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Initial teacher training from the QSC perspective articulated with the STEAM approach

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Abstract: In this study, we used the Socioscientific Question (SQ) linked to the theme "pollution of the Bodocongó Reservoir", articulated with the interdisciplinary knowledge of the areas that make up the STEAM approach. The aim was to identify the contributions of these approaches to the initial training of teachers. The methodological path began with a training course on the use of SQ and STEAM approach in the Basic Education classroom, divided into three stages: presentation of the course; discussions on SQ and STEAM references; and elaboration of an SDII on the topic in question. The participants were 15 students from different undergraduate courses at UEPB. The data collection instrument was a questionnaire with two subjective questions. In turn, the obtained data were analyzed in light of the Collective Subject Discourse (CSD) framework. The results of CSD 1 and 2 justify the contributions of the training course to the initial training of these teachers.

Keywords*:* Transdisciplinarity. Collaborative Work. Training Perspectives.

Formación inicial docente desde la perspectiva QSC articulada con el enfoque STEAM

Resumen**:** En este estudio utilizamos la Cuestión Sociocientífica (QSC) vinculada al tema "contaminación del Embalse Bodocongó", vinculada al conocimiento interdisciplinario de las áreas que conforman el enfoque STEAM. El objetivo fue identificar las contribuciones de estos enfoques a la formación inicial docente. El camino metodológico se inició con un curso de capacitación sobre el uso de QSC y el enfoque STEAM en el aula de Educación Básica, dividido en tres etapas: presentación del curso; debates sobre los puntos de referencia QSC y STEAM; y preparación de un SDII sobre el tema en cuestión. Los participantes fueron 15 estudiantes de diferentes carreras de la UEPB. El instrumento de recolección de datos fue un cuestionario con dos preguntas subjetivas. A su vez, los datos obtenidos fueron analizados a la luz del marco del Discurso del Sujeto Colectivo (CSD). Los resultados de DSC 1 y 2 justifican las aportaciones del curso de formación a la formación inicial de estos docentes.

Palabras clave: Transdisciplinariedad. Trabajo Colaborativo. Perspectivas de Formación.

Formação inicial de professores na perspectiva QSC articulada com abordagem STEAM

Resumo: Neste estudo, utilizamos a Questão Sociocientífica vinculada à temática "poluição da Açude de Bodocongó", articulada aos saberes interdisciplinares das

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áreas que compõem a abordagem STEAM. O objetivo foi identificar as contribuições dessas abordagens na formação inicial de professores. O percurso metodológico iniciou-se com um curso formativo sobre o uso de QSC e abordagem STEAM em sala de aula da Educação Básica, este foi dividido em três etapas: apresentação; discussões sobre referenciais QSC e STEAM e elaboração de uma SDII sobre a temática em tela. Os participantes foram 15 estudantes de distintas licenciaturas da UEPB. O instrumento de coleta de dados foi um questionário com duas questões subjetivas e os dados obtidos foram analisados à luz do referencial do Discurso do Sujeito Coletivo. Os resultados dos DSC 1 e 2 apontam contribuições para a formação inicial dos participantes, portanto, os dados revelaram um aprendizado dinâmico e significativo aos envolvidos no processo.

Palavras-chave: Tema Social. Abordagem Transdisciplinaridade. Perspectivas Formativas.

1 Introduction

Educational challenges in contemporary society are broad and reflect the rapid and complex changes that the world is facing (Amorim, 2024). In this sense, education systems have been adapting to social and technological demands, with the aim of providing equal and quality access to education for all people. These changes are the result from growth population and technological advances, which have generated environmental impacts due to the inadequate disposal of solid, liquid and technological waste produced by contemporary society (Lopes *et al*., 2024).

In this context, educational actions must meet the preparation of students, aiming at reflection and action in relation to climate issues, environmental conservation and sustainable development, which constitutes a challenge for educational institutions in integrating sustainability into school curricula effectively (Cunha, 2017). In this sense, Dionor and collaborators (2020) state that teachers and schools must organize planning based on social themes relevant to students and the school community.

The beginning of 1960s was marked by the emergence of education based on Science, Technology and Society (STS) in Europe, the United States, Canada and Australia. In Brazil, its milestone occurred in the 1970s, with the aim of providing discussions on the challenges of implementing science and technology in the social context, in addition to reflecting on the ethical, environmental and technological dimensions (Cunha, 2018). Still in the national scenario, studies in STS were consolidated with the research of Mortimer, Roseli Pacheco and Santos, which indicate that training for citizenship in education is part of the context of the literacy movement in science and technology (LCT). In turn, Santos (2007) states that this has been

associated with studies of public understanding of science for all and education in STS - Science, Technology and Society (Campello, 2003; Mamede and Zimmermann, 2005; Cunha, 2017). In this line of research, the main definitions have been synthesized by different authors and periods, building theoretical contributions to support this field of STS research (Santos, 2007; Santos, 2012).

In this perspective, Santos (2012) states that pedagogical practices and academic research in science teaching have given increasing attention to Social Scientific Issues (SSI), and several researchers have focused on investigating the use of SSI as a guiding axis in the process of articulating popular, school and scientific knowledge (Pansera and Carvalho, 2017). Scientific literature reports that the use of SSI allows us to discuss the problems arising from the growing industrialization process, which, when carried out inadequately, has harmful consequences for the environment, such as climate change, intense droughts, loss of biodiversity, burning, forest fires, deforestation, water scarcity and soil degradation. Therefore, it is necessary that QSCs are discussed in teaching-learning processes with the intention of raising awareness among people about the importance of environmental preservation, in addition to collaborating with the learning of popular, academic and scientific knowledge, as well as contributing to professional training.

