teaching-Learning Sequence (TLS) for the study of organic functions.

Regarding the development of didactic proposals on basic sanitation, we highlight the works of Carvalho and Silva (2022), Firme (2022), Spiandorin (2019), and Aguiar (2019). Firme’s (2022) study presents CTS Education as its theoretical framework, as does the present research; however, its contribution is linked to the development and analysis of an intervention in the context of higher education, whereas our purpose is to broaden the debate on the theme of basic sanitation within basic education, specifically in the final years of lower secondary education.

With regard to interdisciplinarity, despite the polysemy associated with the term, we assume a collective and collaborative perspective among teachers of different disciplines (in our case, Physics and Biological Sciences) who organise themselves for the planning, development, and analysis of educational activities,

aiming for a broader understanding of phenomena (social, scientific, and pedagogical) through the knowledge produced in the dynamic relationships between the different disciplines and their multiple forms of knowing (Santos et al., 2019; Pombo, 2005).

CTS-FREIRE ARTICULATION

The CTS (Science-Technology-Society) movement emerged in the mid-twentieth century and expanded in central capitalist countries as contradictions became evident in the relationship between scientific, technological, and economic development and social well-being (Almeida & Strieder, 2021). Scientific and technological advances began to raise concerns, particularly regarding environmental impacts and the threats arising from the development of weaponry for wars, prompting a reconsideration of science and technology (Auler, 2002). Within this context, discussions about the interactions between science, technology, and society intensified, giving rise to the CTS movement.

This broader social movement reverberated within the educational sphere, contributing to the development of a scientific education aimed at fostering citizenship, concerned with the cultivation of values for the common good and the promotion of greater social participation — thereby enabling individuals to take informed decisions on scientific and technological issues (Santos, 2011; Rosa & Strieder, 2021).

Regarding the articulation between Freirean perspectives and CTS Education, Maraschin, Fonseca, and Lindemann (2023) propose a discussion to distinguish between the expressions CTS-Freire and Freire-CTS. This differentiation can be understood as the identification of a theoretical–methodological spectrum that helps to “clarify the intentions of proposals conceived from Freire with articulations to CTS aspects, and also from CTS Education with incursions into the principles of Freirean pedagogy” (Maraschin, Fonseca & Lindemann, 2023, p. 327).

The distinction between Freire-CTS and CTS-Freire lies in the way the theme is constituted within the teaching proposal. In studies where the theme is determined by the teacher—often based on curricular guidelines—there is a closer approximation to CTS Education. However, when the theme emerges from the systematic investigation of the students’ social and cultural contexts (in the construction of the *generative theme*), there is a stronger alignment with Freirean assumptions. Nevertheless, the themes selected by teachers, although related to global issues, may also present direct implications for students’ daily lives (as in the case of the theme of basic sanitation, which is the focus of this study).

This is because the teacher may foster dialogue, problematisation, and epistemological curiosity—characteristics central to Freirean pedagogy. In this way, “[...] Freirean categories tend to allow society to make a critical reading of the contemporary world, fostering more active participation in discussions that

involve everyday life, including in the scientific-technological dimension” (Maraschin, Fonseca & Lindemann, 2023, p. 329).

In relation to the CTS-Freire articulation, Auler and Delizoicov (2006) highlight that the theoretical assumptions of this approach, such as the pursuit of democratisation in decision-making on social issues involving science and technology, share common elements with the theoretical–philosophical matrix of Paulo Freire’s thought. Freire’s political–pedagogical project envisions the reinvention of society—a process consolidated through the participation of those who, today, are immersed in the “culture of silence” (Freire, 1987), subjected to conditions that turn them into objects rather than historical subjects. To overcome this culture, the constitution of a more democratic society must be understood as an ethical imperative (Rosa & Strieder, 2021).

Three assumptions can be regarded as fundamental within the CTS-Freire articulation in educational processes: the problematization of scientific–technological activity (to whom do scientific and technological productions serve?), the expansion of the culture of participation (enhancing students’ exercise of voice) and the teaching of science through real-world issues, with an emphasis on social contradictions (CTS themes) (Almeida & Strieder, 2021; Kobata, 2024). It is important to emphasise that, although these objectives are distinct, they can be understood as complementary, allowing the three dimensions to coexist within a single educational practice. Therefore, even with their differences, each plays an important role in improving the teaching and learning process in science. In the didactic proposal that constitutes the focus of this study, we sought to articulate all three dimensions. The following section highlights the CTS theme that guided the educational intervention process.

BASIC SANITATION: CONCEPTS AND A BRIEF HISTORICAL OVERVIEW

Basic sanitation is fundamental to maintaining physical, mental, and social well-being within a society. Its importance and its association with human health date back to the earliest civilisations and evolved alongside the development of various cultures (Brazil, 2004). In the development of the Greco-Roman civilisation, for example, there are several references to sanitation practices, such as the construction of the famous Roman aqueducts. The lack of dissemination of knowledge about sanitation during the Middle Ages led to significant regression due to the misuse of water resources, characterised mainly by the irregular disposal of waste and the discharge of sewage into the streets, which resulted in successive epidemics.

Today, even with the wide availability of communication media, ignorance about sanitation remains common, as does the absence or difficulty of access to these essential services.

According to the World Health Organization (WHO), sanitation refers to the control of all factors in the environment that relate to human and animal health,

characterising a set of socioeconomic actions aimed at reducing or preventing risks to living beings. According to the 2023 report by the United Nations Children's Fund (UNICEF) and the WHO, as of 2022, around 1.5 billion people worldwide still lacked access to safely managed sanitation services.

