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Science, Technology, and Society in Science Teacher Education: An Analysis of a Collaborative Proposal

Raviéllen Vieira Barros[i]
State University of Southwest Bahia, Jequié, BA, Brazil

Paulo Marcelo Marini Teixeira[ii]
State University of Southwest Bahia, Jequié, BA, Brazil

Beatriz Santos da Silva[iii]
Ipiaú State High School, Ipiaú, Bahia, Brazil

Abstract
Introduction. This study examines the affordances of Science-Technology-Society (STS) Education as a conceptual framework for science pedagogy and its role in fostering reflexive praxis within the continuing professional development of teachers. Methodology. This is a qualitative, intervention-based study of the action-research type, conducted from a collaborative perspective. Data were collected through participant observation and field notes, combined with semi-structured interviews. The analysis was constructed based on emerging categories derived from textual data, including descriptions and reflections, using categorical analysis as the methodological approach. **Results.** The results obtained point to the potential of Science-Technology-Society Education frameworks to trigger and inform certain reflections**. Discussion.** These results were analyzed based on the following categories: (a) reflections on the nature of science and the relationships within Science-Technology-Society; (b) reflections on the curriculum; (c) reflections on science teaching and its relationships with citizenship education.

Keywords
teacher education; teaching practice; education for citizenship.

Ciência, Tecnologia e Sociedade na formação de professores de Ciências: análise de uma proposta colaborativa

Resumo
Introdução. O artigo analisa as potencialidades da Educação Ciência-Tecnologia-Sociedade como referência para a educação em Ciências e seu papel na promoção de processos reflexivos na formação continuada de professores. **Metodologia.** Trata-se de uma pesquisa qualitativa de natureza interventiva do tipo investigação-ação, desenvolvida em uma perspectiva colaborativa. Os dados foram produzidos por meio de observação participante e registros de campo, combinados com uma entrevista semiestruturada. A análise foi construída a partir de categorias emergentes obtidas na base textual oriunda dos dados, incluindo descrições e reflexões, utilizando como metodologia de trabalho a análise categorial. **Resultados.** Os resultados obtidos apontam para potencialidades dos referenciais da Educação Ciência-Tecnologia-Sociedade no sentido de disparar e subsidiar algumas reflexões. **Discussão.** Analisaram-se tais resultados a partir das seguintes categorias: (a) reflexões sobre a natureza da ciência e as relações Ciência-Tecnologia-Sociedade; (b) reflexões sobre currículo; (c) reflexões sobre ensino de Ciências e suas relações com a formação para cidadania.

Palavras-chave
formação de professores; prática docente; educação para a cidadania.

Ciencia, tecnología y sociedad en la formación del profesorado de ciencias: análisis de una propuesta colaborativa

Resumen
Introducción. Se analiza el potencial de la Educación en Ciencia, Tecnología y Sociedad como referencia para la enseñanza de las ciencias y su papel en la promoción de procesos reflexivos en la formación continua del profesorado. **Metodología.** Se trata de un estudio cualitativo, intervencionista y de investigación-acción, desarrollado desde una perspectiva colaborativa. Los datos se recopilaron mediante observación participante y notas de campo, combinadas con una entrevista semiestructurada. El análisis se construyó a partir de categorías emergentes obtenidas de los datos textuales, incluyendo descripciones y reflexiones, utilizando el análisis categórico como metodología. **Resultados.** Los resultados obtenidos señalan el potencial del marco de la Educación en Ciencia, Tecnología y Sociedad para desencadenar y apoyar algunas reflexiones. **Discusión.** Estos resultados se analizaron con base en las siguientes categorías: (a) reflexiones sobre la naturaleza de la ciencia y las relaciones Ciencia, Tecnología y Sociedad; (b) reflexiones sobre el currículo; y (c) reflexiones sobre la enseñanza de las Ciencias y sus relaciones con la educación para la ciudadanía.

Palabras clave
formación de profesores; práctica docente; educación para la ciudadanía.

1 Introduction

Studies based on Science-Technology-Society Education (STS Education) frameworks in recent decades highlight the challenges of its implementation in Brazilian basic education, especially regarding teacher education. There is a consensus in the literature that the effectiveness of STS practices depends, among other factors, on teachers who understand and identify with these frameworks (Auler, 2002; Binatto, 2015; Campos; Severo, 2023; Fernandes; Strieder, 2017; Mendes et al., 2024).