In agreement, this research is a section of related data to a stage of the doctoral thesis of the first author in the postgraduate program in science teaching and mathematics education – PPGECM/UEPB. This study is part of the field of socio-environmental studies, with the purpose of collaborating with the initial training of teachers based on the QSC entitled pollution of the Bodocongó Reservoir. Regarding the methodological aspects, the research was articulated with the STEAM approach, from the English Science, Technology, Engineering, Arts and Mathematics, with the purpose of discussing problems linked to the social issue of the Bodocongó Reservoir.

In this sense, the research problem arose: is it possible to collaborate with the initial training of teachers based on the developments of the QSC entitled “pollution of the Bodocongó Reservoir”, articulated with the STEAM approach, considering the ethical, economic, historical and socio-environmental aspects present in the water source? Social Scientific Issues aligned with STEAM practice connect science to students' daily lives, providing them with opportunities to learn science in a broad context and in their surroundings, in addition to collaborating in facing challenges that

are linked to their social reality, which are culturally relevant and naturally connect to various subjects in the school curriculum (Won et al., 2021).

Therefore, this research aimed to develop an integrative investigative didactic sequence (SDII) to teach school content in basic education using the STEAM approach based on the QSC “Pollution of the Bodocongó Reservoir”, focusing on the teaching-learning-application triad, in addition to observing whether the actions of the training course enabled the development of teaching skills and competencies for teaching in the contemporary world, verifying whether the socioscientific themes contributed to the professional training of the study participants.

According to Won and collaborators (2021), socio-scientific issues aligned with STEAM practice connect students with the reality of their daily lives, by addressing SCI with the STEAM approach, contributing to the education of students, bringing together STEAM areas in the teaching process. This, in this way, allows for a broad view of knowledge, given the integration of teachers in the planning of school activities.

2 Theoretical aspects of SCI and STEAM approaches in Basic Education

The STS education movement has repercussions in contexts linked to the speed with which science and technology develop and directly or indirectly interfere in social relations, adding to society's participation in decision-making processes (Santos, 2007; Santos, 2012; Cunha, 2017; Cunha, 2018). In this sense, science teaching curricula with an emphasis on STS have been developed worldwide since the 1960s. The central objective of these curricula is to prepare students to exercise citizenship, characterized by an approach to scientific content based on the students' social context (Santos and Mortimer, 2002; Santos, 2007).

According to Auler and Bazzo (2001) and Santos (2012), contemporary changes and social dynamics contribute to scientific and technological development, meeting the demands of society. At this point, it is important to highlight that society has the right to participate in the decision-making processes that involve its destiny, considering the democratization of decision-making processes as a fundamental premise.

In this context, Santos (2012) states that the use of SSI in teacher training offers a solid structure to involve students and teachers in a meaningful and relevant scientific

discourse for the development of students' scientific literacy. However, although most teachers recognize the value of working on SSI in their pedagogical practice, they report having limited knowledge about SSI and often do not have the confidence and support necessary to articulate the knowledge linked to SSI.

School work with QSC implies initial training that enables students to engage with these topics, giving them the confidence to discuss socio-scientific issues that are embedded in the local and global context, considering that understanding the socio-cultural problems in which they are inserted constitutes a fertile field for the construction of school and scientific knowledge, as well as its relationship with social, cultural, environmental and ethical factors (Santos, 2012; Cunha, 2018).

In this scenario, Ribeiro states that QSC discussions “contribute to the scientific education of citizens, as they present the potential for constructing an image of real and human scientific activity and promote essential skills for active and responsible citizenship” (Ribeiro 2021, p. 80). Corroborating this thought, Martinez Pérez (2012), Silva et al. (2017), Pugliese (2017) and Hendrickson et al. (2020) state that, through the STEAM approach, it is possible to articulate QSC knowledge using interdisciplinarity between areas of knowledge. With this approach, students understand the content to explain real-world phenomena and problems, which are not limited to the school environment, but relate to different knowledge in different contexts in which they are inserted (Pugliese, 2017).

From this perspective, STEAM education is an integrative approach that allows the development of argumentation with the elaboration of actions and the resolution of problems faced in local communities, in addition to outlining a path of broad and contextualized analysis of the problem investigated, working with knowledge without limitations of areas and promoting reflective thinking about the object of investigation. In this sense, these actions contribute to the development of individual and collective protagonism among students, teachers, and representatives of the school community (Calil and Pugliese, 2019; Chung *et al*., 2020; Sigit, Ristanto, and Mufida, 2022; Chistyakov *et al*., 2023).

In this context, STEAM approach highlights the dimension of sustainability, articulating it with economic, political, social, and individual decisions, which need to be part of an education based on problem-solving. These problems are considered necessary to introduce dialogues and develop the skills and abilities required by

society in the 21st century, as well as to relate to issues linked to the Sustainable Development Goals (Haesen and Put, 2018; Calil and Pugliese, 2019; Chung *et al*., 2020; Sigit, Ristanto, and Mufida, 2022).