Basic sanitation in Brazil is a crucial issue that directly affects the population's quality of life, public health, and the environment. Despite significant advances in recent decades, the country continues to face major challenges in this field. One of the main aspects of the sanitation problem in Brazil is the lack of access to safe drinking water—a critical issue that has long compromised the health and quality of life of millions of people.

Federal Law No. 11,445, enacted on 5 January 2007, defines *basic sanitation* in its Article 3 as comprising a set of services, infrastructure, and operational facilities for: a) the supply of potable water; b) sanitary sewage; (c) urban cleaning and waste management; and (d) drainage and management of rainwater, including the cleaning and preventive inspection of urban networks (Brasil, 2007). Contextualising basic sanitation is essential for understanding it as a theme that reveals the social contradictions present in both national and international realities. As discussed in the previous section, this aspect constitutes a key assumption of the CTS-Freire articulation adopted as the theoretical–methodological framework of this study.

Given its close connection to social reality, it is important to discuss basic sanitation within the educational context in which the didactic proposal was developed. In this sense, it is essential to examine the neighbourhood of Itararé (Vitória, Espírito Santo), the location of the school where the study was carried out and where most of the students reside.

The neighbourhood emerged around the 1950s, initially through settlements in marshy areas, followed by an expansion toward the hillsides as residents sought refuge from flooding during the rainy season. The precarious conditions, combined with frequent flooding, persisted until the early 1960s. Over time, several landfill operations were carried out, both by the government and by local residents. Today, the neighbourhood is divided into two areas: Itararé, corresponding to the lowlands, and Alto Itararé, which covers the hill area (Oliveira, Moreira & Lyra, 2005).

Although the students' age does not allow them to have experienced these historical developments directly, such events continue to influence the daily lives of the local population to this day.

RESEARCH METHODOLOGY

The research presented in this study is characterised as an intervention-type study (Damiani et al., 2013). The environment in which the pedagogical intervention and the resulting research were developed was a municipal public lower secondary school located in the city of Vitória, in the state of Espírito

Santo, Brazil. The school is situated in the neighbourhood of Itararé, in the western area of the city, between Maruípe and Leitão da Silva avenues.

The development and validation of the teaching sequence (TS) were part of the activities of an interdisciplinary subproject in Physics and Biological Sciences within the Pedagogical Residency Programme (PRP) at a federal public university. The school served as one of the subproject's hubs and, since 2022, has been a space for the development of both teaching and research projects, under the supervision of the project advisor — the third author of this article, referred to here as Rosa.

The intervention was implemented by one of the residents (the first author of this research), together with the classroom teacher, referred to as *Hugo*, from June to August 2023. It involved approximately 30 students from the only Year 7 class in the afternoon shift. Conceptual discussions related to basic sanitation were already part of the curricular guidelines of the municipal education network for Year 7, which explains the choice of this particular class.

Two instruments were used for data generation in this research: (I) The field diary, kept by the first author of this article, containing records from both the conception of the teaching sequence and its development in the classroom; and (II) The conversation circle, conducted with members of the interdisciplinary subproject in Physics and Biological Sciences, an undergraduate research student, and a master's student under the supervision of the project advisor, here referred to as Mylla.

The field diary represents a form of recording everyday situations experienced during the research, enabling a deeper understanding and interpretation of the events and the multiple realities observed within the school community. The process of lesson development and the investigation of the elements that materialised the CTS-Freire Education approach were part of the school's daily life, which justified the use of the field diary as a central instrument of documentation and dialogue in this research.

Thus, the field diary was used to record moments, dialogues, spatial descriptions, and observations. Some entries were written directly during classroom activities, while others were made later at the first author's home, using memory as an essential resource for reconstruction. As Araújo et al. (2013, p. 54) explain:

The diary has been employed as a means of presenting, describing, and organising the experiences and narratives of the research subjects and as an effort to understand them. [...] It is also used to portray the procedures of analysis of the empirical material, the reflections of the researchers, and the decisions made during the research process; therefore, it provides evidence of the unfolding of research from its initial design to its conclusion.

In conjunction with the field diary, the **conversation circle** was held on 8 November 2023 and conducted by the first author, who audio-recorded the session with the participants' consent. The meeting lasted two hours and

included eight participants, among them the classroom teacher (Hugo), the advisor (Rosa), and the master's student (Mylla). The conversation circle is a unique moment of sharing, as it promotes active listening and the exercise of voice among all participants. The narratives of those involved are constructed interactively—through agreement, disagreement, or complementarity.

This methodology was chosen for its potential to bring together contributions from individuals in both the fields of Physics and Biological Sciences, thereby fostering a broader understanding and reflection on the teaching sequence under analysis. As Warschauer (2001, p. 179) notes:

Conversation not only develops the capacity for logical argumentation but, by proposing the physical presence of the other, also involves relational abilities, emotions, respect, the skills of listening and speaking, waiting one's turn, integrating oneself into the flow of dialogue, confronting differences, and the effort to put oneself in another's position.

The guiding questions for the conversation circle were designed based on the assumptions of CTS-Freire Education, particularly concerning the proposition and pedagogical mediation during the teaching sequence lessons. These assumptions were mainly established through dialogue with Almeida and Strieder (2021) and the categories proposed by Cardoso and Strieder (2023).

