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The formative itinerary based on the STS education and the analysis of the mobilization of teaching knowledge

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ABSTRACT

Based on the changes in contemporary society and national guidelines for basic education and teacher training, research is needed to analyze the processes of teacher training and performance, such as those in the New High School. This article investigates the practice of a Chemistry teacher/researcher in a formative itinerary based on Science, Technology, and Society (STS) education and the framework of Pedagogical Content Knowledge (PCK). The methodology involved a case study in a 3rd-year high school class in the educational itinerary Life Cycle of Materials, with eight activities: school observation, questionnaires, debates, mock jury, investigation of the chemical composition of materials, and the creation of posters about eco-points. The corpus included field notes, recordings, and transcriptions of classes and dialogs with teachers and students, analyzed through Discourse Textual Analysis. The discussed themes involve two emerging categories: "Socio-environmental Discussions" and "Teacher-Student Relationship," which address the relevance of new components to the structuring categories that compose the DCK framework, highlighting the influence of social and affective interactions and environmental themes in the selection of activities, the mobilization of teaching knowledge, and the critical formation of students. The results indicate that interpersonal relationships and social, environmental, and economic debates contribute to the definition of teaching practices and to the reflection on the professional formation of the teacher/researcher. Moreover, the STS approach promotes the development of argumentation skills, critical reflection, and socio-environmental awareness in students.
KEYWORDS: Teacher training; Science teaching; Secondary School; Didactic content knowledge; Society and education.

O itinerário formativo com base na educação CTS e a análise da mobilização de conhecimentos docentes

RESUMO

Com base nas mudanças da sociedade contemporânea e em diretrizes nacionais para a Educação Básica e a formação de professores, tornam-se necessárias pesquisas que analisem os processos de formação e atuação docente, como os do Novo Ensino Médio. Este artigo investiga a práxis de uma professora/pesquisadora de Química em um itinerário formativo fundamentado na educação Ciência, Tecnologia e Sociedade (CTS) e no referencial do Conhecimento Didático do Conteúdo (CDC). A metodologia envolveu um estudo de caso em uma turma do 3º ano do Ensino Médio, no itinerário formativo Ciclo de Vida dos Materiais, com oito atividades: observação escolar, questionários, debates, júri simulado, investigação da composição química dos materiais e confecção de cartazes sobre ecopontos. O corpus incluiu diário de campo, gravações e transcrições das aulas e diálogos com professores e estudantes, analisados por meio da Análise Textual Discursiva. Os temas discutidos envolvem duas categorias emergentes: "Discussões Socioambientais" e "Relação Professora-Estudantes", que abordam a relevância dos novos componentes às categorias estruturante que compõem o referencial do CDC, evidenciando a influência das interações sociais e afetivas e das temáticas ambientais na seleção das atividades, na mobilização do conhecimento docente e na formação crítica dos estudantes. Os resultados indicam que relações interpessoais e debates sociais, ambientais e econômicos contribuem para a definição das práticas de ensino e para a reflexão sobre a formação profissional da professora/pesquisadora. Ademais, a abordagem CTS favorece o desenvolvimento de habilidades de argumentação, reflexão crítica e consciência socioambiental nos estudantes.

PALAVRAS-CHAVE: Formação de professores; Ensino de Ciências; Ensino Médio; Conhecimento didático do conteúdo; Sociedade e Educação.

INTRODUCTION

High school education in Brazil, according to Marra and Almeida (2023), has undergone several reforms, including changes in the secondary, industrial, commercial, and agricultural models (1942), the junior high and technical model (1961), and the first and second levels (1971). In the 1980s, the institutionalization of mandatory professionalization came into effect when there was an overvaluation of professional training in relation to knowledge, and public policies were aligned with education aimed at the needs imposed by the labor market (Marra & Almeida, 2023).

As part of the significant process of change in the context of basic education and teacher training, the implementation of the High School Reform provided for by the National Common Curricular Base is included. The creation of the New High School (NHS) took place through Law No. 13,415 of 2017, which provided for the establishment of the new teaching model in all national educational institutions from 2022 onward. This measure was marked by a series of opposing reactions, ranging from protests throughout the country to the occupation of schools by students (Andrade & Motta, 2020).

The high school reform involved several factors and individuals, making the proposal complex and questionable. Many teachers who were already working in schools had not received adequate knowledge and skills to work in the NHS during their initial and continuing education. This is because, in teacher education courses, including those in the area of Natural Sciences, the contents with the new characteristics and methodologies that encompassed the Formative Itineraries were not addressed (Lotta et al., 2021). In the study conducted by Raimundo and Fagundes (2018) in the CAPES Journal Portal from 2001 to 2016, a significantly smaller number of studies focused on continuing teacher education is indicated when compared to initial education. Although there has been an increase in recent years, research involving continuing education is still not as common.

