

## Paulo Freire's theory of knowledge: The application of a didactic sequence in the teaching of science

### ARTICLE

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### Abstract

This research is a case study that aims to develop and analyze the application of a didactic sequence based on Paulo Freire's theory of knowledge in a 9th grade science class at a public school located in Fortaleza, Ceará. The data were obtained through the analysis of semi-structured questionnaires, applied online, so that students presented their knowledge about the importance and impacts of chemistry on society and their lives, and the concepts of properties and transformations of matter. The results indicate that the didactic sequence developed provided an environment for critical reflections on the student's social context, contributing to their training and stimulating critical thinking about the role of Chemistry in the development of society.

**Keywords:** Paulo Freire; Theory of Knowledge; Didactic sequence; Chemistry Education; Elementary School.

### Teoria do conhecimento de Paulo Freire: aplicação de uma sequência didática no ensino de ciências

### Resumo

Essa pesquisa configura-se como um estudo de caso que tem como objetivo desenvolver e analisar a aplicação de uma sequência didática fundamentada na teoria de conhecimento de Paulo Freire na disciplina de Ciências em uma turma do 9º ano do Ensino Fundamental, de uma escola pública situada em Fortaleza/Ceará. Os dados foram obtidos por meio da análise de questionários semiestruturados, aplicados de forma online, de modo que os alunos apresentassem seus conhecimentos sobre a importância e os impactos da química na sociedade e em suas vidas, e os conceitos de propriedades e transformações da matéria. Os resultados apontam que a sequência didática desenvolvida proporcionou um ambiente de reflexões críticas do contexto social do aluno, contribuindo para a sua formação e estimulando o pensamento crítico sobre a papel da Química para o desenvolvimento da sociedade.

**Palavras-chave:** Paulo Freire; Teoria do Conhecimento; Sequência didática; Ensino de Química; Ensino Fundamental.

## 1 Introduction

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Chemistry as a curricular component is present in Brazilian schools throughout elementary, middle and high school. The National Common Core Curriculum (BNCC), which aims to guide the development of science curricula throughout elementary school, organizes the syllabus into three thematic units: Matter and Energy, Life and Evolution and Earth and Universe. Content related to the area of chemistry is introduced in the thematic unit "Matter and Energy" from the 1st year of elementary school, which covers content such as: the study of materials and their transformations, sources and types of energy (Brasil, 2018).

Science teaching content, specifically that related to chemistry, is still seen by students as difficult and distant from their reality. Some reasons for this problem are the transmission of content in a technical way, prioritizing the memorization of formulas and theories, as well as the complex way in which content is approached in science textbooks, making it difficult for students to learn (Barbosa *et al.*, 2021). Based on Paulo Freire's conception, Gomes and Guerra (2020) point out that the adoption of educational practices that are decontextualized from the student's social reality make the content meaningless, stimulating memorization and hindering the understanding of the relevance of the didactic content.

Given this scenario, it is important for educators to reflect on the use of methodologies that enable students to participate in the construction of knowledge, with the aim of forming critical citizens (Negri *et al.*, 2022). In this way, students will see the application of the knowledge acquired in the classroom in everyday situations, motivating them to seek out new knowledge and consequently increasing their academic performance (Gomes and Guerra, 2020).

The BNCC presents ten general competencies for Basic Education at all levels: Early Childhood Education, Primary Education and Secondary Education, articulated in the

construction of knowledge, the development of skills and the formation of attitudes and values, under the terms of the National Education Guidelines and Foundation Law (LDB). Among the skills mentioned in the document, the development of the student's critical awareness is present at all stages of schooling. This enables students to associate the knowledge acquired in the various areas with the development of society, exercising the role of citizen in an autonomous and conscious manner (Brasil, 2018). The educator Paulo Freire, in his works, advocates an educational model that stimulates the criticality of students throughout the learning process during the schooling period, so that didactic content is not only transmitted, but also enables students to exercise their ability to think critically (Carvalho *et al.*, 2022).