The session began with a brief presentation by the resident who carried out the intervention, reminding the group of the teaching sequence. Afterwards, the discussion was organised around key guiding questions:

Is the theme social in nature? Did the problems addressed reflect the students' social and everyday realities? Did the problematisation, as presented, provide elements for the analysis of social situations mediated by relevant scientific knowledge? Was the relationship between society, environment, science, and the social implications of the theme clearly established? How was the mediation conducted? Did the resident adopt a dialogical stance? The interpretation of participants' narratives was also based on the assumptions of CTS-Freire Education.

This study is part of a broader research project coordinated by the third author, registered under CAAE number 44931315.4.0000.5542, and approved by the Research Ethics Committee on 28 August 2015.

ANALYSIS AND DISCUSSION: THE PROCESS OF VALIDATING THE TEACHING SEQUENCE

The elaboration and validation of the teaching sequence analysed in this research are directly related to the method presented by Guimarães and Giordan (2013), as it concerns the validation of a teaching sequence. The authors propose a method for the elaboration and validation of teaching sequences based on a systematic analysis of consecutive evaluations of the elements that constitute the

sequence — namely, its elaboration, application, and outcomes. A process known as EAR (Elaboration–Application–Re-elaboration).

ELABORATION OF THE TEACHING SEQUENCE

The process of constructing and validating the teaching sequence (TS) arose from the experience of the authors within the PRP-UFES, whose work plan fostered the practice of collaborative research for the production of teaching knowledge, contextualised through the theory–practice relationship at the University–School interface (Coelho, 2024).

Based on these references, a more comprehensive process was achieved which, in addition to organising the stages of the teaching sequence’s development, provided support for systematic analyses and consecutive evaluations from a scientific perspective — all within the curricular framework of the Pedagogical Residency Programme. Therefore, the three stages described in the EAR process can be viewed through the lens of this productive and restructured process, taking into account the specific characteristics of the programme’s formative actions.

In this sense, following Dalvi (2023), who reformulated the validation process and established it as EAAR (Elaboration, Application, Analysis, and Re-elaboration — Table 1), this study adopts a perspective that incorporates collaborative research into the structure proposed by Guimarães and Giordan (2013).

Table 1

Stages of the EAAR Process Applied to the Development of the Teaching Sequence

Stage	Meaning
Elaboration	Conception of the teaching sequence (TS) from an interdisciplinary perspective, taking CTS-Freire Education as a reference.
Application and Analysis	Application in the classroom as part of the intervention carried out through the Pedagogical Residency Programme.
	Implementation in the classroom as part of the intervention carried out through the Pedagogical Residency Programme. Joint analysis conducted with the resident, the classroom teacher, the supervising professor of the Pedagogical Residency Programme–UFES, other residents, a master’s student, and an undergraduate research student in the field of Physics Education.
Re-elaboration	Considerations regarding aspects that could be improved and reconstructed in the teaching sequence.

Source: Author’s own work (2025).

PLANNING AND ELABORATION

In this first stage, the processes of planning and elaborating the teaching sequence (TS) took place, consisting of the definition of the theme, the types of approaches, and the organisation of the teaching plan, based on the school timetable. The construction of the TS involved the collaboration of the coordinating professors, the classroom teacher, and the residents who made up the core of the Pedagogical Residency Programme at the school, as well as other key contributors, such as undergraduate research students and master's students — thereby maintaining the collective perspective within which the intervention was conceived.

The theme defined was basic sanitation, precisely because it directly affects people's quality of life. Once the theme had been established, possible theoretical frameworks were analysed according to the school's reality and dynamics. The social nature of the theme, combined with the historical context of the neighbourhood in which the school is located, supported the elaboration of the TS based on CTS-Freire Education.

The design of the TS — from the planning phase to the definition of its final version — lasted approximately two months. Its construction took place in the school environment, in the science classroom, which served as the working space of the classroom teacher, Hugo. Several tools were used to assist in developing the lesson plans and interventions, including the graphic design platform Canva, the online document editor Google Docs, and YouTube.

Fortnightly meetings were held at the school with members of the PRP core team to analyse and discuss the lesson plans produced by the residents. In this way, each proposal could be refined until the best version was achieved in accordance with the intended objectives. This type of collective training offered a range of benefits, as it created a space for the sharing of ideas, knowledge, and experiences, enriching learning and providing different perspectives based on each participant's background and experience.

At this point, the teaching sequence was titled “Basic Sanitation in Action: Building Conscious Communities.”

The title of the teaching sequence aims to refer to Paulo Freire's concept of consciousness, and for this reason, we also included the term “conscious communities” in the title of this article. This concept distances us from naïve perspectives associated with fatalistic or simplistic explanations of social problems (including those related to basic sanitation). The process of developing critical awareness — or conscientization — requires not only the unveiling of reality but also a “critical pedagogical effort supported by favourable historical conditions” (Freire, 2024, p. 84).

The meeting with the teaching core was marked by highly relevant comments and reflections. From the descriptive aspects recorded in the field diary, it was possible to obtain a more comprehensive and refined product. Some of the narratives produced by the participants were recorded in the field diary:

Do you know something we could try to do? A field trip to a water treatment plant (Field diary, 2023)

[...] because in this way, the students would be able to see and learn up close how these more complex processes occur until the water reaches their homes. In addition to providing a learning experience outside the classroom environment, it would fit well with the proposal of a CTS approach [...] (Field diary, 2023).

A relevant contribution, resulting from the discussions that took place at the school, was related to bringing the theme of the TS closer to the school reality and to the students themselves, as recorded in the field diary:

Regarding the first lesson, instead of showing them global images of the sanitation situation, why don't you present images of regions near where they live? This way, they can associate the issue with their own realities (Field diary, 2023).

