

# Implications of the analysis of teaching content in its logical-historical aspect for the definition of didactic actions<sup>1</sup>

Implicações da análise do conteúdo de ensino em seu aspecto lógico-histórico para a definição de ações didáticas

*Marta Sueli de Faria Sforini<sup>2</sup>*

*Cleder Mariano Belieri<sup>3</sup>*

*Carlos Roberto Beleti Júnior<sup>4</sup>*

---

## ABSTRACT

This essay aims to demonstrate how the analysis of the logical-historical movement of the content to be taught theoretically equips teachers in defining teaching actions aimed at developing students' theoretical thinking. The manuscript is based on Dialectical Logic, Cultural-Historical Theory, and Developmental Teaching Theory. To understand the implications of this analysis in defining teaching actions, an analysis exercise of the content on the physical state changes of water from the Natural Sciences curriculum component is presented as an example. The analysis of the logical-historical movement allows identifying what is central to understanding the conceptual system being taught, as well as recognizing the various objects and phenomena that can gain intelligibility through its appropriation. This analysis changes the way content and teaching methods are conceived.

**Keywords:** Teaching; Conceptual Learning;

---

## RESUMO

Este ensaio visa apresentar como a análise do movimento lógico-histórico do conteúdo a ser ensinado instrumentaliza teoricamente o professor na definição das ações de ensino que visam o desenvolvimento do pensamento teórico dos estudantes. O manuscrito fundamenta-se na Lógica Dialética, na Teoria Histórico-Cultural e na Teoria do Ensino Desenvolvimental. Para a compreensão das implicações dessa análise na definição das ações de ensino, é apresentado, como exemplo, um exercício de análise do conteúdo mudanças de estado físico da água, do componente curricular Ciências da Natureza. A análise do movimento lógico-histórico permite identificar o que é nuclear para a compreensão do sistema conceitual objeto de ensino, bem como reconhecer os diversos objetos e fenômenos que podem ganhar inteligibilidade por meio da sua apropriação. Essa análise altera o modo de se conceber o conteúdo e a forma de ensino.

**Palavras-chave:** Ensino; Aprendizagem Conceitual; Didática.

---

<sup>1</sup> English version by Carlos Roberto Beleti Júnior. E-mail: [carlosbeleti@ufpr.br](mailto:carlosbeleti@ufpr.br)

<sup>2</sup> PhD in Education from USP, Post-Doctorate in Education from Unicamp, and Retired Professor from the Graduate Program in Education at the State University of Maringá - UEM. Orcid: <https://orcid.org/0000-0002-9614-2075>. Email: [martasforini@uol.com.br](mailto:martasforini@uol.com.br).

<sup>3</sup> PhD in Education from the State University of Maringá; Professor of Basic Education and Lecturer at UNIFATECIE University Center. Orcid: <https://orcid.org/0000-0003-0693-7235>. E-mail: [bellieri@gmail.com](mailto:bellieri@gmail.com).

<sup>4</sup> PhD in Education from the State University of Maringá - UEM, Professor at the Federal University of Paraná - UFPR, Jandaia do Sul Campus. ORCID: <https://orcid.org/0000-0002-0158-8673>. E-mail: [carlosbeleti@ufpr.br](mailto:carlosbeleti@ufpr.br).

## 1 Introduction

Anyone who has prepared a lecture, a teaching unit, or a course knows that planning must consider various aspects: available time for content development, class duration, number of students, physical infrastructure, and available teaching materials. These are significant factors tied to the operational field of educational organization. However, before making operational decisions, it is crucial to have clarity about the quality (type) of education we aim to provide to students.

Authors of Cultural-Historical Theory emphasize the role of school education in the comprehensive development of the individual, as they believe that it is through conceptual learning, primarily facilitated by educational institutions, that an individual has the opportunity to develop. This is because "the human consciousness undergoes transformation through the gates of scientific concepts" (Vygotsky, 2001, p. 290). A similar position is taken by Davydov (1988, p. 172) who states that "education plays a guiding role in mental development, primarily through the content of assimilated knowledge."