When it comes to professional knowledge, the teacher can be seen as a professional who develops their teaching practice through their knowledge and the processes of action and reflection. In this sense, Parga-Lozano and Mora-Penagos (2021) point out that in teacher education, knowledge is required that involves articulations and their construction, the context in which it will be taught, and the understanding of how students learn, without leaving aside the content itself. From this perspective, the fundamental knowledge that is specific to teachers involves Didactic Content Knowledge (DCK): a structured and emerging knowledge from professional practice (Parga-Lozano & Mora-Penagos, 2021) linked to the field of training and to the discipline taught by the teacher, as is the case with Chemistry.

In this article, an excerpt from a dissertation analyzes the praxis of a Chemistry teacher/researcher within the formative itinerary developed based on Science, Technology, and Society (STS) Education and the framework of Didactic Content Knowledge (DCK).

DIDACTIC CONTENT KNOWLEDGE (DCK) IN THE PERSPECTIVE OF CHEMISTRY TEACHING

Shulman (1986) introduced one of the first theories on teacher knowledge, Pedagogical Content Knowledge (PCK), translated as Pedagogical Content Knowledge, considered an autonomous type of knowledge related to the specificities of teaching content. Through discussions, adaptations, and modifications in the context of Ibero-American research, PCK came to be referred to as DCK. That is, as knowledge arising from the teaching profession that develops throughout training and enables the process of (re)construction of the teacher's professional identity, especially in Chemistry education (Parga-Lozano & Mora-Penagos, 2021).

For Parga-Lozano and Mora-Penagos (2021), DCK is a type of idiosyncratic knowledge that is based on the contextual and historical needs of each class and each teacher. It is the result of hybridization involving knowledge and beliefs. These include: Disciplinary knowledge—related to the specific knowledge of the subject taught by the teacher, that is, their knowledge about the content and references; Psychopedagogical knowledge—referring to the teacher's knowledge in thinking about the subject matter or the content taught from the student's perspective; Metadisciplinary knowledge—related to the teacher's understanding of “what” and “how” knowledge has changed or been constituted; and Contextual knowledge—referring to the teacher's knowledge to organize the environment, classes, and activities according to the class being taught (De Paula, Sangiogo & Pastoriza, 2024).

Based on social, scientific, and technological changes, there was a need for the DCK to be rethought in order to meet new demands. This includes considering topics such as resource sustainability, climate change, ecosystems, and human health. In the literature, Zhou (2015) proposed Environmental Pedagogical Content Knowledge (EPACK), which was translated into the Ibero-American context by Parga-Lozano (2024) as Environmental Didactic Content Knowledge (E-DCK). This is an emerging field of DCK based on the interactions of the social aspect of STS education, perspectives focused on sustainability, and environmental issues. According to Parga-Lozano (2024), through E-DCK, it is possible to develop proposals based on STS education, scientific and technological literacy, scientific education with and for citizen action, and reflection on socio-environmental issues in society.

As domains of expertise, E-DCK comprises: Environmental Knowledge (EK), Content Knowledge (CK), and Didactic Knowledge (DK). By integrating these knowledge types (Figure 1), the development of E-DCK becomes achievable.

Figure 1

Generating Domains and Combinations of E-DCK

Domains			Combination		
Environmental Knowledge (EK)	+	Content Knowledge (CK)	➡	Environmental Content Knowledge (ECK)	E-DCK
Content Knowledge (CK)	+	Didactic Knowledge (DK)	➡	Didactic Content Knowledge (DCK)	
Didactic Knowledge (DK)	+	Environmental Knowledge (EK)	➡	Environmental Didactic Knowledge (EDK)	

Source: Adapted from Parga-Lozano (2024, p. 26)

By mobilizing E-DCK, the teacher enables the exploration of themes beyond disciplinary content, such as those related to Chemistry. In the context of teacher education, when addressing themes based on STS education, they mobilize knowledge related to critical and reflective questioning of the scientific, technological, environmental, and social contexts. This influences the way teachers in diverse contexts plan and develop their classes, guided by discussions and reflections related to science and technology as human activities (Pires, Costa & Moreira, 2022).

For Freire (1996), reflection on praxis occurs when the teacher critically (re)thinks their pedagogical practice, (re)establishing strategies for the qualification of their professional identity, because "it is by thinking critically about today's or yesterday's practice that one can improve the next practice" (Freire, 1996, p. 21). Thus, continuing education can be understood as a relevant process within the constant changes occurring in society and school curricula.