[...] it would also be interesting to bring in news stories from their neighbourhood, to investigate how the sanitation issue unfolds there, in order to foster discussion during the intervention [...] (Field diary, 2023).

The excerpts above present the narratives recorded as notes in the field diary, which capture ideas, perceptions, and conclusions arising from the discussions. The other participants in the discussion group expressed agreement through gestures and brief comments, supporting the points raised in the narratives. These contributions allowed us to reflect on the differences between the initial proposal we had and the goals we wanted to achieve, thus reinforcing the assumptions of CTS-Freire Education. In other words, bringing images, videos, and news that highlight the contradictions between the different realities of regions near the students' neighbourhood made far more sense, enabling an encounter of voices and lived experiences (Cardoso & Strieder, 2023).

One of the most significant changes resulting from these debates was the addition of more lessons to the teaching sequence. This was because the aim was not for the content to be transmitted in a unidirectional way, but rather approached dialogically—beyond physical and biological aspects—to integrate with each student's lived reality. This created a collective learning environment in which students could speak and be heard, reinforcing the importance of the exercise of voice (Cardoso & Strieder, 2023).

The initial version of the teaching sequence consisted of six lessons, organised as follows:

Lesson 1 – The History of Basic Sanitation: Unveiling the Past; Lesson 2 – Basic Sanitation: A Right for All?; Lesson 3 – What Services Are Part of Basic Sanitation? Lesson 4 – Understanding Parasitic Diseases; Lesson 5 – Water Treatment and Distribution; Lesson 6 – Practical Lesson: Simulating the Stages of a Water Treatment Plant.

THE PROCESS OF IMPLEMENTATION AND ANALYSIS OF THE DIDACTIC SEQUENCE

This stage of the research began with the interventions conducted in the 7th-grade class of the school. At several points during this stage, the participation of Special Education professionals was crucial for ensuring the inclusive development of the lessons.

The first class followed a dialogic approach and presented the historical context of basic sanitation, highlighting ancient water distribution systems and emphasizing the construction of Roman aqueducts. Three-dimensional didactic models were used as teaching and learning tools. This lesson was important for sharing with students the origins of services related to basic sanitation, clarifying that it represents a long-standing achievement that has evolved over many years to reach its current form.

The second class adopted a more critical dialogic format and aimed to understand what students already knew about the topic, enabling them to establish connections with their own realities. Initially, students were asked about their knowledge of basic sanitation—what it was, which services it encompassed, what problems arise from its absence, and what the situation is like in the country and in their local region.

During this moment, the field diary was essential, as many observations were recorded. Regarding students' verbal expressions, body language, and general observations, some excerpts were particularly representative:

Health (...) Life (...) Clean water for us (Field diary, 2023).

It ensures drinking water for us! (Field diary, 2023).

It's used to treat water (...) sewage (...) (Field diary, 2023).

The lack of sanitation can cause the spread of diseases and harm our health (...) (Field diary, 2023).

From these records, it can be understood that students were not yet able to explain in more complex terms what basic sanitation actually entails. In general, they tended to associate it mainly with the treatment and distribution of drinking water. On the other hand, the connection between water quality and the transmission of diseases through contaminated water was recognized. This indicates a partial appropriation of scientific knowledge, corresponding to level 3 of knowledge mobilization and appropriation, according to Cardoso and Strieder (2023).

In the second part of this lesson, images depicting nearby regions with contrasting sanitation conditions were presented for students to describe and compare. The main goal of this activity was to address the social dimension of the topic, particularly its relation to inequalities; therefore, a more dialogic approach

was adopted. The activity was highly effective, evolving into a form of open discussion in which students were able to identify the regions and their defining elements, unveiling the contradictions present in the city. As a result, they reported:

Pollution, flooding (...) sewage (Field diary, 2023)

A very polluted place, an open ditch – there will be dengue there! (Field diary, 2023)

Polluted sewage, full of trash!” (Field diary, 2023)

Água poluída, casos de doença e poluição (Diário de campo, 2023).

Polluted water, cases of disease, and pollution (Field diary, 2023).

A cleaner city, with more trees... (Field diary, 2023).

A more organized place! (Field diary, 2023).

No sewage and no pollution. (Field diary, 2023).

During the interaction with the students, the set of services that make up basic sanitation was presented: (I) public supply of drinking water; (II) collection, treatment, and proper final disposal of sanitary sewage; (III) drainage and management of urban stormwater; as well as (IV) urban cleaning and (V) solid waste management. In addition, throughout the class, Law number 11.445—the Federal Basic Sanitation Law—was introduced, thus enabling students to learn about their rights.

In this context, during the conversation, students also shared their own experiences related to basic sanitation in their neighborhoods, which further fueled discussions about sanitation inequality. They reported:

Look, teacher, water is often missing up on the hill, so I don't think the sanitation system here is very good (Field diary, 2023).

That's true, on my street it's the same (...) the water even came out kind of yellow once (Field diary, 2023).

On my street, everything floods when it rains! (Field diary, 2023).

From the students' statements, it is evident that there are problems related to basic sanitation services in their neighborhoods, as these do not function as they should. Thus, within the framework of the CTS-Freirean (Science-Technology-Society-Freire) approach, the intervention sought to unveil reality, overcome the culture of silence and the notion of scientific-technological neutrality—elements that are fundamental for developing critical consciousness, reflection-action, and social transformation (Freire, 1987, 1992; Auler, 2002).