The STEAM approach has at its core three main anchors of the teaching and learning process: i) The teaching-learning methodology, which should be based on projects or challenges connected to the students' social contexts, as well as the development of vocation for future professional choices; ii) The curriculum, which is organized by competencies and with interdisciplinary integration between areas of knowledge; and iii) The work developed at school, which should be linked to issues of the students' social context, as well as its relevance to social problems (Haesen and Put, 2018; Bedar and Al-shboul, 2020; Sigit, Ristanto and Mufida, 2022; Sung, Lee and Chun, 2023).

Work with the STEAM approach at school should consider pedagogical strategies according to the dichotomy of school curriculum versus teaching practices, with an interdisciplinary view between areas of knowledge. From this perspective, the teacher is the mediator of the teaching process and, in turn, the students are the protagonists of the construction and application of school and scientific knowledge in solving sociocultural problems, respecting the plural aspects of the community in which the school and the students are inserted (Holbrook, Rannikmäe and Soobard, 2020; Yohan Hwang et al., 2023).

3 Methodology

This research is anchored in the qualitative method, which emphasizes the understanding of the phenomena to be investigated. This method allows for a better understanding of the actions in a given teaching-learning process. From this perspective, Borba, Almeida and Gracias (2018) state that research needs to be complemented by proposals that analyze daily school life, pointing out that the qualitative method is the most appropriate, since it allows different perspectives on the objects of study in the educational field.

In this context, the research carried out was exploratory in nature, which, according to Gasque (2007) and Gil (2019), aims to "explore" in order to provide greater familiarity with the research problem, aiming at the construction of hypotheses. To this end, exploratory research uses a methodology anchored in bibliographical

research, interviews, application of instruments with people who have had practical experience with the problem investigated, in addition to analysis of examples that stimulate the understanding of the researched object. In these examples, there is an improvement of ideas or the discovery of intuitions observed in the classroom, which, in itself, is a space for exploration, as it allows the researcher to explain ideas often raised by the participants during the presentation of the research problem (Gil, 2019).

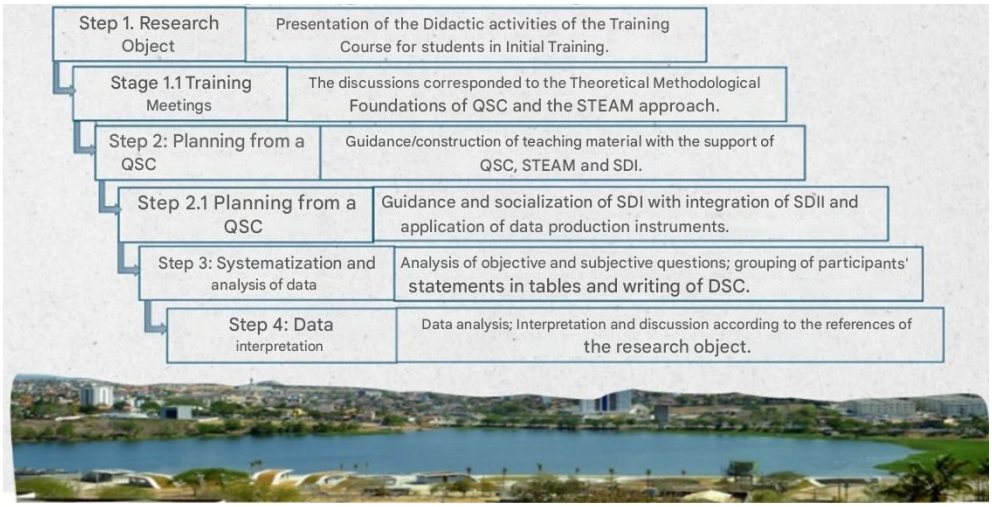
With this guideline, it is important to point out that the teacher-researcher cannot carry out research in isolation. It is necessary that it be in line with all the legal prerogatives of the school space and its articulation with the elements of the school curriculum, as well as with the skills and competencies recommended by official documents. Furthermore, cooperative activities should be considered to enable the exploration and articulation of knowledge from different areas of the curriculum. These aspects are important to deepen and understand the nuances of the research (Gil, 2019; Ventura, 2007).

The methodological path of this research was organized in three stages. The first was the presentation of the training course entitled Use of Socioscientific Issues with a STEAM Approach, in which the course activities were presented and their relevance to the training process was justified, as well as their inclusion in basic education, in addition to providing a reflective environment in the training process of the research participants. In the second stage, the researchers held discussion groups with the participants about the theoretical contributions of the QSC and the STEAM approach, respectively. In this segment, the actions involved training activities for planning the research actions. The third stage, in turn, consisted of orientation meetings for the elaboration of the investigative didactic sequences (SDI) on the QSC Pollution of the Bodocongó Reservoir. Subsequently, the SDI plans were integrated between the STEAM areas and formed the Integrative Investigative Didactic Sequence (SDII).

The study was developed at the Oficina Pedagógica de Química, located in Block A of the Centro de Tecnologia e Ciencia of Campus I of the Universidade Estadual da Paraíba, in Campina Grande, PB. This study was articulated with the contributions of the QSC and the STEAM approach. In its development, the QSC entitled Pollution of the Bodocongó Reservoir was the object of investigation. Figure 1, below, shows the systematization of the planning and methodological path of the

research stages.