In this work, we investigate the potential of STS Education frameworks in the design and implementation of a continuing education (CE) proposal. We start from the understanding that the dissemination of these frameworks in CE can contribute to the training of educators capable of articulating STS within the school daily life, promoting reflections on the social, political, and ethical impacts of science and technology. This perspective aligns with progressive pedagogies and conceptions of teacher education that

value autonomy, criticality, and a commitment to education for citizenship and social participation (Contreras, 2018; Saviani, 2021, 2024).

In our view, formative processes must provide teachers with a theoretical and epistemological framework involving an understanding of the nature, philosophy, and sociology of science, as well as an awareness of their political and social commitment. It is within this context that the investigative experience that originated this article is situated, the objective of which was to analyze the potential of STS Education frameworks to trigger reflective processes and foster changes in the pedagogical practices of Science teachers participating in a collaborative CE group. In this manuscript, we present an excerpt from a broader investigation developed within the scope of the first author's master's thesis (Barros, 2018), in which we analyze the limits and potentialities of a continuing education process guided by the assumptions of the STS Movement.

The school daily life presents challenges that hinder the effectiveness of continuous formative processes. Among them, work overload, professional devaluation, and excessive bureaucratic demands stand out as factors that compromise teacher engagement. Added to this is the absence of interdisciplinary spaces in schools, which should favor dialogue and collaborative learning among educators (Barros, 2018; Silva; Souza, 2022). Such structural difficulties contribute to the precarization of teacher education and, consequently, of teaching conditions in Brazilian public schools (Teixeira, 2018).

Paradoxically, it is within this same space marked by tensions that the school is configured as a privileged locus of professional learning. Review studies conducted by Oliveira, Lima, and Azevedo (2023), examining productions between 2017 and 2021, indicate that teacher education is consolidated, above all, within the institutional spaces and times of the school itself. According to these authors, productions in the field converge in pointing out that moments of continuing education, collective studies, and peer exchanges constitute fundamental devices for professional development. It is further evidenced that teaching is constructed in daily practice, with the school being the setting where pedagogical actions are permanently reworked.

The process of teacher education must ensure constant updating and the development of new competencies to deal with emerging social demands (Vaillant;

Marcelo, 2015). According to Nóvoa (2005), the school has assumed an increasing number of tasks, becoming much more complex and requiring skills from teachers that were not previously required. Imbernón (2010) adds that this accumulation of responsibilities generates uncertainty regarding the teaching role and imposes the need for solutions to increasingly complex problems, often situated beyond individual capacities. We do not defend, however, a form of education aimed at the adaptation of teachers to the adverse conditions of basic education. On the contrary, it must be a space for critical formation and the search for alternatives to processes that tend to undermine the autonomy and working conditions of teachers. Despite the difficulties, it is necessary to insist on the creation of formative spaces that stimulate reflection and the construction of new possibilities.

2 Methodology

Among qualitative approaches, we frame this work as interventionist research of the action-research type, developed from a collaborative perspective. Its characterization as action-research occurred as it articulated the understanding and transformation of the investigated educational reality through problematization, planning, intervention, reflection, and the reorientation of practices. As characterized by Carr and Kemmis (1988), action-research implies a collective self-reflective movement oriented toward the improvement of practices and the conditions in which they take place. In the present study, this movement materialized in the formative meetings, in the shared analyses of texts and practices, and in the joint construction of possibilities for curricular reorganization under the STS perspective.

Parallelly, the research is strongly anchored in the tradition of collaborative investigations, which emerged in the late 1990s as an alternative to traditional practices based on technical rationality, seeking to bring researchers and teachers closer in formative partnerships (Ibiapina, 2016; Teixeira; Megid Neto, 2017). The articulation of these approaches sought to strengthen the dialogic character of the proposal, aiming to break the distance between researchers and teachers, valuing the production of knowledge situated within the school context. The investigation was conducted in a cooperative

environment, in which the first author of this article acted as a mediator and participant in the reflective process, maintaining a horizontal posture with the group.