From this perspective, the school needs to be attentive to contemporary demands, in addition to providing teachers with adequate training and conditions for the exercise and development of the profession. The teacher assumes the role of a teacher-researcher, as initial training alone will not account for all the obstacles and changes in the educational context. This is especially important considering the plurality in the classroom, learning difficulties, emotional problems, inclusive education, and environmental issues. Therefore, the teacher who reflects on their praxis can mobilize and (trans)form their professional knowledge, as in the case of E-DCK.

THE NEW HIGH SCHOOL AND EDUCATION IN SCIENCE, TECHNOLOGY, AND SOCIETY

The National Common Curricular Base for High School was defined in December 2018 and attached to the document approved in 2017. Initially, it only included the reformulation of the Curricular Base for Early Childhood Education and Elementary Education (Andrade & Motta, 2020) and specific competencies and skills for the curricular components of Portuguese and Mathematics. Consequently, in high school, the Curricular Base is part of the New High School, which provides for "both the curriculum reform established by the BNCC and the

reform in workload established by the Full-Time High School program" (Andrade & Motta, 2020, p. 5).

In this way, the High School Reform consists of a mandatory and common part for all schools, represented by the Curricular Base, and another part organized by a diversified and flexible model, the formative itineraries. Thus, the departments of education and schools have autonomy to elaborate pedagogical projects considering the context and the needs of students, provided that they are in accordance with the Curricular Base and offer at least one formative itinerary (Andrade & Motta, 2020).

Contrary to what official documents state, many teachers and members of the educational community do not agree with the implementation of the new teaching model. There is concern from both the Chemistry teaching community and other areas of knowledge about the direction of basic education in the country. In Rio Grande do Sul, the state's Curriculum Framework for High School was published, a normative document that aims to consider the cultural, economic, and educational issues of society in Rio Grande do Sul. In this way, the Curriculum Framework ensures changes in high school to promote the development of essential learning, contemplate the expectations of youth, and the local and regional characteristics of communities enriched by the historical, economic, environmental, cultural, and world-of-work contexts experienced in the territory (Rio Grande do Sul, 2018, p. 272).

The teaching proposal presented by New High School enables the inclusion of studies and practices associated with various themes, such as environmental themes (Marra & Almeida, 2023), for example. These themes can be explored as they cut across several areas of knowledge, such as Portuguese, Mathematics, Chemistry, Physics, Geography, and Biology. They also involve the individual in the discussion by questioning the physical environment they occupy and the one that integrates the "Life Cycle of Materials" itinerary offered by the school. This context constitutes the object of study of this article.

Despite the criticisms of the NHS and its implementation, the first author of this text, as a Chemistry teacher in continuing education—and in view of the reality of the current public school system, which involves the presence of formative itineraries—considered the planning, experience, and analysis of the educational reform context to be relevant. This change has presented the teacher with new challenges, technological developments, and scientific advances, as well as new social contexts. This scenario has prompted the planning of teaching activities through a formative itinerary, which constitutes an STS approach.

Bouzon et al. (2018) point out that teaching with a focus on STS education provides an approach that goes beyond traditional teaching and learning processes within school walls. It emphasizes the use of "understanding of content not as an end in itself, but as a means capable of promoting the critical formation of the individual" (p. 2), which aligns with the proposals of new formative itineraries. Furthermore, according to Santos and Mortimer (2002), the STS approach aims, in addition to understanding, to enable individuals to interact with the scientific and technological elements of social life by using scientific knowledge.

It is worth noting that, in the context of the field of STS studies, different terminologies reflect distinct perspectives. According to Domiciano and Lorenzetti

(2020), the STS movement refers to the historical and critical dimension that questions the traditional teaching model. It is an academic field that analyzes and systematizes STS studies. STS education, in turn, relates to the incorporation of these discussions into the educational context, integrating them with teaching processes and the development of students. Finally, the STS approach brings together different teaching and learning strategies and methodologies to address STS education issues through projects and diverse activities, enabling students to understand the S, T, and S articulations in a contextualized, critical, and conscious way (Domiciano & Lorenzetti, 2020).

In this sense, it is understood that science and technology are present and impact everyday life and society. At the same time, society can seek mechanisms of understanding and validation that impact science and technology in a more conscious and responsible way. Thus, the teaching of Science and Chemistry within the STS educational approach represents an important strategy for including individuals in social life in an active and more responsible manner.

THE CONTEXT AND THE METHODOLOGICAL PATH

The research, of a qualitative nature, is based on the case study (André, 2013), which stands out for providing a more comprehensive understanding regarding "focusing on a particular phenomenon, taking into account its context and its multiple dimensions," in addition to valuing "the unitary aspect," while also emphasizing "the need for situated and in-depth analysis" (André, 2013, p. 97).