In the third class, the various services encompassed by basic sanitation were explored in greater depth. Notes recorded in the field diary were fundamental in revealing that most students reduced these services to water and sewage

treatment and distribution. Therefore, it was necessary to broaden the discussions on this topic.

Regarding the system of treatment and the arrival of piped water in their homes, students were asked about the process. Most were unable to explain how it occurs; however, they provided answers related to the operational stages. They reported:

Oh, I know the water goes into the tank (...) passes through the pipes, and reaches us clean (Field diary, 2023).

It's CESAN that brings it (Field diary, 2023).

At this point, each stage of water treatment and distribution carried out at a Water Treatment Plant (ETA) was explained, highlighting the importance of each process.

The issue raised during the discussion group prior to the interventions—about bringing the topic closer to the students' reality—was also implemented in this lesson through the use of news reports portraying the indignation of residents from Serra (a city in the metropolitan region of Vitória) regarding the quality of the water supplied to their homes. In this context, the responsibility of the companies designated to ensure this service—specifically CESAN, which was even mentioned by one of the students—was emphasized.

In the fourth class, the topic of diseases transmitted through contaminated water was addressed. In previous lessons, the importance of drinking water for maintaining human life and its relationship with the provision of basic sanitation services had already been highlighted. Thus, the objective of this class was to encourage students to relate the emergence and proliferation of such diseases to their causative agents and to sanitation conditions.

Regarding the diseases and their causative agents, emphasis was placed on helminth infections—parasitic diseases caused by worms that inhabit the human body and can lead to various illnesses. According to the World Health Organization (WHO), these are among the most common diseases worldwide. Helminth infections have high incidence rates in some regions of Brazil, generating serious public health problems. In general, they are associated with living and hygiene conditions within communities, occur more frequently among populations with low socioeconomic status, and primarily affect children. In this sense, this intervention was extremely important for fostering reflection and learning about etiological agents and preventive measures for several pathologies.

In the fifth class, a field visit was carried out to the Vale Esperança Water Treatment Plant (ETA Vale Esperança), located in the city of Cariacica, Espírito Santo (ES). Throughout the visit, students demonstrated great enthusiasm by asking questions and actively participating in discussions. Regarding this activity, the resident responsible for the intervention recorded the following reflection in her field diary:

[...] Being able to provide this kind of experience for the students was very gratifying. They were guided throughout the visit but had the freedom to explore the environment and act autonomously and collaboratively. It was an excellent class that enabled meaningful learning outside the school environment, connecting scientific and technological processes to their daily lives, as it was a moment in which they acquired essential knowledge, such as identifying the river responsible for supplying their neighborhood (Field diary, 2023).

In the following week, a sharing session was held with the students to discuss their experience during the visit to the ETA, along with the sequence of lessons on the topic of basic sanitation. The sixth class began with a conversation about the visit, aiming to understand what students thought of the activity, what knowledge they had acquired, and what their main observations and memorable moments were. In this regard, several excerpts were highlighted in the field diary:

Oh, I liked it, I found it all very interesting, like (...) how the water gets there and how it's treated! (Field diary, 2023)

Oh, I loved that thing that sprayed water! (Field diary, 2023).

(...)and also that part with the (...) thing with bubbles in the water." (Field diary, 2023)

At this point, together with the supervising teacher, Hugo, the students' comments were used to promote a brief discussion and review of important concepts covered during the visit. For example, in the first statement above, the student referred to the "thing that sprayed water," which was related to the filter washing process shown during the visit. In the second statement, the student mentioned the "thing with bubbles in the water," which prompted a review of the concept of flocculation—one of the stages in the water treatment process. Since these moments had particularly caught the students' attention, it was important to ensure that they fully understood what was happening.

This discussion was essential for carrying out the second part of the class, which consisted of a practical activity in the Science classroom. The objective of this lesson was to simulate, on a small scale, the stages of the water treatment process. For this activity, students were divided into four groups and received a worksheet containing detailed instructions, along with a kit that included the necessary materials (plastic bottle, cup or container, spoon, scissors, cotton, sand, gravel, and activated charcoal). Students demonstrated great autonomy throughout the practical activity, performing and discussing each step collaboratively.

[...] What caught my attention the most was that the students began to question the transformations occurring at each stage, relating them to the steps they had learned during the previous lessons and throughout the visit. They asked why a certain event was not happening. This was extremely important for the development of the class, since not all groups achieved the expected results, which further emphasized the complexity of these stages and reinforced the importance of their proper execution and functioning to ensure the supply of quality water (Field Diary, 2023).

From this point onward, we also began interacting with the narratives of the participants in the discussion circle. The knowledge, experiences, and educational backgrounds of each participant were key factors in enriching the debate. Some excerpts from the discussion circle highlight the dialogical interactions established among the participants:

When we talk about a social theme, is there a definition? For example, is basic sanitation a theme that reveals Brazil's contradictions? (Mylla)

I think we can understand a social theme as one that, in its essence, reflects the contradictions of the national reality (...). For instance, could basic sanitation be considered a theme that exposes Brazil's social contradiction? (Rosa)

Absolutely, right? Because it touches several dimensions — political, economic, and rights-related (...). So, for me, 100% (Mylla)

Because do you remember the presentation she gave? I really liked it! On one side, Praia do Canto; on the other, the peripheral region. That shows a contradiction! And if we think about the treatment and distribution techniques you presented (...) they are all in place (Rosa).

They could be applied anywhere, right, in principle (Mylla).

So why don't they exist in those places? And why do others have them? (Rosa).