The project was developed in the context of High School in a public school within the state education system of Bahia. Initially, the proposal was presented to a group of teachers in the areas of Natural Sciences and Mathematics. Despite initial engagement, most participants withdrew over the eight months of work, primarily due to structural reasons, such as the accumulation of workloads in different schools and cities, as well as the absence of pedagogical coordination capable of articulating the Complementary Activities (ACs). The details of the process of constitution of this group and the specifics of the collaborative experience are described in Barros (2018).

Only one teacher remained until the end of the process, so the excerpt presented in this manuscript represents the analysis of this singular experience, whose results must be understood in their context. This aspect, however, does not imply a decharacterization of the collaborative proposal, since this perspective guided the project from its conception, with collective planning, horizontal dialogue, and shared construction of the formative actions that involved the entire initial group (Barros, 2018). In this study, the teacher who remained in the project is identified by the pseudonym Raquel. This teacher holds a degree in Biological Sciences and is a specialist in Biology teaching, with 17 years of experience in the region's public school system.

The research data were produced through participant observation and field records, which composed a reflective memorial prepared during and after each meeting (Lüdke; André, 2013). In total, seven formative meetings took place, initially conducted during the ACs and subsequently at other times and spaces, including classroom actions. At first, the group meetings focused on theoretical studies and reflections using STS Education frameworks (Santos, 1999; Santos; Mortimer, 2002; Teixeira, 2003).

The memorial included descriptions and records of the interactions between the researcher and the participant, transcriptions of the audio recordings of each meeting, and articulations with the literature of the project. According to Bogdan and Biklen (2013), field notes evolve from initial descriptions to the stage of analytical reflections. In addition to the observations, a semi-structured interview was conducted with Raquel at the end of the process to record her impressions of the continuing education experience and articulate

them with the records made by the researcher (Bogdan; Biklen, 2013; Lüdke; André, 2013). The participant's statements were identified by the acronym R-E, followed by the meeting number (for example, R-E05).

Data analysis occurred continuously throughout the development of the project. The audio recordings were transcribed and reviewed, serving as a basis for detailed descriptions and successive revisitings of the memorial. This process allowed for the progressive enrichment of the analytical material, based on the dialogue between empirical data, literature, and the researcher's reflections. Finally, categorical analysis was adopted as the methodological procedure (Bogdan; Biklen, 2013), enabling the identification of patterns and significant elements. The categories emerged gradually from the textual material, as abstractions were constructed from the grouping of data. As pointed out by Ibiapina (2016), this movement of constant revisiting of the data allowed for a deeper understanding of the research corpus and the definition of the molar categories that grounded the discussion of the results.

3 Results and Discussions

Based on the data analysis, the reflections developed throughout the project were organized into three main categories: (a) reflections on the nature of science (NOS) and STS relationships; (b) reflections on the curriculum; and (c) reflections on science teaching and citizenship. We understand reflection as a critical and intentional process that enables teachers to analyze their practice, question assumptions, and reframe their pedagogical choices beyond the technical dimension. In the tradition of Social Reconstruction, Zeichner (1993) argues that reflection must consider social and political contexts, aiming for the transformation of practices toward equality and justice.

In this perspective, we align with the understanding of Binatto, Chapani, and Duarte (2015), who attribute a democratic and emancipatory character to teacher reflection, conceiving practice as a space for the production of knowledge and the problematization of naive conceptions of science and technology (S-T) still present in teacher education.

a) Reflections on NOS and STS Relationships

Within the scope of the formative meetings with Raquel, discussions on the NOS, prompted by the texts analyzed throughout the collaborative process, constituted a central axis of reflection, favoring the deepening of our studies on STS relationships. We reflected on how science is treated in the classroom, addressing issues such as scientism, the non-neutrality of science, the problematization of mythologized conceptions of scientists, and the discussion of science as a dynamic activity embedded in diverse social contexts. Below, we present some of these discussions and reflections.

During one of the meetings, Raquel noted that students frequently arrive at Biology classes with conceptions shaped since childhood, especially regarding mythologized images of scientists. The teacher's observation aligns with a series of studies developed in recent decades that identify conceptions of the NOS and the predominant stereotypes about science and scientists among students and teachers at different educational levels (Kosminsky; Giordan, 2002; Lima; Silva, 2025; Machado; Razera; Guimarães, 2017).