Figure 1: Flowchart of the research methodological path.



Source: Research collection.

As shown in Figure 1, the stages of the training course were composed of distinct moments. The first moment involved the presentation of the proposed activities for the training course on Socioscientific Issues (SSI) and the STEAM Approach. At the end of this moment, students were invited to participate in the course entitled Use of Socioscientific Issues Articulated with the STEAM Approach. The second moment was characterized by the first stage of the training course. These moments were held over a period of eight weeks, with two-hour meetings per week.

Dialogues and interactions between teacher-researcher and student and student-student were prioritized in these meetings, with the aim of sharing academic, popular, and scientific knowledge, anchored in the scientific literature on the theoretical and methodological assumptions that articulate the understanding of SSI. Regarding the understanding of the theoretical and methodological assumptions of the STEAM approach, these were addressed in seven weekly meetings, each lasting two hours. In these meetings, the researcher mediated the dialogue with the research participants by presenting slides, scientific articles and books, showing the importance of this approach for working with transdisciplinarity in basic education schools. It was understood that this approach is worked from a project perspective, which must start from a social theme and consider the context of the school. This justifies its alignment with socio-scientific issues.

The third stage of the training course began with a discussion circle mediated by the research teachers, who directed the activities related to socio-scientific issues

and their importance for work in the classroom in Basic Education. During the discussion circle, questions were raised regarding the approach to SSI in the planning of teaching activities: i) Why do we advocate that SSI be worked on in basic education?; ii) What would be the best SSI?; iii) To work with SSI, should we choose a specific pedagogical approach?; iv) Can SSI be approached from a transdisciplinary perspective?

During these questions, the research participants argued that SSIs in schoolwork, in general terms, promote critical thinking, lead students to make ethical decisions, enable engagement with social issues and contribute to the understanding of science in real and relevant contexts. By exploring SSIs, students are encouraged to reflect on how science impacts their lives and society, developing greater critical awareness — with interdisciplinary and transdisciplinary learning — and promoting students' ability to solve complex problems.

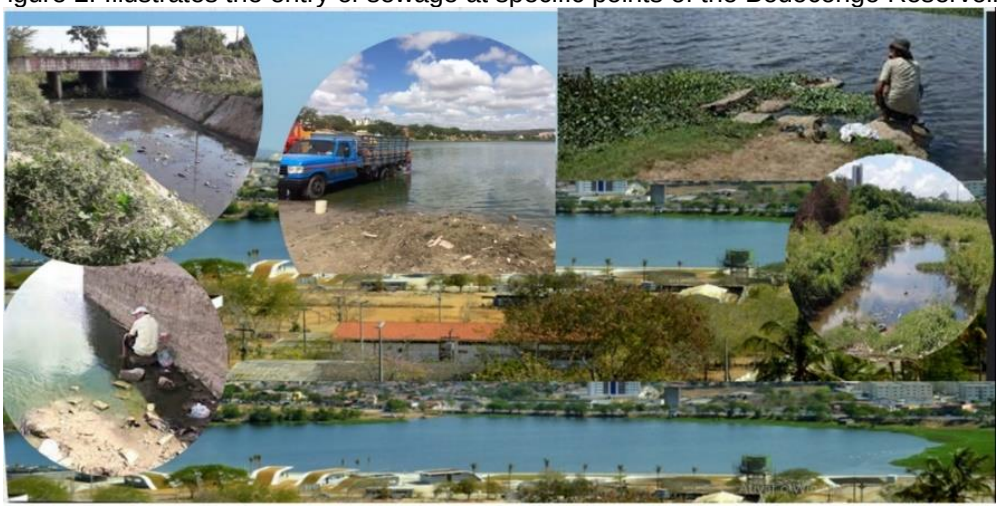
Then, researchers and participants reflected on the actions, procedures and reflections arising from the training course, seeking to mitigate the difficulties encountered throughout the course. At this point, the researchers asked participants to present questions that considered SSI, presenting issues related to deforestation, environmental pollution, electronic waste, basic sanitation, water scarcity, river pollution, pesticides, healthy eating, Bisphenol A (BPA), among others. At this point, collective considerations were made on the topics presented. The researchers then presented the problem of pollution at the Bodocongó Reservoir and invited participants to visit the site.

After visiting the water source, the participants decided that the social theme to be articulated with the teaching process would be the QSC entitled Pollution of the Bodocongó Reservoir, since it is a historical environment for Campina Grande - PB. Another point was that this QSC includes school subjects from the BNCC and the diversified base of high school education, corroborating the research of the first author, focused on the STEAM approach and the QSC. Figure 2 shows some records made during the on-site visit.

Based on discussions on the chosen theme — Pollution of the Bodocongó Reservoir — socio-environmental problems were listed and, based on them, guidelines were constructed for planning anchored in the STEAM approach and in the QSC, with direct application in the classroom from a collaborative perspective. Next, a

conversation circle was held with reflective discussions on the critical points of the water source. This was an important action for the construction of STEAM activities, which corroborates the understanding of the QSC. To seek solutions to the problems of the Bodocongó Reservoir, the participants presented contributions and suggestions related to their areas of activity, with the aim of collaborating with possible solutions to the problems listed in the visit to the reservoir. The SDII constitutes the planning of the actions of the training course. At this stage, the research teachers sent a calendar to the participants, informing them of the beginning of the production of teaching materials linked to the QSC. Subsequently, the meetings were weekly, collective and/or individual with the research teacher. On these occasions, it was possible to develop investigative didactic sequences (SDI), which later became the integrative investigative didactic sequence (SDII), based on the QSC Pollution of the Bodocongó Reservoir with the insertion of the STEAM approach.