Based on Paulo Freire's theory of knowledge, the general objective of this work is to develop and analyze the application of a didactic sequence based on Freire's Dialogic and Problematizing Education. Specifically, the intervention will be carried out in the subject of Science, addressing the content of Chemistry: Properties and Transformations of Matter, with a 9th grade class from a public school located in Fortaleza, Ceará. In order to meet the general objective, the following specific objectives were set: to check, using a mixed questionnaire, the prior knowledge of 9th grade Chemistry students about the Properties and Transformations of matter; to develop and apply a didactic sequence on the Properties and Transformations of matter based on Paulo Freire's Dialogic and Problematizing Education; to evaluate the students' understanding of the subject after applying this didactic sequence, comparing it with the knowledge they presented in the first questionnaire applied.

## Teaching chemistry in elementary school

Chemistry is the science of matter and its transformations, through which we can understand material phenomena and act on them, modifying them and keeping them under control. It plays a fundamental role in everyday life, making a crucial contribution to satisfying the needs of humankind, providing important materials for the advancement of

Physics, Biology and Pharmacology. It also contributes properties and procedures to science and technology (Lehn, 2011).

According to Santos (2011), even though chemistry has made a significant contribution to development and increasing society's quality of life, it has also generated problems, such as increasing social inequalities, the risk of accidents and environmental problems involving the chemical industry. Understanding the importance of this science in the development of society, the author points out that chemistry education should encourage students to take an interest in social issues linked to the area, in order to develop a critical stance on the problems linked to the applications of chemistry in society. According to Santos and Schnetzler (1996), students must acquire fundamental chemical knowledge in order to act actively in society, making decisions that are aware of their consequences.

According to the BNCC, scientific chemical knowledge is introduced to students from the 1st year of elementary school through the subject of Natural Sciences, which introduces initial concepts about Chemistry, Physics and Biology. The purpose of learning science is not only to develop scientific literacy, but also to give students a new vision of the world around them so that they can build knowledge based on the theoretical contributions of science (Brasil, 2018). In this way, science teaching in primary and secondary schools should enable students to relate the scientific knowledge acquired during their school years beyond the school walls, making them aware of their education (Delizoicov; Angotti; Pernambuco, 2009).

Therefore, in elementary school, chemistry concepts should be approached using less complex methodologies, based on the student's experience through situations that bring chemistry closer to their daily lives. This aims to develop the basis of chemical thinking, so that the student can reach secondary school with a broader perspective and a well-structured foundation (Guimarães; Faria, 2019). Starting from this point, the teacher should transmit knowledge of basic chemical concepts without prioritizing the use of symbologies, theoretical models and chemical formulations (Zanon; Palharini, 1995).

However, the literature points to various problems that make it difficult for students to learn, such as: approaching content in elementary school with little meaning (Araújo; Tristão; Santos, 2021); using methodologies that encourage the memorization of formulas, nomenclatures, presenting content without correlation to everyday life (Souza, Cardoso, 2019; Gonçalves, 2021), all of which contribute to distancing students from the content and strengthening the view of chemistry as a difficult subject. For Zanon and Palharini (1995, p.15) "it is not uncommon for chemistry to be reduced to content, which has led to a general lack of familiarity with the area, a kind of chemical illiteracy that leaves gaps in the education of citizens".

Faced with these problems, teachers must look for methodologies that encourage student participation in the teaching and learning process. This involves developing critical thinking by reflecting on the content being covered in the classroom with their social environment, moving away from the traditional teaching model in which the teacher transmits knowledge to the student without stimulating critical reflection. Educator Paulo Freire calls this traditional educational model "banking education", and points out that through this model there is no knowledge, as students are not guided to learn about the subject, but to mechanically memorize the content narrated by the educator (Freire, 2020).

In contrast to the traditional model of education, Paulo Freire proposes a pedagogy based on dialogue and problematization. This approach aims to encourage students to act as beings capable of problematizing their reality, reflecting on the social context in which they live. In this way, both the educator and the student learn from each other through a constant exchange of knowledge (Gomes; Guerra, 2020).