Cachapuz et al. (2005) term this set of distortions an "impoverished" view of science. Besides discouraging students, such conceptions create obstacles to understanding the NOS. In an investigation into possible distorted views of science, the authors list a series of commonly found problems: decontextualized view; individualistic and elitist conception; empirical-inductivist and atheoretical conception; rigid, algorithmic, and infallible view; unproblematic and ahistorical, "finished" view; exclusively analytical view; and accumulative and linear view.

On one hand, we believe that various social spaces (schools, universities, social networks, cinema, etc.) influence the construction of these stereotypes. On the other hand, our classes do not seem to facilitate their deconstruction, as we are excessively concerned with conceptual content to the detriment of building approaches toward issues related to the NOS. In one of her statements, the teacher problematized the topic as follows:

> *I never [...] forget [...] when the Jornal Nacional [national news] presented: 'Now all diseases will be solved; the mapping of the human genome has been completed'; as if it were something accessible to me and you. As if it were like this: ready, now we have the solution to all problems. They use sensationalism (R-E05).*

The teacher's statement points to one of the myths criticized in STS literature: the myth of salvationism (Auler, 2002; Rosa; Auler, 2016; Santos, 2007) and evidences a movement toward problematizing the view of science underlying this discourse. In the continuation of the debate, the teacher added:

> *It's what you say: it is scientifically tested, so it has credit, it has validity. It could be poison, it doesn't matter, but it had the little stamp there [...]. That is, science is infallible [...], whereas, when we study a certain theory, that theory can later undergo changes (R-E07).*

This almost divine perspective attributed to science reveals itself as an obstacle to changing people's positions regarding the *ethos* of science (Santos, 1999), since for many people, errors are not admitted in the process of scientific knowledge production. Such conceptions hinder the understanding of science as a process that also involves intuition, trials, and errors.

Another issue discussed with Raquel was the difficulty students have in understanding the coexistence of more than one theory regarding the same phenomenon. This difficulty is also reinforced by the school when we, as teachers, deny students the opportunity to learn about theories or currents of thought that go against what is understood as "true"; when we offer content disconnected from the history of science and how that science was produced.

By restricting teaching to a single theoretical perspective, one risks denying students the opportunity to know different scientific propositions and explanations for the same phenomenon, which can convey the false impression that scientific knowledge is finished and immutable. Contrasting such a perspective, Santos (1999) argues that scientific knowledge is always provisional and uncertain, being continuously revised and reconstructed in light of new discoveries. It is important to define that we are addressing here the importance of working with the confrontation of scientifically grounded theories, rather than denialist arguments and/or those linked to so-called pseudosciences.

Raquel also highlighted how Biology and Science textbooks often present narratives about biological evolution that devalue the contribution of Jean-Baptiste Lamarck, despite his relevant role in proposing that species change over time. In this sense, incorporating elements of the History of Science is fundamental to problematizing

simplistic and preconceived views that still persist in didactic materials (Krizek, 2024; Martins, 1998).

In another moment of discussion, the teacher pointed out that the way Biology—and education as a whole—is fragmented makes it difficult for themes such as these to be developed in class, as each teacher remains enclosed in the world of the canonical content of their discipline. She also considers that the workload for the Biology discipline is not sufficient to address so many specific aspects of the content plus discussions on the History of Science and the NOS. The question of what to prioritize in class ends up being a choice made by teachers, and in this universe of important things, aspects of the NOS tend to be neglected.

Raquel also criticized the repetition of practical classes with predictable results which, despite their experimental appeal, reinforce a reductionist and spectacularized view of science restricted to the laboratory. The repetition of these stereotypes among students and teachers suggests that teacher education also contributes to their perpetuation, as we have not been deconstructing such problematic representations (Machado; Razera; Guimarães, 2017). Faced with this reality, we emphasize the need for the systematic insertion of discussions on the NOS in teacher education, recognizing STS studies as important triggers for this movement.

As a possible way to overcome these problems, Machado, Razera, and Guimarães (2017) mention the inclusion of historical approaches to Science that are capable of contemplating the details involved in the processes of knowledge construction. In the authors' words: “[...] if the nature of scientific knowledge is not questioned, teachers will teach an ideology that reinforces and dogmatizes methods and techniques of a science that no longer exists” (Machado; Razera; Guimarães, 2017, p. 635).