Figure 2: Illustrates the entry of sewage at specific points of the Bodocongó Reservoir.



Source: Research collection.

The scientific literature reports that the didactic sequence, module or unit has been a topic of interest in the Education area for quite some time. Zabala (1998) states that the Didactic Sequence (DS) is a unit of pedagogical intervention consisting of a "set of ordered, structured and articulated activities for the development of educational objectives with a beginning and end known to teachers" (Zabala, 1998, p. 18). It is an instrument with well-defined theoretical assumptions, which involve its planning, elaboration, application and validation, strengthening pedagogical practices (Giordan, Guimarães and Massi, 2011; Motokane, 2015). In line with this thinking, Motokane (2015) states that an investigative didactic sequence collaborates with the teaching

approach through active investigation and discovery by students. Instead of simply transmitting information to students, the teacher designs activities that encourage students to explore a topic, ask questions, formulate hypotheses, collect and analyze data, and reach conclusions on their own. This approach places students at the center of the learning process, promoting curiosity, autonomy, and critical thinking.

In an investigative didactic sequence, students can carry out experiments, field research, debates, collaborative projects, and other activities that lead them to explore concepts in an active and engaging way, developing independent thinking, problem-solving, and critical analysis skills, making them more reflective learners and prepared to face the challenges of the globalized world (Motokane, 2015; Gomes, Bilessimo, and Silva, 2020). The studies researchers were 15 students from the following undergraduate courses: 3 from the undergraduate course in Chemistry, 2 from the History and Mathematics courses and 1 representative from each of the following undergraduate courses: Biology, Physics, Portuguese Language, Geography, Philosophy, Sociology, Physical Education and English Language.

The data production instrument was a semi-structured questionnaire with open and closed questions. According to Gil (2019), this instrument helps to identify opinions, beliefs, feelings, interests, expectations and situations experienced in relation to the objects of study. In this sense, the scientific literature reports that the use of the questionnaire as a data production technique has the following advantages:

> i- it makes it possible to reach a large number of people, even if they are dispersed over a very large geographical area, since the questionnaire can be sent by mail; ii- it implies lower personnel costs, since the questionnaire does not require training of researchers; iii- it guarantees the anonymity of responses; iv- it allows people to respond at the time they deem most convenient; v- it does not expose researchers to the influence of the opinions and personal aspects of the interviewee (Gil, 2019, p. 128-129).

The use of questionnaires in qualitative research is justified by several reasons, which are related both to the characteristics of the qualitative methodology and to the specific objectives of the research. They allow for the collection of detailed data, in which participants can express their opinions, feelings and experiences in depth about the object of investigation. In general terms, the use of questionnaires in qualitative research is justified by their ability to collect detailed and rich data, their flexibility in formulating questions, their efficiency in terms of time and resources and their potential

to reveal reliable information about participants' perceptions and attitudes, contributing to a comprehensive and robust understanding of the object studied (Gil, 2019).

The data were analyzed in light of the Collective Subject Discourse (CSD) framework, a technique that, according to Figueiredo, Lefèvre and Lefèvre (2005), represents a change in qualitative research, allowing us to understand the thoughts, representations, beliefs and values of a group on a given topic, using scientific methods to understand the challenge that the CSD seeks to respond to, which is the self-expression of collective thought or opinion.

These authors use Key Expressions (KE), extracted from the verbal material of each statement, which best describe the content. Regarding the Central Ideas (CI), the one with the largest impact on the participants' speeches stands out, describing the meanings present in the statements of each response and in the sets of responses from different individuals, which present a similar or complementary meaning.

Anchorings (AC) are a pillar of the collective subject's discourse that brings together the different statements that converge to the same discourse, describing the ideologies explicit in the verbal material of the individual or grouped responses, to systematize the DSC, which is the sum of the ECH present in the statements, which have CI and/or CA of similar or complementary meaning, written in the first person singular to represent the thinking of a collective. This data is organized in maps called Discourse Analysis Instrument (IAD), according to Lefèvre and Lefèvre (2005).

Scientific literature advocates the organization of qualitative data through the DSC method, as these can be produced from testimonies, interviews, questionnaires, newspaper articles, letters, conversation circles, among others (Lefèvre and Lefèvre, 2005).

4 Participants' assessment of the training course

The data were tabulated in Tables 1 and 2, based on the analysis method of Lefévre and Lefévre (2005). Subsequently, the results were analyzed according to the structuring of the collective's subject discourse, according to DSC 1 and 2.

Table 1: Systematization of participants' responses regarding the understanding of QSC.