## Paulo Freire's Dialogic and Problematizing Education

Understanding the importance of developing critical awareness in students, educator Paulo Freire in his works presents an educational model that stimulates students' critical thinking through a dialogical relationship between educator and student. For Paulo Freire, dialog is part of human historical nature. It is through dialog that human beings meet

to reflect on the knowledge they have mastered and also on the knowledge they do not know, making it possible to critically transform their reality (Freire; Shor, 1986). When teachers understand the importance of using dialogue in the classroom and use it as a teaching methodology, they assume the position of knowledge mediator, providing students with moments to reflect on their role and experiences in the world, arousing students' curiosity and mobilizing them to transform their reality (Lopes, 2011). Freire argues that dialog does not cancel out the possibility of teaching:

it finds this act, which is completed and sealed in the other, that of learning, and both only become truly possible when the educator's critical, restless thinking doesn't hinder the student's ability to also think critically or start thinking (Freire, 1992, p.60).

However, for educators to put dialogue into practice in the classroom, they need to respect the student's knowledge. They need to understand that the student is not a blank sheet of paper and that knowledge is systematically deposited during their schooling (Delizoicov; Angotti; Pernambuco, 2009). Therefore, it is necessary to nurture a horizontal teacher-student relationship, in which the teacher puts themselves in a humble position, recognizing that the student is also the bearer of knowledge (Gadotti, 2004).

By assuming this role of knowledge mediator, the teacher enables the student to act in the teaching and learning process as an active subject, being encouraged to problematize existing situations in their social context. As they encounter complex scenarios, it is up to the educator to assist in the critical reflective process to identify and systematize the problems and thus develop possible solutions to the issues presented (Freitas, 2022).

In Freire's conception, problematizing education is based on creativity and stimulating action and reflection on reality (Freire, 1979), in which the educator and student develop a critical stance in a dialogical relationship about knowledge and its interaction with the world (Freire, 1985). This educational theory plays an important role in explaining and making students aware of the importance of their role in the world, so that they can contribute as citizens in the search for individual or collective solutions to society's problems (Carniatto; Fochezatto, 2023).

With regard to scientific and technical knowledge, Freire points out that it should be conducted in a dialogical way, problematizing the discovery of this knowledge, analysing the historical dimension of knowledge, its insertion in time and its instrumentality. The author also points out that historical facts should not just be narrated to students, but that students should reflect on why and in what context the knowledge was discovered (Freire, 1985). During this process, the teacher needs to present scientific knowledge associated with the students' reality, guided by their historicization (Silva, Souza and Costa, 2022). For science teaching, corroborating the author's theory, the BNCC highlights the need to "associate content and explanations with the historical evolution of the scientific knowledge involved (Brasil, 2018, p.323)".

Understanding the importance of historical contextualization, problematization, dialogue and the development of criticality, some researchers have systematized Paulo Freire's theory of knowledge in order to apply it as a teaching method. An example of this is Delizoicov, Angotti and Pernambuco's (2009) three pedagogical moments, organized into: initial problematization, organization of knowledge and application of knowledge. Other studies based on Paulo Freire's theory of knowledge have been applied to elementary school science, such as that by researchers Araújo, Tristão and Santos (2021). The authors analyzed the application of a didactic sequence to help develop chemistry content for 6th grade students. They used methods of investigative approaches to stimulate problem-solving in a dialogical way about science content, specifically the subject of water and its physical states, explaining the concept of chemical elements, atoms and physical transformations. They concluded that there had been an improvement in the teaching and learning process of the students assessed and an understanding of science as a process under construction, close to the students' reality.

In another study, Carniatto and Fochezatto (2023) promoted pedagogical activities in a 4th grade class based on Paulo Freire's Problematizing Pedagogy, addressing the use of agrochemicals in food production, encouraging students to reflect on the advantages and disadvantages of using these agrochemicals and the impacts on the environment and human health. The researchers concluded that, in addition to providing contact with

scientific productions, it was also possible to promote an environment in which the students, through dialog, could question and form a critical opinion on the problem.

In view of the above, the focus of this research is to develop and apply a didactic sequence, based on Paulo Freire's problem-solving theory, which will focus on dialogue, historicization and the students' knowledge of the properties and transformations of matter in the subject of Science, aimed at teaching Chemistry in the 9th grade of Primary School.

## 2 Methodology

This work is a case study and was carried out with 50 students in 9th grade at a municipal school in Fortaleza, Ceará, in October 2023. The students, selected by the institution itself based on the criterion that they were enrolled, were divided into two classes of 25 students, in the morning and afternoon shifts.