If we agree with the idea that this is the type of education that should be provided in the school context, we must analyze how to incorporate this educational potential when planning the teaching of scientific concepts. This analysis should consider three elements that are fundamental to the organization of teaching: content, subject, and form. In other words, the actions involved in developing a teaching plan include analyzing what to teach (teaching content), whom to teach (the learning subject), and how to teach (methodological approach).

Analyzing each of these elements separately already indicates favorable and unfavorable didactic paths for teaching scientific concepts, but it is in their combination that we find support for organizing teaching. In this text, we will specifically discuss the analysis of teaching content.

When we say that the first action to be performed by the teacher is the analysis of the content, it means that it is not enough for them to define or list the scientific concepts that will be taught and then select or devise tasks to be carried out in the classroom by the students. Between defining the content and selecting these tasks, it is necessary for the teacher to study the content themselves.

Much has been said about the necessity for teachers to master the content they teach. However, mastering content involves more than just understanding what is in textbooks, being able to present it fluently, and guiding students through the tasks found therein. For a teacher to instruct on the concepts from various knowledge areas in a way that enables students to use them as tools for understanding the phenomena of the world they live in, the teacher must possess a deep understanding of the concept to teach it effectively.

Kopnin (1978) provides a pathway to achieving this mastery. He suggests that the starting point for studying a concept is to understand its logical-historical movement. Through this approach, it is possible to grasp the essence of the concept to be taught, its general core, origin, and connections with other concepts.

But what is the logical-historical aspect of a concept? How can this knowledge assist us in thinking about how to organize teaching? These questions guided our studies and the development of this theoretical article, which aims to show how analyzing the logical-historical movement of content to be taught can theoretically equip teachers to define teaching actions that aim to develop students' theoretical thinking.

The first part of this essay, based on Kopnin (1978), focuses on understanding the logical-historical movement as a means to comprehend the teaching content. In the second part, as an example, we analyze a curricular content to illustrate how this understanding influences the way teaching is planned.

## **2 Theoretical Foundations Guiding the Analysis of Content to be Taught**

Firstly, it is crucial to understand what concepts are and why they are necessary for the education of students. This discussion, seemingly peripheral, is what helps us to define what is central when teaching them in school. Vygotsky states, "The reciprocal relationship of concepts, their internal belonging to the same system, makes the concept one of the most fundamental means for systematizing and understanding the external world" (Vygotsky, 2012, p. 27).

It is common to consider that learning curricular content is important for students to perform well in school, in selection processes, or in competitions they may enter. Thus, the learning of concepts might seem to have value only within the scope of schooling itself or to meet the formal requirements for entry into the job market. However, as Vygotsky (2012) highlights, the value of concepts lies in their ability to systematize and understand the external world; they are tools that allow the phenomena of the world to become intelligible to the individual.

The contents of the various areas that make up the school curriculum, before being academic, are knowledge produced by humanity in addressing real problems and needs in the interaction of human beings among themselves and with the objective world and its phenomena. From the perspective of historical-dialectical materialism, scientific concepts are understood as living elaborations directly associated with the historical needs of subjects to understand and intervene in reality. For example, the concepts of photosynthesis, sandy soil, democracy, and fraction were not produced merely to identify: this is photosynthesis, this is sandy soil, this is democracy, this is a fraction, i.e., to name things and phenomena. They were produced by humans as they sought to understand the functioning of plants to intervene in them, know the best soil for cultivation, differentiate and analyze forms of political organization, and manage non-whole quantities, respectively. In other words, concepts are tools for human actions.

This does not mean that the verbal definition of the concept should be disregarded, as naming is something that facilitates the communication of

knowledge by synthesizing in the word the generalization about objects and phenomena. According to Vygotsky (2001), the word is the simplest unit of thought and language, therefore, it is a phenomenon of thought materialized in language. It can be said, then, that the concept is a generalization; that is, it gathers in a general class, term, or proposition, a set of objects or phenomena.

Thus, concepts are not merely labels with which we simply name objects and phenomena; at their base is a way of knowing and systematizing “the things of the world” to be able to control and intervene in them, when possible<sup>5</sup>. They are, therefore, knowledge that is linked to human activity, produced throughout history.