We believe that achieving an education that problematizes S-T issues is directly related to the level of teacher education. Providing students with more complex discussions requires that teachers be trained within this same perspective. It appears that the collaborative process examined here allowed the teacher to take some interesting steps in this direction.

b) Reflections on the Curriculum

As reflections highlighted in this category encompass aspects of the challenges faced in consolidating a curriculum aligned with an STS Education project when, in practice, the pedagogical approach developed in schools seems to move in a divergent direction. The primary issue discussed centered on the following question: how can STS discussions be prioritized in a school reality where the curriculum and assessment essentially prioritize the teaching and learning of canonical contents, as defined by Santos (1999)?

By canonical contents, according to the aforementioned author, we understand those traditionally present in school curricula that primarily value their academic and disciplinary character, generally decontextualized and distant from social, cultural, and political dimensions, among others.

In this discussion, Raquel also expressed concerns regarding the student assessment system, arguing that the National High School Exam (Enem) and university entrance exams (vestibulares) do not align with STS Education, which, in her view, hinders its implementation in the classroom. She proposed the following question:

> *What is the use of my Biology succeeded in forming a critical citizen in Biology if, in the entrance exam, he has to know what mitosis and meiosis are [...]. The big problem is this: you modify high school and the entrance exam... I mean, the entrance exam is the stepping stone... because if the student follows this Science-Technology-Society shift for you to work with in the classroom, they will not succeed in the entrance exam (R-E02).*

Investigations conducted on Enem between 2009 and 2016 indeed point to a purely conceptual and disciplinary profile of the evaluative process regarding the Natural Sciences, with little attention paid to the Society dimension and issues involving citizenship (Cunha, 2021; Stadler; Hussein, 2017). However, a more recent study indicates a significant advancement on this issue, suggesting the increasing insertion of STS dimensions in the exams between 2015 and 2022 (Mendes et al., 2024).

Starting from the teacher's concerns regarding the possible neglect of scientific content, we discussed some objectives of STS Education suggested by one of the texts studied: a) acquisition of knowledge; b) utilization of skills; c) development of values (Santos; Mortimer, 2002). Raquel considered this structure interesting, as it aims for both

the dimension of values and that of scientific content. Thus, she understood that the idea of setting content aside is not a premise supported by STS Education.

We also discussed the curricular categories presented by Aikenhead (2005). The teacher stated that she perceived herself operating between categories 2 and 3[1]. Despite finding a curriculum that offers more space for social issues and themes interesting, such as categories 4 and 5, Raquel argued the following:

> *As a teacher, I'll tell you one thing: one of the difficulties I have in working with social themes is precisely the number of classes. In the case of our school, there is no way to work with those two Biology classes given such an absurd curriculum [...] (R-E06).*

Based on this issue, we presented and discussed with the teacher the perspective of "STS grafts" (*enxertos CTS*) (García; Cerezo; López, 1996), in which STS themes are included in classes and related to scientific content, the true guides of the curriculum. We also emphasized that in the current form of curricular organization in Basic Education—marked by disciplinary division, content-based structuring, and the teacher education model itself—the implementation of an approach entirely based on STS (Aikenhead's category 8) proves to be unfeasible.

However, this does not invalidate the relevance of STS grafts or, according to Aikenhead's (2005) definition, the progressive incorporation of STS elements into the traditional curriculum, maintaining attention to scientific content while enriching it with social, technological, and cultural problematizations. Utilizing this strategy in class, even gradually, is an important step toward breaking with the purely content-oriented tradition. Despite the progress in discussions, the teacher reiterated her difficulties in operationalizing STS Education in High School: *"In High School, there is no way [...], here is content that won't fit, there is content that is very distant, so it's better for you to be more conceptual" (R-E06).*

Such an argument demonstrates a posture of resistance to changes and, to a certain extent, reveals skepticism regarding the proposal of different curricular alternatives.

[1] The curricular classification proposed by Aikenhead (2005) comprises the following categories: (1) STS content as a motivational element. (2) Occasional incorporation of STS content into the syllabus. (3) Systematic incorporation of STS content into the syllabus. (4) Scientific discipline (Chemistry, Physics, and Biology) through STS content. (5) Science through STS content. (6) Science with STS content. (7) Incorporation of Sciences into STS content. (8) STS content.

The extensive curriculum and limited time lead many teachers to prioritize the fulfillment of pre-fixed content in formal curricula and/or textbooks to the detriment of reflective practices. Given this, it is essential to point out that teachers must exercise their autonomy in choosing themes to be taught and selecting methodological strategies to be employed in class.