[...] So that's the social contradiction. And when we talk about the term social, it's to see whether this becomes evident in the work, because this problematic CTS approach has this commitment to unveiling contradictions and broadening students' understanding of them. In my view, those images help greatly to illustrate these contradictions. They show a simulation, as if pipes were reaching the houses, but there's nothing there... I think they point exactly to that, right? The technology exists—so why doesn't it reach there? It's not because it's up on a hill that physics dictates the water can't be distributed upwards, because there's already technology for that! We have the technical means and tools to make the water rise (Rosa).

And it contrasts with the islands — Ilha do Boi, Ilha do Frade — right? They're at even higher elevations, yet have 100% guaranteed sanitation services (Mylla).

In fact, during the intervention, we brought this discussion to the students: Don't you see Reta da Penha over there? On one side, there's Praia do Canto, and on the other, your neighborhood [...] so how is basic sanitation in your neighborhood? How is waste collection? Does it flood when it rains on your street? And what about in Praia do Canto? [...] (First Author).

We didn't tell them which place it was, right? We agreed not to reveal it. So, just by looking at the images, they said, "Oh, I know where that is", because those are places they visit — they move around, go to the beach, pass through those areas, they know them. These are places close to their own neighborhood, yet they show a completely different reality from theirs (Teacher Hugo).

The dialogue excerpts reveal a consensus among participants regarding basic sanitation as a *social theme*. At the local level, participants highlighted the differences between the Itararé neighborhood (where the school is located) and the Ilha do Frade and Ilha do Boi neighborhoods (considered upper-class areas in

the city of Vitória, Espírito Santo). Although these neighborhoods share similar geographic features, being situated at higher elevations, they have markedly different access to essential services, including sanitation.

Concerning the second issue, the problems of basic sanitation are part of the students' social and everyday reality. During several moments of the discussion circle, participants pointed out connections with local problems. In this sense, the proposal is concerned with promoting a "contextualization of knowledge derived from elaborated culture (in this specific case, the culture of science and technology), integrating it into the students' reality" (Nascimento & Von Linsingen, 2006, p. 108).

From the perspective of the discussion circle participants, the problematization process provided elements for the analysis of social situations mediated by relevant scientific knowledge, as seen in the following exchanges:

When you read the students' statements, they brought up some key words related to reality, and it is interesting to see how these words shift throughout the proposal and how other words emerge along the way. Because saying "sewage, dirt..." refers to concrete things, but to understand reality, we need abstraction. What lies behind this dirt? Unequal public policies and a series of broader issues. From a scientific point of view, a clear contrast is the issue of the islands we have in Vitória — how water reaches them easily, but not the "hilltops" (Rosa).

Scientific knowledge, right! (Mylla).

Considering that the school's territory is also an island, right! (Professor Hugo).

That's true... And considering there are tools and methods... Why isn't it done? (Rosa).

Regarding the establishment of a relationship between society, the environment, science, and the social implications of the topic, it was possible to conclude from the narratives that this relationship was indeed established. Throughout the development of the intervention, several elements engaged in dialogue with the theme of basic sanitation at both global and regional levels. It is important to note that, during the discussion circle, an extremely relevant issue was raised concerning the responsibility for ensuring the provision of basic sanitation services, which was suggested as an addition to the final version of the didactic sequence. Continuing with the exchanges, the following narratives were recorded:

Especially when she talks about simple machines, if we think about the sequence she presented — for example, the technical visit is a culmination — because we are able to address and visualize all the concepts that were applied, from the functioning of water collection, the difference in height, gravity, to biological and chemical aspects, why treatment is necessary to obtain quality water, where this water comes from, why it cannot be used as it is, the diseases related to it (...) so these classes in non-formal educational spaces highlight the importance of school field trips, as they emphasize and integrate all these dimensions — science, technology, and society (Professor Hugo).

So, it would also be a way of achieving this theoretical-practical articulation, because we also do that in the classroom (Rosa).

Because these processes, in reality — in real life, right? — they are not isolated! (Professor Hugo).

Exactly, they are not! (Rosa).

A topic that I'm not sure whether you addressed in this sequence, but it's also about responsibility, right? Which level of public authority is responsible for each of these services? For example, in drainage or treatment services (...) sometimes it's even confusing for us as adults — like, "Oh, this service is the state's responsibility, or the city's (...)" (Mylla).

What Mylla says is very important, because when we look at this in practice, people don't know whom to turn to, so they start looking for something in the municipal government, when in fact it is the state's responsibility. People get completely lost — you go to these agencies, and they don't provide any guidance! (Professor Hugo).

The fifth guiding question revisits the importance that mediation brings to the educational sphere, enabling learning through constructive interaction, stimulating critical thinking, and strengthening interpersonal bonds, thus creating an environment conducive to the exchange of ideas. The excerpts below represent the interaction among participants during the discussion circle in relation to this question.

When we talk about approach, it's not just about thinking of the topic itself; it's about thinking how I relate in the classroom, how I relate to knowledge, how I relate to the students (...) And how I make connections between the students' reality, my own reality, and scientific knowledge (...) So, the way you develop the class is important in this process of fostering problematization (Rosa).

(...) I understand dialogue as this relational aspect — not only I speak and you listen — but how different ideas circulate, and how scientific knowledge and reality circulate within the classroom. Did that happen? Or was there only scientific discourse? (Rosa).

No, I think that when the researcher or we ourselves asked questions by showing the photos and questioning the students, we ended up creating that bond with them, putting ourselves on an equal footing to, from there, address the scientific part. So yes, there was this communication with the children. Of course, it's always very limited by the educational stage — 7th grade... It has to be something much less complex — but even so, we managed to work on many aspects: social, scientific, and technological (Professor Hugo).