A concept can have its genesis revealed by its history, which allows us to understand it as the product of the solution to problems arising from needs that appear in certain contexts, becoming an instrument of human activity at that moment (Leontiev, 2004). The logical analysis of this historical process enables the explication of the essential properties of the object, which allows us to recognize it in the present, even when it has become the basis for more complex knowledge.

Discussing the logical-historical pair, Kopnin (1978) argues that by understanding this contradictory unity, we can comprehend the genesis of knowledge and the path of its development, that is, how it has changed over history.

The inseparability between the logical and the historical is explained by the author in the following way: “the logical (movement of thought) is the reflection of the historical (movement of the phenomena of objective reality)” (Kopnin, 1978, p. 84).

For Kopnin (1978), the historical pertains to the transformations of objective reality and human beings, while the logical allows for the capture and reproduction

---

<sup>5</sup> *The potential of concepts is significant, but the production of knowledge does not occur outside the contradictions inherent in a class society. Thus, the class that dominates the means of production also largely controls the conditions for the production of knowledge. For this reason, science is not always produced to meet human needs in general, but to serve the interests of this class. It thus also serves as a basis for the production of commodities aimed solely at generating profit, as well as for the production of ideas that naturalize and legitimize the current mode of production of human existence, leading to a conserving action and not to the realization of a transformative activity.*

of the essential properties of these transformations and represents them through abstractions. The logical is considered as the means that enables thought to comprehend the historical process of the real development of the world, which can be understood as "[...] the reflection of the historical in theoretical form [...] it is the reproduction of the essence of the object and the history of its development in the system of abstractions" (Kopnin, 1978, p. 183). Thus, it can be stated that "the historical is primary in relation to the logical; the logic reflects the main periods of history" (Kopnin, 1978, p. 184). The author adds:

Logic provides the form of development in its pure aspect, which, literally, in all its purity, is not realized in any historical process. However, the logical form of development reflects the historical process, hence it is necessary to interpret it (Kopnin, 1978, p. 184).

In this way, Kopnin (1978) argues that the logical does not reflect the historical movement with all its causes and different movements that determine it. Therefore, in the process of understanding reality in its movement "[...] the logical is the historical freed from the causalities that disturb it" (Kopnin, 1978, p. 184), that is, free from the specificities, deviations, and back-and-forths typical of the production of knowledge. In turn, the abstractions of the historical movement are generalized with the help of language and come to reflect "[...] the historical process in an abstract and theoretically coherent form" (Kopnin, 1978, p. 184), with this coherence achieved through the logical.

This means that, in the study of an object (theory/concept/content), it becomes necessary to investigate its history. However, this is not a matter of a linear recapitulation of history, as it is not necessary to follow this history in all its contingencies and details, but to understand the history of the production of this knowledge as a tool of human activity. Kopnin (1978) asserts that, if apprehended in this way, the object of study will not have an empirical character for the subject, because the logical will provide a theoretical vividness to its

understanding, making the content comprehensible, explainable, and theoretically coherent. Therefore:

The theory of the object provides the key to studying its history, while the study of history enriches the theory, correcting it, completing it, and describing it. It is as if thought developed according to a circle: from theory (or logic) to history and from there again to theory (logic); furthermore, according to the law of the negation of the negation, there is not a retaking of basic definitions, but the creation of new concepts, arising from a profound and meticulous study of the object's history (Kopnin, 1978, p. 186).

As can be observed, the logical-historical aspect allows us to understand the object of study, but also the human way of producing knowledge. Thus, knowledge about objects and phenomena, even scientific knowledge, ceases to be understood as absolute truth, with existence in itself, to be comprehended as a product of the human pursuit of grasping reality, driven by needs that have emerged throughout history. In other words, knowledge is seen as a human product in motion.

The logical reflects not only the history of the object itself but also the history of its knowledge. Hence, the unity between the logical and the historical is a necessary premise for understanding the process of movement of thought, the creation of scientific theory (Kopnin, 1978, p.186).