P	ECH – key expression	IC – Central ideas	AC – Anchors

1	[..] "cover social aspects related to scientific knowledge". [..] "Relates teaching and learning to citizenship training".	Idea a: Social aspects Idea b: Citizenship Training	
2	[..] "Issues of great importance for the citizen's knowledge" [..] "Presents little-known implications" [..] "Questions about the problems involved in everyday life"	Idea a: It is important to know Idea b: Present in everyday life	A: Understanding social issues (IC: a1; a4; a5 and a6;)
3	[..] "QSC are everyday themes" [..] "we must bring them to the classroom"	Idea a Present in everyday life Idea b Elements of the School Curriculum	B: Importance of citizenship training (IC: b1)
4	[..] "Problems related to people's well-being" [..] "Through scientific knowledge, think of measures to solve problems"	Idea a Social thinking Idea b Collaborative measures and Proactivity	
5	[..] "Scientific issues aim to solve problems in the social environment" [..] "They are present in the school environment" [..] "everyone should participate in this process"	Idea a Social problem Idea b School contexto Idea c Collaborative work	C: The importance of knowing yourself (IC: a2 and a8)
6	[..] "problems located in everyday life and affect quality of life" [..] "must be worked through a methodological approach"	Idea a Social problem Idea b Teaching Methodology	D: They are part of everyday life (IC: b2; a3 and b5)
7	[..] "complex and controversial problems" [..] "Ethical values based on social coexistence" [..] "bringing together science and society" [..] "aim to improve the environment in which we live"	Idea a Conceptual definition	E: Should be part of the teacher's planning (IC: b3; b6; c8; b9 and b10)
8	[..] "issues of our daily lives" [..] "social problem that relates science to technology" [..] "reflection to possibly solve the problem"	Idea a Everyday contexto Idea b Conceptual definition Idea c Reflective practice	
9	[..] "involves a social issue" [..] "problems experienced by society" [..] "applies scientific knowledge"	Idea a Social contexto Idea b Articulation of concepts	F: Teamwork (IC: b4 and c4)
10	[..] "are problems of the social environment"	Idea a Social Context	G: Conceptual understanding (a7; b8; a9 and a10)

	[..] “needs intervention from the environment scientific”	Idea b Articulation of concepts	

Source: research data, 2024.

In DSC 1, the ACs originated from the ICs represented the following: the understanding of Social Issues are expressions that reveal the understanding of the study participants as suitable to the knowledge construction process; the importance of Citizenship Training as an expression that justifies the stimulation of QSC for teaching practice; the importance of knowing oneself as expressions that signal the characteristics related to the theoretical knowledge constructed in the course by the research participants; they are in the Daily Life as expressions that emphasize the relevance of knowing the methodological assumptions of QSC, in addition to corroborating the understanding of the elements that, intrinsic to the school routine, should be part of the Teacher's Planning. These expressions show that the research participants recognize the importance of planning, as well as highlight the relevance of inserting QSC in the teaching and learning processes, to enable classes that are more connected to the reality of the school context. Furthermore, the expression Teamwork reveals that the study participants were able to understand the theoretical and methodological assumptions of the QSC, since these signal collaborative and cooperative work. The expressions related to Conceptual Understanding, in turn, are motivating, since they revealed that the research participants valued the formative moments of the course, demonstrating their commitment to research and their concern with the field of teaching.

Corroborating the authors Lefèvre and Lefèvre (2005) and Batista et al. (2020), as well as the statements of the research participants, the description after systematizing the data for the construction of DSC 1 occurred as follows:

> With regard to the approach of social aspects and scientific knowledge, I believe that socioscientific issues have the potential to show the problems of the social environment. It presents implications related to people's well-being and the problems that are located in their daily lives and that, consequently, affect their quality of life. I draw attention to the importance of knowing the problems that involve daily life, as these have little-known implications and these can be tools to articulate the QSC questions in relation to school work. At school, I intend to work in the classroom through a reflective methodological approach, based on the problems experienced by the community. With QSC, it is possible to apply academic and scientific knowledge to think about and mediate actions that enable the participation of all students in solving complex and controversial problems. I also point out that socio-scientific issues help to promote dialogue on fundamental ethical values for social coexistence, related to science, with the aim of improving the environment in which we live. I also emphasize that technology is an ally in helping to understand the

problems of the social environment.

Table 2: Systematization of data regarding the Participants' understanding of the STEAM approach

P	ECH – key expression	IC – Central ideas	AC – Anchors
1	1 [..] "use for understanding everyday problems" [..] "favors active learning"	Idea a: Teaching Approach Idea b: Conceptual understanding	A: application in social issues (IC: a1; c2; b3 and b4)
2	[..] "STEAM enables work by project" [..] "it is necessary to be known and applied" [..] "it enables the awakening of critical sense".	Idea a: Conceptual understanding Idea b: Importance of knowing Idea c: Teaching approach	
3	[..] "STEAM contributes to the development of skills" [..] "Critical and creative thinking" [..] "the STEAM approach is important in school work"	Idea a: Conceptual understanding Idea b: Teaching approach	B: Theoretical understanding (IC: b1; a2; a3; a4; a5; a7 and a8)
4	[..] "a more connected approach" [..] "through transdisciplinarity" [..] "puts us in pictures of our daily lives" [..] "integrated knowledge is closer to reality" [..] "gains meaning and enables the understanding of facts"	Idea a Conceptual understanding Idea b Collaborative work Idea c Teaching approach	
5	[..] "this approach encompasses all areas of science" [..] "local, global and economic aspects of region" [..] "enables students to grow in school" [..] "makes this knowledge pay off"	Idea a Conceptual understanding Idea b School context Idea c: Teaching Methodology Idea d Reflective Practice	C: Theoretical assumption (IC: b2; b4; b6; b9 and b10)
6	[..] "STEAM enables more attractive teaching" [..] "increases and develops the student's capacity" [..] "enables critical knowledge on various issues"	Idea a Teaching Methodology Idea b Critical thinking	D: Methodological assumption (IC: c5; a6; b7; b7; b8; d8; and a9)
7	[..] "works with various problems" [..] "associates the implications of areas of knowledge" [..] "encourages citizenship training"	Idea a Conceptual definition Idea b Teaching Methodology	
8	[..] "STEAM addresses social	Idea a Conceptual	