This study began with an exploratory bibliographical survey to deepen knowledge of Paulo Freire's Theory of Knowledge, Problematizing and Dialogical Education, as well as expanding the state of the art in search of scientific studies that applied this theory to science teaching. Next, a didactic sequence was developed and applied, based on Paulo Freire's Dialogic and Problematizing Education, on the content of properties and transformations of matter, configuring the descriptive and explanatory aspect of this research.

For data collection, semi-structured questionnaires were used, applied online using the GoogleForms platform. In order to meet the specific objectives set for the study, the questionnaires contained six questions, organized into three objective and three discursive, which dealt with the importance of chemistry in students' lives and in society in general, and the subject of properties and transformations of matter, the content defined for the investigation. Two questionnaires were administered: the first focused on the students' previous knowledge of the subject of the properties and transformations of matter; the second, on the knowledge acquired after applying the didactic sequence.



## Drawing up the didactic sequence

9 The didactic sequence "consists of a teaching procedure in which the specific content is focused on linked steps or stages, making the learning process more efficient" (Dubeux; Souza, 2012, p. 27). With this in mind, a didactic sequence was developed on the subject of the properties and transformations of matter, which focused on dialogue between educator and student, considering the historicization of knowledge about the properties and transformations of matter and the problematization of this knowledge. The didactic sequence was organized and applied in three meetings, as shown in the Flowchart (Figure 1).

Figure 1 - Didactic sequence on transformations of matter

**THEME: TRANSFORMATIONS OF MATTER**

**BNCC skills to be developed:** (EF09CI02) Compare quantities of reagents and products involved in chemical transformations, establishing the proportion between their masses

**Didactic sequence execution time:** 3 lessons.

**Duration of the didactic sequence meetings:** 2 hours/class.

**DIDACTIC SEQUENCE**

1

- Application of questionnaire 1 on the importance of chemistry and transformations of matter;
- Survey of students' prior knowledge on the subject;
- Historical context on the important transformations of matter in society;
- Discussion about the impact of this knowledge on our lives.

2

- Revision of the concepts of Physical and Chemical Transformations;
- Presentation of the concepts of Chemical Equations, Balancing and Weighting Laws;
- Contextualize with chemical reactions that have a major impact on the development of society.

3

- Group dynamics, the class will be organized into groups, the teacher will present some chemical reactions and the students will investigate the impacts of the reaction on society, one group will present the positive impacts while the other group will talk about the negative impacts;
- Final debate on the importance of chemical knowledge and its contribution to the development of their role as citizens;
- Application of Questionnaire 2 to survey the knowledge acquired on the subject.

Source: Elaborated by the author (2023)

At the first meeting, the first questionnaire was administered to survey the 9th graders' prior knowledge of the subject. This was followed by a presentation of the concept of transformations of matter and a contextualization of the subject with chemical discoveries made throughout history, which have contributed to the advancement of society.

In the second meeting, the concepts covered in previous years of elementary school were reviewed. After the review, the 9th graders were introduced to the concepts and specificities of chemical transformations, such as balancing chemical equations and weight laws.

In the third meeting, the didactic sequence on properties and transformations was applied, based on Paulo Freire's theory of knowledge. The students were divided into four groups of six. Each group was given a booklet about a chemical reaction, explaining its importance and its contribution to society. Each group was given a computer to do further research on the reaction in the booklet. The aim of the dynamic was for two groups to present the negative impacts and the other two the positive impacts of the chemical reaction in the booklet. At the end of each presentation, the 9th graders were encouraged to debate the facts presented, enabling them to develop critical thinking on the subject. Finally, the second questionnaire was administered to the class to survey the knowledge acquired after applying the didactic sequence.

### 3 Results and Discussion

The two questionnaires were administered at the first and last meetings with the class. Through these questionnaires, the 9th graders were able to present their knowledge of the importance of chemistry in society, the impact of chemistry on their lives and the concepts of properties and transformations of matter.