Therefore, studying the logical-historical aspect of concepts allows teachers to understand them as living productions linked to reality, which gives them social sense and meaning. This understanding is what equips the teacher to research teaching methods through which the student can also apprehend them from the same perspective, as social products necessary for thinking and acting in the world.

Given the discussion presented up to this point, we can infer that planning the teaching of a concept fundamentally requires the teacher to study its conceptual system, its genesis, as well as reflect on its contextualization in

contemporary times. This study enables the teacher to comprehend the content to be taught as a tool of human activity created at a specific time, but which still helps us interpret various phenomena of the present moment.

From the perspective of the educational process, this discussion becomes important because, in the formation of each individual, as they appropriate the thought objectified in the concepts, "[...] in their individual intellectual development, humans briefly repeat the entire history of human thought" (Kopnin, 1978, p. 186).

Based on Kopnin (1978), we can consider that understanding the content of teaching requires "[...] reproducing the real historical process of its development, but this is only possible if we know the essence of the object" (Kopnin, 1978, p. 184). That is, we need to direct our attention beyond the formal definitions of the concept, in search of what is essential to it.

But how do we come to know the essence of the study object? It is necessary to know the history to understand the essence of the object, and it is necessary to know the essence to be able to recognize it in history<sup>6</sup>. Thus, we find ourselves in a challenging circle, uncertain where to begin the study of the object. Kopnin (1978) states that dialectical materialism breaks with this circle by considering that:

The scholar should begin the study of the object from the end, starting from its most mature form, the stage of development where essential aspects are sufficiently developed and are not obscured by coincidences unrelated to it. The study of the higher, mature phase of the object's development is based on primary definitions of its essence. These definitions are abstract, not sufficiently in-depth but indispensable as a guideline in the study of the historical process of development of the object; they serve as a starting point in the study of the object, as they reflect to a certain extent the process of affirmation and development of the studied object (Kopnin, 1978, p. 184-185).

---

<sup>6</sup> For a better understanding of this process, Kopnin provides the following example: "Knowing the essence of the State presupposes knowledge of the history of its emergence and development, but one must study the history of the State having some knowledge of its essence as a social phenomenon, because otherwise one might mistake a gentile organization of the primitive communal system for a State" (Kopnin, 1978, p. 185).



The author asserts that the study of an object should begin with its most developed form, from which its essence should be deduced. This essence serves as a means to study the historical process that resulted in the object's development. The historical process, however, does not mean a linear and dated retake, but rather a movement marked by qualitative leaps that facilitated its development. To identify these leaps, one must be guided by the essence of the object.

In the same vein, Moura (2014) states:

The educator's act is to grasp the historical movement of the concept and then extract what is considered relevant to be systematized in school as teaching content. This is why the history of the concept should not be seen merely as illustrative of what should be taught. It is the true guide of educational activities (Moura, 2014, p. 11).

Thus, the emphasis on historical processes as a way to understand the significance of the concepts to be taught guides us on what is essential for students to appropriate. In the face of teaching content, some questions help us analyze it: What links exist between this teaching content and human activity? Why did this knowledge emerge? What historical need does it respond to? What problems related to human existence does this content still help to answer?

Through the analysis provoked by these questions, the teacher is able to transcend the formal definitions of concepts, unite and integrate into a system of concepts the essential connections, deducing what is nuclear and thereby understanding different objects and phenomena in the world. This path of analysis reinforces the premise presented at the beginning of the text: the content of teaching is not merely the verbal definition of the concept but encompasses the relationship between the nuclear of the concept and the essential connections with other concepts, as well as its linkage to various objects and different phenomena that can be understood through it.

### **3. Implications of the Analysis of Teaching Content for the Definition of Didactic Actions**

Given the previously discussed analysis of the logical-historical aspect of the concept, we now address the second triggering question of this article: how can this knowledge help us think about the way to organize teaching?