In this case study, a Chemistry teacher/researcher in continuing education was involved. She alternated between acting as a teacher and a researcher of her own practice (Maldaner, 2000) in a public school located in the northern zone of the city of Pelotas, RS. The case study was carried out through observation and the development of a teaching project with the aim of addressing the objective presented in this article.

The teaching project was proposed and developed in the formative itinerary "Life Cycle of Materials" and elaborated based on the STS educational approach (Santos & Mortimer, 2002). This perspective seeks to develop citizens' scientific and technological literacy, helping students build the knowledge, skills, and values necessary to make more responsible decisions about issues involving science, technology, society, and their interrelationships (Santos & Mortimer, 2002). And, consistent with the syllabus:

> The Curricular Component aims to promote knowledge of environmental policy, instruments, and the national environmental system for the development of environmental education actions integrated with conservation, recovery, and environmental improvement programs. It aims to develop an understanding of the importance of the Solid Waste Law for public authorities, companies, the population, and waste pickers. Additionally, it provides knowledge of national and regional waste policies, production, composition, and characterization of recoverable waste, valorization technologies, reuse, recycling, waste reuse, and biomass for energy. The goal is to encourage the construction of social values, knowledge, skills, attitudes, and competencies directed toward the environment, emphasizing local issues (Rio Grande do Sul, 2024, p. 131).

However, the students noticed an important point: the classes were not being conducted in direct relation to the proposed itinerary and there was no possibility

of choosing the itinerary they wished to attend. Therefore, the lead teacher, in order to meet the students' demand, addressed the topic of pharmacy, which was initially of interest to the students. The organization and elaboration of the teaching project by the teacher/researcher involved eight activities (Table 1), which included the initial contact with the class, allowing the construction of the thematic approach called the "Cycle of Materials," in reference to the formative itinerary.

Table 1

Identification and Description of the Activities

Identification of the Activities	Description of the Activities
A1	Recognition of the School Context and Observation of the Lead Teacher's Classes
A2	Class Identification Questionnaire
A3	Presentation of the Theme: Cycle of Materials
A4	Investigating the Chemical Composition of Materials
A5	Mock Jury on the Use of Biodegradable Packaging
A6	Destination of Packaging
A7	Preparation of Posters about Ecopoints in Pelotas
A8	Final Assessment Activity

Source: Author's own work (2024).

The classes were developed in a 3rd-year high school group (totaling 16 class hours of 45 minutes), which had 28 enrolled students aged between 17 and 19 years. All of them expressed an interest in attending a university or a technical course, and some planned to work concurrently with their studies. It is worth noting that the students were experiencing their first fully in-person academic year after the pandemic.

The data produced and obtained, such as the class identification questionnaire, the teacher/researcher's field diary, the recordings of transcribed classes, and the materials written by the students, constitute the corpus of analysis and were submitted to Discursive Textual Analysis. This analytical procedure enables the deconstruction of the obtained data, the grouping of significant units that show similarity, and the subsequent communication of results through the production of metatexts (Moraes & Galiazzi, 2006).

In this sense, based on the information presented and after data collection, the unitarization process was carried out. This process involves the separation and detailed analysis of each piece of data obtained in the initial and final teaching project, in the teacher/researcher's field diary, in the questionnaires, and in the works developed by the student group. Thus, for the identification of subjects, the following coding was used: for students, E1 and so on; for the teacher/researcher, PP. Empirical data were coded as follows: A1, A2, etc. for classes; T for class

transcriptions; DC for records generated in the field diary; Q for questionnaire records, followed by the student's number; and PA1, PA2, etc. for lesson plans.

DTA enabled the production of two emerging categories, entitled "Socio-environmental Discussions" and "Teacher-Student Relationship," in addition to the a priori categories, which involved the components of DCK: Disciplinary Knowledge/Beliefs (CD), Metadisciplinary Knowledge/Beliefs (CM), Contextual Knowledge/Beliefs (CC), and Knowledge/Beliefs about Psychopedagogy (CP), according to Parga-Lozano and Mora-Penagos (2021). Due to limitations of space and focus, this article addresses the emerging categories. Furthermore, the research was submitted to the Human Research Ethics Committee and approved under CAAE: 57095622.2.0000.5317, opinion number: 6.602.546.

TEACHER MOBILIZATIONS IN THE FORMATIVE ITINERARY: SOCIO-ENVIRONMENTAL DISCUSSIONS AND THE TEACHER-STUDENT RELATIONSHIP

In this section, two emerging categories are presented, which address components beyond the categories explicitly discussed in the four components of DCK. This is done through the identification of elements that stood out in the mobilization of knowledge by the Chemistry teacher/researcher: "Socio-environmental Discussions" and "Teacher-Student Relationship." These two categories involve processes of mobilizing teaching knowledge when planning, developing, and analyzing the context under study. This included the formative itinerary "Life Cycle of Materials," organized and developed based on the STS education framework.