At the first meeting, the first questionnaire was administered, which focused on surveying the students' prior knowledge on the subject. The three objective questions, with "yes" or "no" alternatives, were worded as follows: "Question 1: Does the knowledge

acquired in science classes about chemistry relate to your daily life?", "Question 2: Do you think that chemistry plays an important role in the development of society?" and "Question 3: Do you think that the chemical knowledge acquired in science classes will help you in decisions you will need to make in adolescence/adulthood?". ", the following answers were obtained: in the first question, 54% did not relate the chemical knowledge acquired in science classes to their daily lives; in the second question, 82% considered that chemistry plays an important role in the development of society; in the third question, 81% of the students stated that the knowledge acquired in science classes will not contribute in the future to decisions they will need to make as teenagers/adults.

It is clear that the students interviewed understand the importance of chemistry in the advancement of society, but do not associate the presence and impact of this chemical knowledge in their lives. Chemistry is an abstract science and its concepts are often presented in a complex way, which can make the subject distant from the students' reality, making the content irrelevant to their lives. Therefore, the use of traditional methodologies, focusing only on theory and not establishing connections with real situations, has negative implications for the development of student learning, such as a lack of motivation to learn the subject, difficulties in understanding the concepts and, consequently, a lack of interest in the subject. According to Carvalho (2022), the use of methodologies that do not relate chemical knowledge to students' daily lives has a negative impact on students' learning, as they are unable to relate the content covered in the classroom to nature and their own lives. For Paulo Freire (2020), the more the educator prioritizes the transmission of knowledge to the student passively, the less they will develop the critical awareness that would result in their insertion into the world as transforming beings.

In the discursive questions, students were asked to cite examples of chemistry's contributions to society and how chemistry is present in their daily lives. Around 60% were unable to give examples of chemical situations or contributions, 16% gave examples of the presence of chemistry in the act of cooking, 14% in medicines and 10% that the chemical knowledge acquired could contribute in the future to taking tests. It was therefore possible to see that the students have little grasp of the content. Although they understand the role

of chemistry in society, as shown in the objective questions, they are unaware of its discoveries and contributions. Furthermore, most of them are unable to relate the presence of chemistry in their daily lives.

When asked about the specific content of properties and transformations of matter, only 7% of the students got the concepts of chemical and physical transformation of matter right, 9% couldn't answer, and 84% couldn't differentiate a physical transformation from a chemical transformation. This was evidenced by the following answers: "they are processes that change the state of matter" (Student 14); "it is the mixing of chemical elements" (Student 16); "they are changes in the state of the chemical element" (Student 42). 93% were unable to cite examples of the presence of chemical transformations in society. According to the BNCC (2018), in the 6th year of elementary school students should be encouraged to develop skills that help them identify evidence of chemical transformations and associate the production of medicines and synthetic materials with scientific and technological development, recognizing benefits and evaluating socio-environmental impacts. However, it is clear that the 9th grade students at the school selected for this research have not developed this skill, and that they reach the final year of elementary school with a deficit in basic concepts.

In the second meeting, after reviewing the concepts presented in previous years of elementary school, the concepts and specificities of chemical transformations were discussed, such as balancing chemical equations and weight laws. They were approached in a contextualized way through an explanation of discoveries throughout history that involved chemical transformations carried out by man and which had an impact on society and everyday situations. Through dialog with the class, the students raised situations present in their social context, identifying the presence of chemical transformations.

In the third meeting, based on the group dynamics, the students had to carry out research on two chemical reactions: the first, on the ammonia synthesis reaction, its historical context, impacts on society and the importance of ammonia for the development of society; the second, on the combustion reaction, its historical context, impacts on society and the use of thermoelectric plants on a global scale and in the Ceará region. All the

students took part and worked hard to carry out the research into the reactions, and were given guidance on research sources for the best performance. Afterwards, the groups were invited to share their results: two groups presented the positive impacts and the other two the negative impacts. Through dialogue, they problematized chemical reactions, providing an environment for students to reflect critically on the impacts of discoveries on human life and the world.

During the debate, the students' critical thinking in relation to the impacts of chemical transformations on society was evident, as the arguments presented were based on data about economic and environmental impacts, as well as the use of scientific discoveries, such as weapons. It was clear that the students perceived an impact on their lives from the combustion reaction, as they discussed the installation of new thermoelectric plants in Ceará and raised questions about the price of energy in their homes and the emission of greenhouse gases, which contribute to global warming.