To answer this question, we find it necessary to take as an example some specific content from the school curriculum of Basic Education. Considering that in meetings of the GEPAE-UEM – Group of Studies and Research on Teaching Activity – we had already collectively analyzed the content concerning the physical state changes of water as a theoretical exercise aimed at developing a teaching plan from a developmental didactic perspective, we chose to continue exploring this content. We analyzed this content from Natural Sciences in order to identify its nuclear aspects, which allow understanding the different changes that occur in the physical state of water and recognizing the various objects and phenomena that can gain intelligibility through this content.

Beforehand, however, we will present the usual way of organizing the teaching of "physical state changes of water," as found in textbooks and didactic guidelines for classroom work, so we can see what changes when the teacher analyzes the content before defining teaching actions. Subsequently, we will present the analysis of the logical-historical aspect of this content, highlighting how this action allows recognizing elements to be included in the teaching of scientific concepts aimed at developing students' thinking.

### ***3.1 The content "physical state changes of water" in a didactic material***

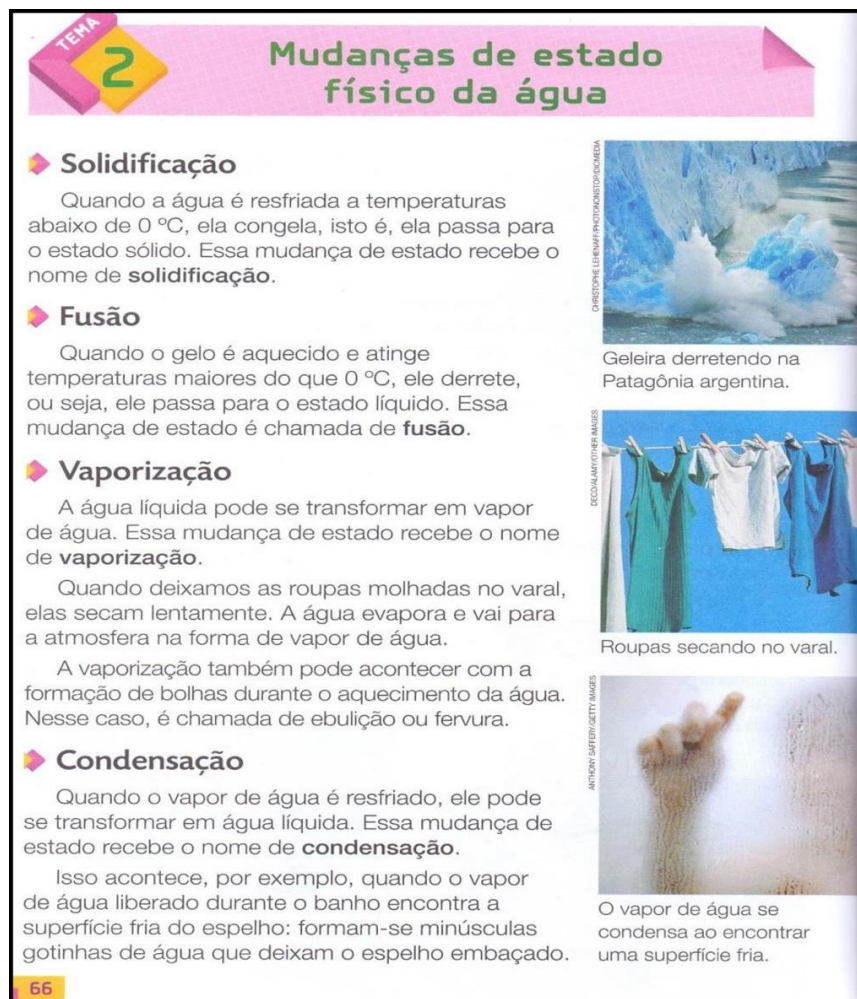
In the early years of elementary education, the content "physical state changes of water," as defined by the BNCC (Brazil, 2017), is a teaching subject in the science discipline, in the fourth and fifth grades. This content immediately involves four concepts: solidification, melting, vaporization, and condensation<sup>7</sup>. In the textbook unit analyzed (Bakri, 2014), each of these concepts was presented through a comment and a corresponding example.