Yes, because we tend to be somewhat afraid of explaining the scientific knowledge behind the topic, right? Out of fear of getting lost. The topic can be just a backdrop for me to explain scientific knowledge, but this approach will say the following: look, at all times this issue of social reality is an element to be brought and reflected upon along with scientific knowledge. And regarding the dialogical posture, you brought that — horizontality — and the idea that the social problem and scientific knowledge permeate the entire didactic proposal (Rosa).

This issue is very interesting because, for example, in the news piece I presented to the students about the end of flooding in their neighborhood — which referred to the installation of drainage systems — they immediately reacted, saying that this was not the reality of their street, that it still floods whenever it rains, and so on. And as Professor Hugo himself had told me, there's nothing better than having them talk about their own neighborhood! (First author of the article).

And this kind of approach is precisely meant to broaden this culture of participation, to expand the culture of reading the world... because, in our society with a fragile democracy, silence is what prevails! People are usually not invited to think about the school curriculum, and so on (Rosa).

Regarding the expansion of the culture of participation mentioned in Rosa's statement, in Freire's theoretical and philosophical framework, it occurs through overcoming the culture of silence (also referenced in the statement), which denies societal participation in decision-making by preventing oppressed individuals from voicing their words (Rosa & Strieder, 2021). Following Freire (1987, 2000), we learn that it is necessary to overcome silencing, go beyond trained behaviors, and stimulate critical, questioning thinking in individuals, aiming for the much-desired (re)invention of worlds.

It is also important to highlight that dialogicity can occur even before the interaction between educator and learner. It is present in the moments preceding the educational act itself, still in the stage of program development:

Hence, for this conception as a practice of freedom, its dialogicity begins not when the educator-learner meets the learners-educators in a pedagogical situation, but beforehand, when the former asks themselves what they will discuss with the latter. This concern with dialogue is the concern with the programmatic content of education (Freire, 1987, p. 47).

Within this logic, engagement with the students' reality throughout the development of this didactic sequence was considered, identifying their perception of this reality. At the end of the discussion circle, the participants were asked whether they would consider an alternative way to develop the sequence to work on basic sanitation:

And you, after analyzing all of this, would you consider an alternative way to develop the sequence to work on basic sanitation? (Rosa).

I'm thinking... maybe if we reversed and swapped the stages, I'm trying to see if that would work well (Professor Hugo).

Maybe start with problematization, I don't know... Because the first class was about the historical background, right? Hmm, I'm not sure... (Dalva).

Yes, I think that makes sense. If we had already started with images, contrasting realities, etc., asking them to analyze that in the context of their own experience, they would definitely highlight the same points they did starting from something already concrete... Then it would connect to basic sanitation, why it exists, what it is, already relating it to open sewage, lack of water, then moving on to the historical context, discussing rights, legal issues, and finally how treatment is done (Professor Hugo).

(...) But I liked this logic of inversion because it would make more sense with the proposition to start by stating that it is a social topic; a social topic has to present contradictions, the contradictions have to align with the students' reality, mainly for them to understand, and then you bring in the other elements afterwards. (First Author).

REELABORATION

During the Application and Analysis phase of the Didactic Sequence (DS), a large amount of information was collected, aiming to analyze the potential of CTS-Freire Education for Science teaching. The students' considerations and the exchanges that occurred during the discussion circle were highly relevant and fostered the phase of re-elaboration of the DS.

During the discussion circle, a key point regarding the development of the didactic sequence was the order of Lesson 1 — *"History of Basic Sanitation: Unveiling the Past"* — and Lesson 2 — *"What is Basic Sanitation?"*. It was understood that it would be better to start the first lesson with problematization (presentation and discussion of images illustrating different social realities) and then proceed with the historical aspect of basic sanitation. In this way, it would be possible to value the students' experiences with basic sanitation and correlate the current reality with the historical context and technologies presented in the interventions. In this sense, although the content is continuous, due to the short period established for each 55-minute class, the order of Lessons 1 and 2 was altered.

Regarding the sixth lesson, based on the first author's analysis, the conclusion was that it would be necessary to divide the practical lesson so that it could be developed across two classes. This is because, during the implementation of this lesson, time was one of the factors influencing the execution of the steps in the guide (the need to extend the time was observed so that the processes could consolidate and the phenomena occur).

Table 2

Final version of the DS: "Basic Sanitation in Action: Building Conscious Communities"

Lesson	Lesson Title	Teaching Resources	Objectives / Intentions
1	Basic Sanitation: A Right for Everyone?	Multimedia projector, board, marker, and diary.	Understanding the initial problem through the presentation of images via multimedia projector, depicting the social contradiction evidenced by unequal access/quality of basic sanitation.
2	History of Basic Sanitation: Unveiling the Past	Multimedia projector, board, marker, didactic models of simple machines, and	Use of the multimedia projector along with didactic models of simple machines to promote understanding and connections regarding the main services encompassed by basic sanitation

		diary.	and the operation of water treatment plants.
3	What Services Are Part of Basic Sanitation ?	Multimedia projector, board, marker, and diary.	Use of resources to understand the main services encompassed by basic sanitation.
4	Learning About Helminthiasis	Multimedia projector, board, marker, and diary.	Use of news, images, and/or videos to assist in understanding the main waterborne diseases caused by the lack of basic sanitation and their social impacts.
5	Treatment and Distribution of Drinking Water.	Field lesson.	Visit to the Water Treatment Plant.
6 e 7	Practical Lesson 1 and 2.	Guide, materials, and reagents for the practical activity, and diary.	Use of practical lessons to promote cooperation among students, allowing them to understand and simulate the stages occurring in a WTP.
8	Basic Sanitation and Citizenship	Multimedia projector, board, marker, paper, pencil, and journal.	Understanding the main agents and/or bodies responsible for providing basic sanitation services. Preparation of a letter addressed to the agencies responsible for ensuring basic sanitation services in the city.