At this point, a debate emerged regarding possible alternatives for curricular reorganization capable of overcoming disciplinary rigidity and favoring interdisciplinary practices. This involves the proposal of a curriculum without disciplinary boundaries, where contents cease to be compartmentalized to be worked on in an integrated manner, based on thematic axes or concrete problems from reality.

Faced with this perspective, the teacher argued that an interdisciplinary reorganization requires a solid mastery of content. She recognized, however, that while she cannot promote structural changes, she envisions the possibility of developing approximations and specific proposals in that direction:

> *There's no point in deluding ourselves and thinking we're going to apply this here [referring to the STS program - category 8]. I'm going to continue being that teacher who works through all the content; if it's possible to apply an STS theme, I'll include it, but there will be a Science fair, and I've already had a different look at it. Why did I have that look? Because I'm having these conversations (R-E06).*

Her statement at this moment reveals a tension between the practice she has consolidated over the years and a willingness to change, evidencing resistance regarding further progress:

> *We have to start creating moments, making this happen. Even if we can't... we have no way to change. I, for example, in my head, I have no way to change the Biology textbook, but I can create STS situations that lead my students to really think... (R-E07).*

The teacher's statements indicate an ambiguous stance: although she manifests skepticism toward structural changes, she demonstrates openness to performing possible interventions within her reality. Thus, the collaborative experience seems to have expanded her willingness to reflect, question consolidated practices, and envision new paths, indicating that initiatives of this nature can "plant seeds" for future transformations, as she herself expresses at the end of the project: "I'll tell you one thing, as long as I work in education, I'll want to be STS" (R-E07).

Although we cannot claim that participation in the project resulted in concrete and immediate changes in the participating teacher's practice, it is possible to recognize signs of a process of awareness and openness to new perspectives that may favor transformations in her professional performance.

c) Reflections on science education and its relationship to citizenship education

Discussions regarding the social dimension of the STS triad also emerged throughout all the formative meetings. In one of these moments, the teacher highlighted the influence of capitalism on people's thinking and on educational programs, which, in her opinion, prioritize technical training as if that were sufficient to form good professionals.

Raquel exemplified this issue by reporting an episode experienced at the school when, during the awareness period for vaccination against the Human Papillomavirus (HPV), some parents of students did not accept that their daughters receive the vaccine. One of them even sought her out to claim that his daughter did not need to be vaccinated because, as a religious person, she would not have casual sexual relations, and that the vaccine would represent a kind of incentive for the early start of the adolescents' sexual life. The teacher drew attention to the influence of cultural and religious issues on the construction of students' knowledge.

Another problem addressed by Raquel was related to cases of adolescent pregnancy among the school's students and the high dropout rates associated with this and other issues of a social nature:

> *The whole point is that the state does not seek to find out what led the student to drop out. The state is not going to want to know something for which it already knows the answer—it is social. They do not want to hear that; they want to think: 'Ah! The class was not interesting; the student likes to idle; the teacher is absent too often.' It is much easier to keep looking at it that way, deducing that (R-E04).*

The set of the teacher's reports reinforces the importance of including discussions in class that articulate scientific knowledge with social and cultural aspects, highlighting the responsibility of educators to promote a type of education oriented toward citizenship. However, this approach can represent a challenge for many teachers. Teixeira (2009), when investigating Biology teachers' representations of education for citizenship, identifies

difficulties such as: gaps in initial and continuing education; precarious working conditions; and a lack of clarity regarding the propositions contained in curricular documents.

Another aspect discussed was the distance created between individuals and the responsibilities they should assume as citizens, especially regarding participation in decisions and discussions about scientific and technological processes. In this regard, Raquel stated: “We only think about citizenship at two moments: at the time of the birth certificate and at the time of voting. You get a birth certificate to be a citizen; you get a voter registration card to be a citizen” (R-E05).

Within this context of discussions, we dialogued about the importance of disciplines in the areas of Human and Social Sciences to support such issues, emphasizing the necessary interdisciplinary character of STS Education. The teacher argued: “In a discussion like this, which science would enter there? Sociology. There, sociology is fundamental, and it is not seen as a science” (R-E05).