---

<sup>7</sup> Considering the age of the students to whom this teaching is directed, the activity presents only four physical state changes. However, it is worth remembering that the physical state changes of matter are: solidification, melting, condensation, vaporization (boiling, evaporation, and calescence), and sublimation/ressublimation.

Figure 1 presents the textbook text that exposes the mentioned content, and Figure 2, a text used in schools in a municipality in the north of the State of Paraná, in the year 2016, for teaching the same content.

Figure 1 - Physical State Changes of Water



Source: (Bakri, 2014, p. 66)

In the textbook<sup>8</sup>, when addressing the concepts of solidification and melting, a specific temperature is mentioned for these state changes to occur. However, no temperature aspect is mentioned for the concept of vaporization. The concept of condensation references cooling. In the images provided, some

<sup>8</sup> The criterion for selecting the book analyzed by Bacaro and Sforini (2021) and Sforini and Bacaro (2022) was its adoption rate among the 25 municipalities that comprise the Regional Education Center of Maringá-PR. In this region, the most adopted book for the three-year period beginning in 2016 was "Projeto Buriti: Ciências," produced by Editora Moderna (Bakri, 2014).

examples of water's physical state changes are shown: ice melting, clothes on a clothesline, and steam during a shower. There are no images linked to the solidification process. The definitions are presented as "labels" that are "attached" to phenomena: "this state change is called solidification"; "this state change is called melting"; "this state change is called vaporization"; "this state change is called condensation." But, when and who named these phenomena? Why are they called this? Why did humans pay attention to these phenomena enough to study them? When questions like these are not presented, the science delivered to students becomes an accumulation of knowledge without human activity, conveying a vision of nature isolated from the needs and interests of humans.

The approach to concepts is centered on definition and description of the phenomenon, associating the word with an example that expresses its meaning. The phenomena (glacier melting, clothes drying on a line, foggy mirror, water droplets on a pot lid after boiling, ice melting in lemonade, etc.) are presented to illustrate the concept, but not to be understood based on it, meaning the concept does not serve its role as a symbolic tool for understanding the phenomena of objective reality.

Furthermore, it is not scientifically explained what state changes—melting, vaporization, solidification, and condensation—are; only examples of each are mentioned. The concepts are presented disconnected from each other, as if they were not the same matter (water) transformed by the same principle (temperature and pressure variations). Thus, each concept is seen as an entity in itself, and the emphasis falls on the names of different objects/phenomena.

Although these are scientific concepts, they are presented in the same way as everyday concepts, i.e., associated with a direct material representation (vaporization: clothes on a line; condensation: foggy mirror; etc.). As Luria (1991) states, a word can be employed in its concrete, figurative, or abstract and generalizing sense. This mode of teaching prioritizes the empirical, figurative sense of words, which is typical of

learning everyday concepts, representing a limitation when it comes to the development of theoretical thinking.

This type of teaching is linked to a didactic principle of traditional schooling, criticized by Davidov (2017), which is the principle of direct visual character. It starts with the sensory comparison of things, seeks their common characteristics, and fixes them through the word. The primary concern is to arrive at naming and its linkage to corresponding examples, not necessarily the understanding of phenomena.

The principle of visual character confirms, not merely and not so much the sensory basis of the concepts, but reduces them to empirical concepts constituting rationalist empirical-discursive, classificatory thought, at the base of which lies only the reflection of the external, sensorially given properties of the object (Davydov, 2017, p. 217).

This is one of the characteristics of concept teaching that justifies its little or no impact on the development of students' theoretical thinking. Keeping the concept linked to an image of a specific situation—a direct material representation—complicates two intellectual operations: abstraction and generalization. In the situation presented through the image, our senses might focus on various aspects of it and not abstract the content, as abstraction requires disregarding the secondary aspects enveloped in the concrete totality and considering only what is essential. Furthermore, the example may lead to a direct association between the word and the image of the specific situation, complicating generalization, that is, the recognition of the word as a concept that encompasses a set of objects or phenomena that can be understood by the same principle.

When this form of exposition is used, learning these concepts tends to lead to a sensory interaction with the phenomena and not to the establishment of a "complex system of their connections and relations that are revealed in the definitions of the object," as Vygotsky (2012, p. 78) states when discussing the potential of conceptual learning for the development of thought.