Although the DCK framework encompasses different types of knowledge mobilized by a teacher, other forms of knowledge and/or components that constitute teaching praxis may still emerge. From the perspective of the teacher/researcher, this knowledge gained importance, becoming emerging categories. In this sense, these other components also integrate the Chemistry teacher's DCK, as these new forms of knowledge prove to be as important as those traditionally established in the DCK framework, namely the conceptions and knowledge of context, disciplinary, metadisciplinary, and psychopedagogical domains.

SOCIO-ENVIRONMENTAL DISCUSSIONS

In this category, economic, social, and environmental issues are addressed, which can be discussed according to the aspects of E-DCK (Parga-Lozano, 2024). Due to the contextual and interdisciplinary nature of the formative itinerary discipline, it enables the mobilization of different relationships articulated to the STS context and the environmental dimension.

In the teaching project, after setting the context of the life cycle of materials, the teacher/researcher (hereinafter referred to as PP) presented and discussed the stages that constitute it. To this end, she showed the video "The Story of Stuff," which addresses certain consumption patterns and demonstrates how human beings contribute daily to the degradation of the planet. It presents the chain of events that begins with the exploitation of natural resources, then moves through

the manufacturing process, purchase, and disposal, until reaching landfills and recycling processes. The activity prompted remarks and discussions, such as the statement by E11, which demonstrated some knowledge related to environmental issues: "We cannot worry only about garbage; there are other processes that are polluting" (E11.T.A3). From this perspective, E7 questions: "If the first plastic that was developed is still around, how do we know that it decomposes?" (E7.T.A3).

The analysis of the excerpts from E11 and E7 refers to the study by Mateus et al. (2009), which indicates that the entire life cycle of packaging involves inputs (materials, sources, and energy) and outputs (products and emissions to air, water, and soil). It is possible to show that there is not only one environmental problem when materials are discarded, but that environmental problems exist at all stages of a material's life cycle, in which exchanges of energy and matter with the environment occur. The video demonstrates that science and technology are not neutral, even though modern societies have come "to trust science and technology as one trusts a divinity. The logic of human behavior has become the logic of technological efficiency, and its reasons have become those of science" (Santos, 2007, p. 6). Numerous environmental disasters and armed conflicts, combined with the intensification of social inequalities, challenge the deterministic view of science and technology. Thus, it is evident that technology, in isolation, has not guaranteed equitable advances in social development. Scientific progress is ambivalent as it promotes improvements in the quality of life while also generating negative impacts on society (Gomes & Zanon, 2019).

This type of discussion goes beyond the knowledge proposed by Chemistry's DCK, as PP needs to mobilize knowledge that goes beyond the disciplinary domain. This is because it requires not only the definition of chemical concepts and analytical knowledge but also integrated knowledge from other areas that encompass the inter- and multidisciplinary field. This integrated knowledge can help in understanding complex problems (Gil Pérez et al., 2001), including the product life cycle and its social and environmental impacts. With regard to chemical knowledge, PP emphasized the contents to be addressed: "I can explore the idea of physical and chemical properties of materials, intermolecular interactions, and the difference between organic and inorganic functions" (PP.DC.A4). This analysis shows that the teaching and learning process in Chemistry can transcend traditional and content-based aspects by linking with the STS approach and by enabling the understanding of the relationships between molecules and organic and inorganic substances with the debate on the longevity of material goods, waste production, and environmental effects linked to physical and chemical characteristics.

Based on the reference to E-DCK, it is possible to verify mobilizations regarding the domains of Environmental Didactic Knowledge and Environmental Content Knowledge (Parga-Lozano, 2024). PP, upon perceiving the statements of E7 and E11, reflected on other causes and environmental problems beyond the theme presented, considering new ways of addressing them in the classroom. In addition, by considering the articulation of chemical contents with STS education, PP promotes reflection on the role of science and technology in society, encouraging the formation of more conscious and critical citizens capable of analyzing and questioning consumption and production practices.

Corroborating this thinking, another point of discussion raised was unrestrained consumerism. The students showed concern about how encouragement to consume new products occurs, such as cell phones, which they considered "disposable." One participant reported: "I had a phone from brand X that lasted for years. When I switched to the one I have now, I realized it will not last even half the time, besides becoming outdated compared to my classmates' phones" (E2.T.A3). Based on the reflections raised in class and E2's statement, PP realized the importance of highlighting to students that society lives in a state of incessant consumption.

In this sense, appropriating understandings such as those of Bauman (2008), who conducts a social analysis of the human condition, helps to understand constant social changes and society's relationship with technology. One of these relationships shows that consumption becomes a form of social belonging, which encourages individuals to quickly replace still-functional goods, reinforcing accelerated production and the disposability characteristic of the contemporary world. When a product is acquired, it soon ceases to be desired, quickly losing its value and needing to be replaced by something new. The now-old item will have no other destination than the trash. This discussion relates to E2's comment.