Source: Own elaboration (2025).

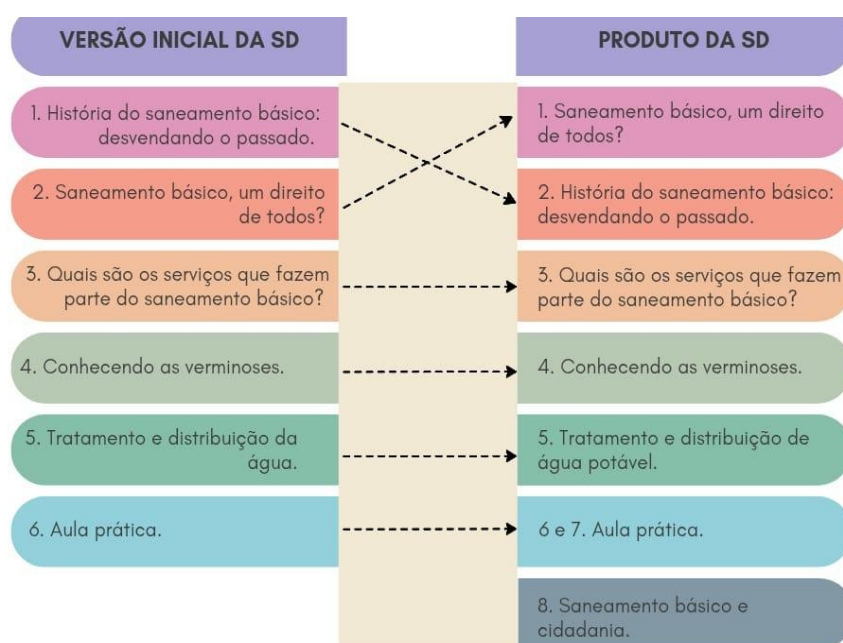
A very relevant suggestion that also arose from the discussion circle was to address in the sequence which agencies/entities are responsible for providing basic sanitation services. To meet this suggestion, the inclusion of a final activity was proposed in which students would write a letter addressing the sanitation conditions in their neighborhood or street. This letter would be written as a form of problematization, request, and/or claim of their rights, based on the scientific, technological, and social knowledge elucidated in the classroom.

In general, studies based on the CTS-Freire articulation advocate precisely for this type of Scientific and Technological Education focused on understanding and transforming reality. The importance of school-based activities and training

processes that explore reflective capacity is also emphasized, so that the scientific knowledge acquired can assist in understanding reality with a view to transforming it (Fernandes, Marques & Delizoicov, 2016). Thus, a new path for curricular structuring is indicated, one that not only highlights scientific content and concepts but also guides actions aimed at social transformation (Auler & Delizoicov, 2015). Therefore, after the interpretative processes, we arrived at a final version of the didactic sequence (Table 2) and highlighted the modifications between the initial version and the version after the re-elaboration process of the didactic sequence (Figure 1).

Figure 1

Comparison of the Initial and Final Versions of the Didactic Sequence (DS).



Source: Own elaboration (2025).

FINAL CONSIDERATIONS

This study describes the process of constructing and validating a didactic sequence (DS) on the theme of basic sanitation, using as a theoretical framework the articulation between the assumptions of CTS Education and the thought of Paulo Freire for its development and analysis. The EAAR process presents itself as a tool for researching teaching practice, contributing to teacher learning and the production of didactic materials validated by relevant theories in the field of Science Education.

In the Elaboration phase, it was possible to identify, select, and analyze the elements that characterize the assumptions of CTS-Freire Education, such as the importance of intentional planning for the educational act, and engagement with

the students' reality, taking into account the specific cultural and social context to guide the selection of content and materials. From the Application and Analysis phase, it was possible to identify how the selected content and the activities developed and implemented established an interrelationship between the didactic sequence and the CTS-Freire assumptions.

Basic sanitation was understood by the group as a socially relevant topic precisely because it highlights contradictions in the national reality that directly or indirectly affect the lives of many people in society. The problems addressed were part of the students' social reality, since the proposal sought to contextualize knowledge derived from the elaborated culture (in this specific case, the culture of science and technology), integrating it with the students' reality. Problematicization provided sufficient elements for analyzing social situations mediated by scientific knowledge.

In the Re-elaboration phase, changes were made to the didactic sequence based on the discussions and analyses conducted throughout the research. Therefore, this work results in an applied, analyzed, and revised product. We emphasize the commitment to share the experiences throughout this didactic sequence.

Pedagogical mediation from the CTS-Freire perspective represents a major challenge, precisely because Science teaching has been culturally grounded in unidirectional practices, replicating what we have experienced throughout our own schooling and, as a consequence, also reflecting the expansion of regulatory educational policies within curricula and institutional assessments. In this sense, understanding the role of the educator as a catalyst in the teaching and learning process—promoting democratic activities and environments that foster dialogue, epistemological curiosity, inquiry, active participation, creativity, critical thinking, and interdisciplinary integration among students is essential.

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