The articulation of Human and Social Sciences with STS-oriented discussions contributes to situating scientific knowledge within its historical and social context, evidencing that science is neither neutral nor isolated, but a human endeavor permeated by political, cultural, and ethical dimensions that must be considered in educational processes.

The issue of “decision-making” was also debated, being one of the central concepts of STS Education that can be used in discussions of themes of social interest. The teacher illustrated the discussion using the theme of consumerism, drawing attention to the importance of considering not only economic criteria, such as efficiency and price, but also ethical and social aspects, including the working conditions involved in production and the possible illegal origin of certain products. She emphasized, however, that in our daily practice, the tendency to evaluate only criteria such as efficiency or economic value prevails, disregarding the social dimension involved in the context of production and consumption of products derived from activities linked to S-T.

We drew attention to the importance of sharing responsibilities when dealing with issues involving S-T that, in some way, articulate with socially relevant demands. In this sense, we need to help develop in our students a responsibility for their actions and for contributing to the construction of a fairer society. In this regard, Raquel argued:

> *"You know that thing, that old story? I'm going to do just like Pilate: 'I wash my hands! You know? It's not my problem; it was the fault of whoever created it; it was the fault of whoever voted; it was the fault of whoever started the war; it was someone's fault; someone's.' It is always attributed to third parties" (R-E07).*

The teacher's statement highlights a central aspect of current discussions regarding S-T: the necessity of sharing responsibilities. The excerpt reveals a common social behavior—namely, the transfer of blame and omission in the face of collective problems, illustrated by the justification that "it is always someone else's fault." In STS Education, this awareness of co-responsibility must be cultivated from basic education so that students become conscious agents of their role in building a fairer future for all.

Another point discussed in our meetings was the need to seek a form of teaching that transcends the objectives of mere academic or preparatory training for students. The teacher emphasized that it is important to work on more than just what "appears most" on university entrance exams or the *Enem*:

> *"It's like I sometimes tell some colleagues: 'Ah! I'm not going to teach that subject.' I say: 'Folks, that doesn't exist. I don't know what my student will be tomorrow. If I don't know what they will be tomorrow, I'm going to teach everything. Not everyone is going to think like a scientist.' It's as if someone without an education were nothing. I always say: 'Study to be happy.' I had one student who really liked tractors. I told him: 'You are a very good tractor driver, but to get your license more easily, you have to study. Study so you can get licensed.' To another, I said: 'Don't you like being a cowboy? You can be a cowboy, you can be a tractor driver, a street sweeper, whatever you want, as long as you don't limit yourself'" (R-E07).*

Based on the arguments presented by Raquel, we consider that the teacher holds a very favorable view toward working with education focused on citizenship formation. Although she views certain difficulties as limiting and, at times, shows skepticism regarding the changes necessary to achieve this, she also understands the importance of education for the broader development of her students as citizens. She believes this should be a relevant aspect of her practice, which, in our view, is a positive factor that opens pathways for possible changes.

5 Final Considerations

Based on the data produced, we identified and analyzed three categories of reflection resulting from the teacher's involvement with the STS Education frameworks. In

this sense, the study highlights the concrete tensions experienced by the teacher when trying to bring her practice closer to these frameworks.

The analysis developed reaffirms challenges already described in the literature, while also explaining how they materialize in everyday school life, evidencing movements of resistance, ambivalence, and openness to change. Thus, we understand that an important contribution of the work lies in the process-oriented understanding of continuing education as a space of potential for the problematization and resignification of teaching conceptions, indicating that, even in the face of institutional limits, it is possible to build ruptures in the traditional content-oriented model.

The category pertaining to reflections on the nature of science included discussions that appeared in all recorded meetings, highlighting the following points of reflection: critique of scientism and the neutrality of science; problematization of stereotypes about science and scientists; science as a dynamic, potentially changeable activity; critique of deformed views of science; problematization of the idea of the infallibility of science; importance of the History of Science for teaching; and limited teacher training in terms of discussions on the NoS.

In summary, promoting a critical approach to science in the classroom requires not only a change in posture but also investments in training and support for teachers, aiming to foster pedagogical practices that contribute to the formation of more conscious and engaged citizens. In this sense, providing discussion spaces oriented by the assumptions of STS Education proved to be a tool with the potential to incite such discussions.