	problems” [..] “takes QSC to the classroom” [..] “motivation and encouragement to learning” [..] “better understanding of knowledge”	definition Idea b Everyday context Idea c Reflective practice Idea d Teaching Methodology	E: Reflective teaching (IC: c5; c8 and a10)
9	[..] “student understanding” [..] “enables transdisciplinarity” [..] “solutions to social problems”	Idea a Teaching Methodology Idea b Conceptual understanding Idea c Social context	
10	[..] “long and very important work” [..] “teaching that goes beyond content and tests”	Idea a Reflective practice Idea b Conceptual understanding	

Source: research data, 2024.

In DSC 2, the ACs originating from the ICs represented the following: in the application sector in Social Issues, the expressions showed the aspects related to the application of the STEAM approach to QSC. Thus, the research participants indicate that the use of this approach envisions the possibilities of application in the knowledge construction process. In this, we can highlight the Theoretical Understanding that they acquired during the formative stage of the STEAM course, which can be observed after the end of the formative course. Regarding the Theoretical and Methodological Assumptions, these expressions show that the research participants were able to systematize some concepts related to the STEAM approach. In addition, they demonstrate that the research participants learned the concepts worked on in the course, demonstrating that they are qualified to understand the theoretical and methodological foundations of the STEAM approach. Regarding Reflective Teaching, the expressions indicated that the course participants signal a change in attitude in the teaching and learning process, pointing out that the STEAM approach presents methodological foundations for the construction of knowledge based on reflective practice. DSC 2, in general, can be constituted as follows:

> Understanding the STEAM approach involves understanding everyday problems. These problems enable the awakening of critical thinking. I emphasize the importance of the STEAM approach for school work, given that, with this approach, it is possible to relate school knowledge to the reality of the problems that emerge from the community to the school. I believe that

> STEAM favors active learning and helps in school work through projects, collaborates with the development of skills and competencies in the field of connectivity. I also point out that, with this approach, it is possible to articulate transdisciplinary teaching based on social problems that are situated in everyday school life, since it encompasses all areas of knowledge, dialoguing with local and global specificities with the purpose of collaborating in the development of millennial skills and competencies. I emphasize that it is necessary to understand and apply the STEAM approach, as it enables school work in an intriguing way. In addition to increasing and developing students' cognitive capacity, it awakens their critical sense, enabling them to understand the social issues that are present in their daily lives. It is a teaching approach that goes beyond school content and tests, as it seeks to involve the school community in transdisciplinary work to identify solutions to the problem addressed in the articulation of the elements of the school curriculum. I also emphasize that the theoretical and methodological assumptions of the STEAM approach consider the local and economic aspects of the region and the influences of the global scope, to articulate the problem issue with school content in a transdisciplinary way, with the purpose of making teaching more attractive and creative. This perspective aims to promote citizenship formation and understanding of social issues. This educational approach ensures that knowledge has a return, motivation and incentive for learning, and, as a consequence, presents solutions to the social problems addressed during the project activities.

The expressed data in Tables 1 and 2 show that the participants of the training course indicated the relevance of knowing and understanding the theoretical and methodological assumptions of QSC and the STEAM approach, as well as the importance of applying them in the planning of teaching work and in classroom development in articulation with the contents of the school curriculum. In this context, we can highlight that the research subjects converge on the integration of theoretical studies with the practical actions of school work, to favor the process of knowledge construction. Following this line of interpretation, Mang and collaborators (2021) are in agreement with the present study, as they argue that the integration between QSC and STEAM is relevant for scientific literacy, in addition to helping teachers to authentically connect science with real-world issues that have social and cultural relevance for the daily lives of students.

Therefore, the key expressions in Tables 1 and 2 are in line with these authors, and also point to the articulation of work using QSC and STEAM, enabling pedagogical practice with ample opportunities for learning, development of autonomy, citizenship formation, and construction of identity. In addition, QSC articulated with STEAM can also contribute to opportunities for students to reinterpret their understanding and representation of science through creative means (Johnson *et al.,* 2020). This justifies the use of teaching strategies designed to develop in students the skills and abilities recommended by legal documents, in addition to the needs required by society in the

face of socio-environmental development in the globalized world.

In this context, the syntheses of DSC 1 and 2, described based on ICs names, were important for grouping the discourse, since there was more than one IC in the same speech, and all were systematized separately in the grouping process. Similar CIs were gathered in a logical and coherent manner with the writing process of the single discourse, written in the first person singular, as stated by researchers in this line of research (Lefèvre and Lefèvre, 2005). In this way, researchers systematized the singular and collective contexts of the participants in the training course, allowing researchers to have a broader understanding of the knowledge of the research participants about the object of study.