In addition, the advertising promises of media advertisements tend to stimulate consumption and interest in the new, which, for Bauman (2008, p. 107), indicates that "every promise must be deceptive, or at least exaggerated, for the pursuit to continue." Some students expressed the perception that we live on a planet that is being degraded by unrestrained consumption, which we witness and in which we participate, often without understanding that we are inserted into a system with limited resources.

In another unit, while discussing excess consumption, E2 pointed out: "When we buy on app X, we are not thinking about the environment and everything else involved, only about having the product" (E2.T.A2). This statement reflects a social concern for the environment. Vargas (2007) argues that socio-environmental conflicts are increasingly frequent in the reality of Latin American countries as a consequence of weaknesses in the implementation of available policies and management schemes for regulating the use and access to natural resources. The author also points out that it is necessary to consider the social and economic dynamics related to natural resources, which are increasingly complex. It is common for the state to find itself without technical, administrative, and/or financial resources to manage conflicts over the use of natural resources, in which, for example, there are major power asymmetries.

These discussions enabled the mobilization of E-DCK, which, in turn, influenced PP's reflection on how classes reach points that are often unexpected or unplanned. It also falls to the teacher to be open to discussing and learning from the reflections raised in class and from dialogue with students. The debates led PP, in practice, to reflect on the themes addressed in class, which may indicate that the class was not productive or was insufficient for not having explored the planned points. However, in these classes, it is actually possible to learn more when students feel comfortable discussing issues that are relevant to them in their own way, supported by their own reality and elements of science. This also helps them become more aware of the life cycle of the products they consume.

In this sense, mobilized by the STS approach itself, the classes were organized with other activities and discussions that incorporate elements of critical education and seek social transformation. This is based on information and understanding of the processes that constitute the cycle of materials. During activity A7, aimed at producing posters about ecopoints in the city, students reported that they were already familiar with the topic from a previous seminar and that they did not wish to produce posters about the color of trash bins, as this had already been covered in another formative itinerary. Thus, PP prepared a class in which new knowledge would be mobilized, based on a theme that had not yet been addressed. In this way, the class was divided into groups, and the study theme was modified and directed towards the disposal of certain groups of materials, including oil, medicines, electronic waste, and general debris.

In the lesson plan (PA7), the activity of creating posters (Figure 2) initially focused on researching materials such as plastic, paper, aluminum, among others, leading to the proper disposal according to bins and their colors. By talking with students and reflecting on the initial planning, PP mobilized and (trans)formed her DCK. She restructured the classes based on another environmental theme by mobilizing the component of Environmental Content Knowledge since she understands the importance of these issues. In this case, she promoted discussions on the cycle of certain materials, mainly focused on waste disposal, but also aimed at leading students to take action in the construction of knowledge, skills, and values that help address environmental problems, including those of improper disposal and its effects (Parga-Lozano, 2024).

In this sense, the activity of producing posters about the ecopoints in Pelotas evidenced a significant movement of reflection and contextualization on the part of PP, who, by basing herself on an environmental problem situated in the students' daily lives, made use of science teaching. Thus, by addressing a theme from the local reality, she met the students' demands, enabling a space in which autonomy and environmental awareness could be fostered (Layrargues & Lima, 2020). The display of the posters to the class and in the school expanded the impact of the action, promoting dialogue and awareness about the environment. This activity goes beyond the classroom context, giving the posters and their content a role in society. It seeks to encourage students' active participation and the conscious use of study spaces.

Figure 2

Display of the Posters Prepared by the Class

Source: Author's own work (2024).

Regarding the mobilizations of E-DCK, a mock jury was carried out during A5, which had not initially been planned. However, as the PP observed the class's interaction with the activities, modifications were made to the original proposal. This indicates the mobilization of professional knowledge, altering approaches and activity methodologies so that students could be the protagonists in the process of constructing their knowledge.

The mock jury aimed to understand the advantages and disadvantages of using biodegradable packaging and discuss its viability. The class was divided into three groups: one in favor, another against a law that required the use of biodegradable packaging, and a third comprised of society, which was tasked with studying and analyzing the implementation of the law and supporting one of the sides. The activity involved having students defend a position before society based on the study of texts provided by PP.

During the mock jury, E23, in his/her position, commented on biodegradable packaging: "These packages are much more expensive; not everyone would be able to buy them" (E23.T.A5) and "We don't need biodegradable packaging; plastic has already been invented" (E23.T.A5). In these statements, arguments against the use of biodegradable packaging can be observed, based on economic and social considerations. The group in favor of their use argued that: "Biodegradable packaging is good because it does not pollute the environment, considering that not all waste is disposed of correctly" (E9.T.A5). In this case, the group based its arguments on aspects associated with the final destination of waste, which may be related to population culture or to those responsible for collection and recycling, as well as to environmental impact, pollution, and material decomposition time.