The groups responsible for the positive impacts addressed the generation of jobs in the region, as one of the groups pointed out: "the construction of thermoelectric plants can generate jobs and contribute to the region's economy and is a reliable and stable source of energy" (Group 1). As for the negative impacts, the groups responded: "thermoelectric power plants have a major environmental impact, releasing greenhouse gases and requiring large volumes of water for cooling, and the disposal of heated water can be harmful to marine life" (Group 2); "Ceará has five thermoelectric power plants, but there is no reduction in the cost of our electricity bills, only an increase in taxes" (Group 2). It was found that the students were able to broaden their knowledge, contextualizing and problematizing the specific chemistry content, actively participating in the development of their critical awareness and acting as critical researchers, in a dialogical relationship with the educator (Freire, 2020).

After applying the didactic sequence on properties and transformations, based on Paulo Freire's theory of knowledge, a second questionnaire was administered to the class. According to the answers, it was possible to see that all the students understood the importance of chemistry for the development of society and that the content covered in

class was related to their daily lives. 96% of the students said that the knowledge acquired in science class will help them in decisions they will need to make in adolescence/adulthood, as can be seen from the comments made by the students: "it will help me to have a better understanding of social problems, so I can give my opinion on the cause, playing my part as a citizen" (Student 03); "I can use it to understand how to use products at home, dispose of things correctly, understand the news" (Student 32).

The students were also asked about the concept and importance of chemical transformations in their daily lives. Rosa and Schnetzler (1998, p.31) state that "understanding the occurrence and mechanisms of chemical transformations also allows us to understand many processes that occur daily in our lives". It was possible to observe that the students understood the concepts and application of chemical transformations in their daily lives, as evidenced by the following answers:

- (1) "Not to cause accidents with chemical products, whether cleaning products or household utensils, such as kitchen gas, pressure cookers, combinations that can be harmful to health" (Student 18);
- (2) "To cook, to understand technological advances, to know how to mix products at home without harming my health" (Student 38);
- (3) "Because they allow us to understand and explain the chemical processes that occur in nature and in the materials that surround us. They are also important for the development of products and substances" (Student 2);
- (4) "Learning about chemistry and the behavior of matter is necessary and important even for possible scientific advances" (Student 8);
- (5) "To understand more about how the substances we have access to on a daily basis are made, and to be careful with the types of things we mix" (Student 12);
- (6) "To understand how we can make new discoveries and solve problems caused by ourselves" (Student 25).

As a result, it was possible to conclude from the findings that the use of a didactic sequence based on Paulo Freire's theory of knowledge as a teaching methodology contributes to improving student learning in relation to chemistry content in the subject of Natural Sciences in Primary School. Therefore, the lack of critical thinking shown in the results of the initial questionnaire may be associated with the use of teaching practices that follow a traditional approach, which focuses on the transmission of theoretical information and formulas without demonstrating the practical application of the content in the students' lives.

In view of this, educators should adopt teaching methodologies that encourage discussion, questioning, problem-solving and the practical application of concepts, in order to provide a learning environment that encourages active student participation, debate and exploration of chemistry-related topics. In this way, critical thinking is developed in the subject not only to strengthen understanding of the content, but also to enable students to develop a critical awareness. This critical awareness is essential for them to be able to play their role as citizens in a meaningful way in society.

## 4 Conclusions

The didactic sequence developed and based on Paulo Freire's theory of knowledge, applied to 9th grade students, provided an environment for critical reflection on the social context of the student in the classroom, contributing to their education and stimulating critical thinking about the role of chemistry in the development of society. It was thus possible to provide a learning environment where students had the opportunity to express their opinions, learn from others and collectively build knowledge related to the content covered in the classroom with everyday situations, developing critical thinking among students, forming more aware, reflective, participative citizens capable of actively analyzing and transforming the reality around them. As Paulo Freire (1985) states, the educator has the important role of providing the student, through the dialogic educator-student relationship, with the problematization of specific knowledge with the reality in which they are inserted, in order to better understand, explain and transform it.

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