In DSC 2, understanding and conceptualizing SQS, we observed different answers to the same question, which, however, indicated that the participants understood the theoretical and methodological assumptions of the study regarding Socioscientific Issues. The data in Table 1 are revealing, showing that the research participants understood the SQS beyond the theoretical-methodological study, justifying their application in the teaching-learning process and suggesting that teachers make their plans based on questions that dialogue with emerging themes in the school context, such as issues of a social and environmental nature.

In this context, the scientific literature reports that teaching involving QSC, linked to the STS movement, has achieved results when applied in the teaching-learning process, awakening in students the importance and motivation to study based on school knowledge, seeking to apply it to solving problems in their communities. In time, we do not want, nor will we be able to train and demand, based on this training, that students be prepared to solve problems related to their communities; however, we expect students to be able to reflect and make decisions, in addition to being able to seek solutions to the problems identified in them (Santos, Silva and Silva, 2018). Corroborating Santos, Silva and Silva, Ratcliffe and Grace (2003) state that QSC are open, of a socio-scientific nature, and in them different positions are possible, both from scientists and from society in general. With them, it is possible to articulate school curriculum content to work with complex situations in the development of ethical, moral, cultural, social and environmental values, respecting popular knowledge and cultural aspects of the community (Genovese, Genovese and Carvalho, 2019).

An analysis of Table 3 shows that DSC 2, written based on the systematized

results, shows that the participants understood the theoretical and methodological aspects of the STEAM approach. The data show that the participants were able to express ideas that relate the theoretical study to schoolwork issues, defending its use in the teaching and learning process of Basic Education. The inclusion of the STEAM approach in pedagogical work favors the development of creative and active learning, proposing innovative teaching based on transdisciplinary projects that dialogue with real-world problems.

Corroborating this line of reasoning, Maia, Carvalho and Appelt (2021) state that this approach contributes to the cognitive development of students, with perception of problems, reflection, logical reasoning and application of concepts in the reworking of possible solutions to the problems of their social context. In this regard, Morán (2015) points out that teaching and learning processes need to present demands that enable the development of 21st century skills. Therefore, it is necessary for teachers to align teaching plans with themes that favor the articulation of this demand, as well as actions that place students at the center of this process of construction and re-elaboration, in a critical and reflective way.

5 Final Considerations

The research sought answers to the influence of QSC and the STEAM approach in the initial teacher training process, from the point of view of students in initial training, with the perspective of improvements in pedagogical practice. In this context, it is relevant to mention the importance of new and continuous studies on the theme of teacher training, from different focuses and approaches. Therefore, given the results obtained from the analysis of the collective subject discourses, expressed in the tables and in DSC 1 and 2, it is concluded that the use of QSC and the STEAM approach can contribute to the training of future teachers, who will be able to pedagogically evaluate and, possibly, use these approaches in their pedagogical practice.

The use of QSC and STEAM approaches associated with a didactic proposal contributed to motivation, interaction and learning during the training course meetings, observing the motivation of the participants regarding professionalization for teaching, with perspectives of collaborating with the improvement of the teaching-learning processes.

This study revealed that, by inserting transdisciplinary actions in the planning of school work, linked to socio-scientific issues for the articulation of popular, school and

scientific knowledge, it contributed to the dialogue between knowledge and worldviews in a collaborative and participatory way, linked to the challenges present in the Socio-Scientific Issue of the Bodocongó Reservoir.

In addition, we noticed that the activities developed in the training course provided possibilities for the construction of knowledge and skills in the area of the research object, considering the theoretical and methodological aspects of socio-scientific issues and the STEAM approach. Charts 1 and 2 show the importance of the training course for building skills and abilities, constituting a fertile space for learning and collaboration. In the construction of this knowledge, critical reflections also emerge on socio-environmental, historical-cultural, economic, political, ethical and social aspects related to the Bodocongó Reservoir, highlighting the importance of the STEAM approach to assist in resolving the SQC.

Therefore, given the results of the research, it is concluded that the training course can contribute to improving teacher training, as they will be able to assess other socio-scientific issues pedagogically and articulate the planning of school work considering the social problems of their community.

Institutions that invest in training their teachers with these approaches will be recognized as producers of innovation and quality. In this sense, the training course on QSC and STEAM for teacher training offered a wide range of benefits to participants, through which they developed critical and interdisciplinary skills between areas of knowledge to deal with sensitive topics and promote educational innovation, with the aim of adding formative values and improving teachers' pedagogical practice, as shown in Tables 1 and 2 and discussed in DSC 1 and 2. It is observed that the use of the aforementioned approaches was well received by participants, with an emphasis on improving learning, motivation and interaction, revealed by the acceptance of the methodology and approach used and the potential for using these in pedagogical practice and in the teaching and learning process of basic education students, contributing to the construction of a more critical, creative, proactive and empathetic society towards social problems in the school context.

At the time, the training course was only the prologue to fruitful actions that we advocate for basic education. Therefore, it is necessary to continue the project with more participants, as well as to include other issues in different training spaces. However, we highlight that one of the encountered barriers was raising awareness among teachers in initial training to join the training course, adapt to the schedule of

training activities and overcome difficulties in understanding the concepts of STEAM areas.

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