The group representing society supported the use of biodegradable packaging and accepted the argument of the favorable group, justifying: "We should always think about the environment, especially those who can afford it. Those who cannot can keep buying the regular ones, but always thinking about proper disposal" (E12.T.A5). Thus, the group representing society considered the two points defended by both groups, opposing and favoring the law, indicating an intermediate path for the proposal, even though they explicitly voted in favor of

the biodegradable packaging group. These discussions, promoted by PP and the students, emphasize STS education through current aspects of contemporary society that encompass the field of science. And not only the understanding of scientific content, but critical reflection on the social, environmental, and ethical implications of decisions related to science and technology (Santos, 2023).

In this way, planning based on STS education and the process of discussion and reflection in the classes mobilized PP's E-DCK knowledge through concepts that go beyond Chemistry. These discussions, in the context of the New High School, allow PP to become more aware of the choice and approach of the themes that constitute the formative itinerary. These topics would probably not be addressed in Chemistry classes without time and space for the analysis and reflection of her teaching practice.

TEACHER–STUDENT RELATIONSHIP

In this category, it was identified that interpersonal relationships, including affectivity, are directly related to teaching practice, to the PPs' enthusiasm in teaching classes, and even to the possibility of thinking about new teaching strategies.

In the following excerpt, taken from the field diary after the second class, evidence can be seen of a closer relationship with the class followed by PP: "At the end of the class, some students asked questions about me; they seemed interested and were seeking to get to know me better" (PP.DC.A2). They asked not only about her personal life, but also about her professional life, seeking to get to know the new teacher better. The statement, in isolation, seems to have little meaning until one considers the scenario of the class as reported by the lead teacher and the expectations that had been created. Previously, the students had shown themselves to be disinterested and cold toward the teacher, often not talking or interacting in class or in extracurricular tasks. PP observed that, contrary to initial expectations, the students' interest had a greater significance in her work with the class. It generated greater empathy between them and the teacher, making her feel good and comfortable in teaching. According to Camargo (2017), "this connection between subjects is essentially constituted through interaction, and it is what allows the communication of thoughts, ideas, feelings, emotions, knowledge, etc." (p. 16). In a scenario of teacher dissatisfaction and student apathy in classes, many teachers go no further than "delivering the mandatory content." However, when a close relationship is created, this contributes to PP beginning to think more sensitively about her students, seeking to establish more interesting and attractive classes.

At the end of class 3, when asking whether the class had liked the activity, one of the students replied: "We liked your class because you brought debates, the way we like" (E10.T.A3). Belotti and Faria (2010) comment on the great challenge faced by educators, which lies in the search to reverse the relationships of misunderstandings, conflicts, and prejudices established between schools, teachers, and students. Based on the statement in A3, PP sought to consider the interests shown by the class, whether by planning more attractive and dynamic classes or by seeking non-repetitive topics of interest to the group. Through

reflection on her teaching practice, she realized that this pursuit arose from the affection that the class had demonstrated during the classes.

In this sense, PP understood that by demonstrating that she was a teacher more receptive to students' demands and expectations and by seeking to provide classes and activities according to their preferences, the teacher-student relationship was highlighted. That is, the personal and affective relationship constituted another element of PP's DCK. Affectivity appears not only as a personal characteristic of PP but as professional knowledge mobilized in teaching practice, which affects planning, the execution of teaching activities, the choice of strategies and methodologies, and consequently, the development of classes. Furthermore, it was possible to make the class feel more comfortable interacting and participating in the proposed classes, compared to the reported disinterest expressed by the lead teacher.

The teacher-student relationship is very important as it allows the establishment of personal positions regarding methodology, assessment, and content. It was precisely this relationship that made it possible to understand the class's needs and make changes to the initial project. For example, in the initial project, an activity was planned that addressed issues related to the life cycle of medicines, since the class had previously studied the topic with the lead teacher. However, when seeking information about topics of interest, it was found that the students would like to have classes on the theme of the itinerary: the life cycle of materials. In light of this, PP made changes to the initial planning to avoid already saturated themes. In this process, an affective bond with the students was also created, which may have contributed to their active participation. By feeling welcomed and valued, they showed interest and engagement during the activities. This perception of affection allowed PP to go beyond the STS theme, which includes the teaching of chemical content, enabled by dialogical and problematizing spaces.