In the category relative to reflections on curriculum, its relationship with evaluative processes in daily school life was identified as an obstacle to the implementation of STS Education, with attention to the following elements: lack of alignment between the current curriculum and STS Education; critique of current curricular documents; critique of market influences on curriculum production; disciplinary fragmentation of curricula; potential of STS "grafts"; problems between the purposes of High School—when thought of only as a bridge to Higher Education (entrance exams, Enem, etc.)—and the more systematic adoption of STS proposals; and the tension between citizenship education and preparation for the aforementioned exams.

Although systemic changes are necessary, collaborative projects and those following the experiences of communities of practice, such as the one described in this study, can favor progress in the understanding of STS interrelations and unveil ideologies linked to S-T (Auler, 2002). We recognize that there is still much progress to be made, but such interventions certainly represent forms of resistance to the difficulties explained.

Finally, in the category of reflections on Science teaching and its relationships with citizenship education, we saw that the process developed enabled relevant reflections in this regard. The discussions highlighted: the importance of ethics in science education; the critique of technical training; the defense of approaches that integrate sociocultural aspects; the impact of beliefs and cultures on conceptions about science; the influence of social inequalities in schools; the low participation of the population in scientific and technological decisions; the limited view of citizenship held by people; the fundamental role of Human and Social Sciences in constructing analyses of the reality in which we live; the need for conscious consumption and social responsibility; and the critique of the tendency to neglect the responsibilities inherent in our social engagement.

The reading and discussion of theoretical texts were essential to avoid discussion approaches based only on common sense and to promote a deeper problematization with the potential to transform teaching practices. Thus, the intensification of the use of these frameworks is necessary, especially in teacher training, since the contributions of STS Education and collaborative research stimulate reflective processes and strengthen the political and social commitment of the school in citizenship education.

It is important to emphasize that the results presented here stem from the monitoring and analysis of the training process developed with only one participating teacher, without pretensions of establishing generalized inferences. It is not, therefore, about extending conclusions and predictions, but about understanding a situated case whose singularities, training trajectories, working conditions, and school context also influence the reflections and tensions evidenced. Thus, the constructed analytical categories should be interpreted as indicative of emerging possibilities and problematizations that offer clues and theoretical-methodological subsidies for new investigations and training experiences.

Despite the difficulties in implementing practices based on STS, we understand that such obstacles should not prevent the engagement of teachers in the necessary changes.

With persistence and, above all, resistance, it is possible to advance gradually in the consolidation of teacher training spaces more consistent with the complexity of schools and the contemporary world.

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Raviéllen Vieira Barros, State University of Southwest Bahia (UESB), Graduate Program in Science Education and Teacher Training, Research Group in Science Education and the STS Movement.
[i] https://orcid.org/0009-0007-1100-1446
Master and doctoral student in Science and Mathematics Education at UESB. Teacher in the state education network of Bahia.
Author Contribution: Project administration, formal analysis, conceptualization, data curation, writing – original draft, investigation, methodology, and resources.
Lattes: http://lattes.cnpq.br/2165661027098663
E-mail: raviellen.uesbio@gmail.com

Paulo Marcelo Marini Teixeira, State University of Southwest Bahia (UESB), Graduate Program in Science Education and Teacher Training, Department of Biological Sciences.
[ii] https://orcid.org/0000-0001-9359-7763

PhD in Education from the State University of Campinas (Unicamp), with a post-doctorate from the same institution. Professor in the Department of Biological Sciences at UESB and in the Graduate Program in Science Education and Teacher Training.
Author Contribution: Project administration, formal analysis, conceptualization, writing – review and editing, methodology, supervision, validation, and visualization.
Lattes: http://lattes.cnpq.br/7287284883600014
E-mail: pmarcelo@uesb.edu.br

Beatriz Santos da Silva, Bahia State Secretariat of Education, Colégio Estadual de Ipiaú
[iii] https://orcid.org/0009-0004-1059-4524
Licensed in Biological Sciences from the State University of Southwest Bahia (UESB), specialist in Biology Teaching. Teacher of Science and Biology in the state education network of Bahia and the municipal education network of Gongogi.
Author Contribution**:** Formal analysis, writing – review and editing, investigation, resources, validation, and visualization.
Lattes: https://lattes.cnpq.br/2805528360276534
E-mail: biamarte@hotmail.com

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***Ad Hoc Partners*:** Daniel Azevedo de Brito and Claudio Alejandro Barrientos Piñeiro

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