Although Castillo and Parga-Lozano (2015) argue that reflecting on feelings and experiences established during teachers' work in the school environment does not characterize a legitimate way of knowing in the scientific field for the (re)construction of Teachers' Professional Knowledge (TPK), it is necessary to consider these aspects related to feelings constructed in this formative space. The sources of TPK are internal, individual, and unique. They include reflection on teaching experiences and feelings, which are fundamental elements that guide teachers' actions in the classroom.

Another representative example of this category involved a question by the PP to the students, asking whether they liked the dynamics of the classes: "Yes. And you could keep teaching us… we liked you, it even makes it easier to understand this itinerary" (E5.T.A6). This unit helps represent the affective relationship with the class because affection is love and is oriented toward the inner state and feeling, being governed by all manifestations that can increase or decrease a way of acting (Osorio Veloso et al., 2020). Thus, affectivity is understood as affection, love, and fondness, but also as allowing the expression of feelings, especially the bond between human beings. These feelings can have an impact on individuals, either by eliciting positive reactions (such as students showing greater acceptance of the teacher) or by triggering negative reactions (if the relationship extends beyond the professional level).

In the same sense, it is understood that affection has a direct influence on the speed at which knowledge is constructed. This occurs when people feel safe, making it easier for them to learn. Thus, affectivity is a positive contributor to the feeling of well-being and trust, factors that are essential for establishing an appropriate and pleasant learning environment (Osorio Veloso et al., 2020).

These affective relationships were always present throughout PP's professional training, in supervised internships, and participation in teacher education programs, such as the Institutional Program of Teaching Initiation Scholarships (or Pibid). Throughout the course, it is common to hear from some more experienced teachers that this affective relationship is not possible in practice because, with the rush of classes, what matters is the content. However, reflection on praxis allows one to understand that, from the first contact with a class after completing the degree in Chemistry Teaching, PP showed that affective relationships, and even affection, are extremely important and should not be neglected. Thus, it is understood that these relationships foster good coexistence in the classroom and make the learning environment more pleasant, awakening enthusiasm, respect, and admiration, both from the teacher and the students. A relationship that enhances the progress and development of teaching activities on the formative itinerary, such as those associated with the STS approach and care for the environment. After all, humans tend to care for what they love, what they value, what they know they are a part of, and have responsibilities for because, according to Freire:

> there is no dialogue [...] if there is no profound love for the world and for people. It is not possible to pronounce the world, which is an act of creation and re-creation, if there is no love to infuse it. As the foundation of dialogue, love is also dialogue (Freire, 1996, p. 79).

In this sense, in agreement with Paulo Freire, the concept of lovingness is understood as something that should be present in teaching and learning relationships and in the interaction between students and teachers. In the relationship of loving the world and instigating reflection on the world in which we live, both the physical world and the world of human relationships are important (Freire, 1996).

FINAL CONSIDERATIONS

The teaching activities developed based on STS education (Science, Technology, and Society) provide the opportunity to explore themes beyond chemical content. An example of this is the mock jury activity, which allowed students to engage in reflection on social, economic, and environmental issues, enabling discussions about the interrelationships between science, technology, and society.

In this way, the activities developed around the theme of the Cycle of Materials enabled the development of critical skills, argumentation, and reflection on the part of the students as they considered the social, economic, and environmental aspects of society around them. During the activities developed based on STS education and E-DCK, students were encouraged to participate in debates, mock juries, and the production of posters on socio-environmental issues. They were required to express critical reflections and their own arguments. These

experiences demonstrate students' engagement with complex problems involving social, economic, and environmental aspects, in addition to showing the development of the aforementioned skills. Therefore, by going beyond merely teaching specific Chemistry content, the teacher/researcher qualified her teaching practice, fostering the formation of conscious citizens with knowledge to face the challenges of contemporary society.

The emerging categories go beyond the field of Chemistry and encompass socio-environmental discussions, affectivity, and also interfere in the teacher's classes, whether in planning or development. Through them, it was evident that interpersonal relationships and social, environmental, and economic discussions are central to the STS approach, in addition to contributing to PP's training. This allowed the teacher to become acquainted with new theories, review concepts, and consequently seek to employ new discussions in future classes.

Furthermore, with the emergence of new categories throughout the analysis, it was possible to infer that the initial DCK proposal can be expanded, as in the case of E-DCK. In this study, two categories emerged that made it possible to broaden the discussions of the DCK framework by addressing socio-environmental issues and the teacher-student relationship. Finally, in conclusion, it is still worth reflecting: What other forms of knowledge does a teacher mobilize in their praxis? And if DCK is an individual form of knowledge, are there other components that can be mobilized, provoking changes in themes, content, educational approaches, teaching methodologies, etc.? In summary, this study highlights the importance of researching one's professional practice context and increasing awareness of teachers' actions and choices throughout their training.

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