The tendency towards nominalism (Sforni, 2004) manifests in the way the concept is understood, as shown in Figure 1, since the concern is to name the phenomenon and not to understand the causes of the physical changes. Thus, the interaction with the presented phenomena remains at a sensory level, in this case, the visual aspect of water change.

As Sforni (2004) explains, in addition to nominalism, which is a tendency of teaching concepts according to formal logic, there is also associationalism. That is, the phenomena are associated with the concept without, however, seeking its explanatory basis, which is common in this mode of teaching concepts.

When analyzing this unit of the textbook, Bacaro and Sforni (2021) highlight that understanding the physical state changes of water is also a fundamental condition for understanding the theme of the water cycle, presented in the same unit (Figure 2).

In the explanation of the water cycle, some concepts that were previously presented are revisited. However, Bacaro and Sforni (2021) observe that the authors do not mention the terms previously cited in the unit (solid state, liquid state, and gaseous state, as well as solidification, melting, vaporization, and condensation) to establish connections between these concepts and the water cycle, which form a conceptual system. That is, as already stated, the concepts are treated in isolation, unlinked from each other. Vygotsky (2001, p. 359) states that "concepts do not arise in the child's mind like peas scattered in a bag. They are not situated one beside the other or on top of each other, without any bond and without any relations." However, when the terms previously mentioned are not referred to in the unit, we can consider that the way they are presented by the textbook may favor them remaining "in the child's mind like peas scattered in a bag," as they appear to be isolated concepts, without connections between them.

Figure 2 - The Water Cycle

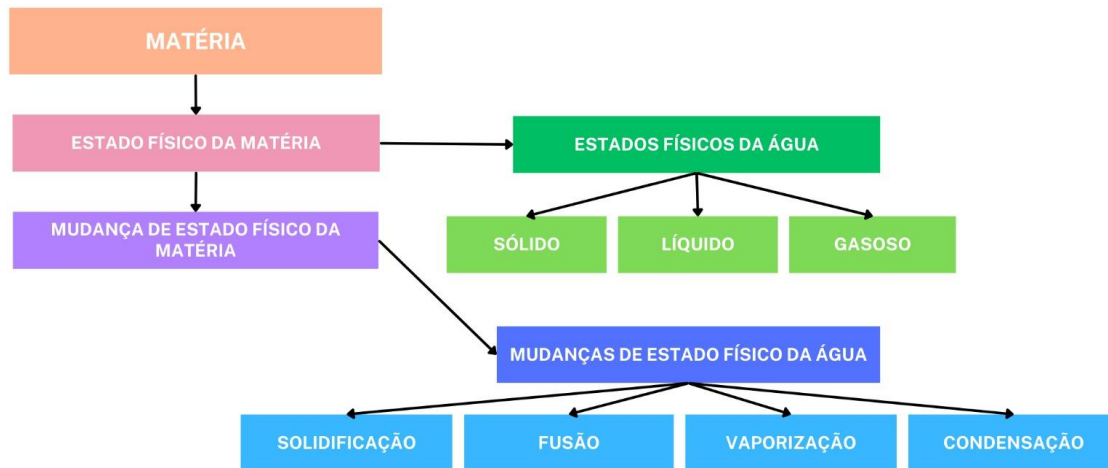


Source: (Bakri, 2014, p. 68)

The two concepts (physical states of water and changes in the physical state of water) are linked to a hierarchically superior concept: changes in matter. The mention of the solid, liquid, and gaseous states in the textbook is linked only to water and not to the more general concept of matter, of which water is a subordinate concept.

The concept of matter is superior, considering its "degree of generality" (Vygotsky, 2001), with the physical states of water being subordinate to the physical states of all matter, as shown in Figure 3.

Figure 3 - Conceptual System Scheme – Physical States of Water



Source: GEPAE-UEM - Study and Research Group on Teaching Activity

Establishing these connections between concepts allows these abstractions to provide conditions for increasingly theoretical generalizations, making various phenomena present in objective reality intelligible. Establishing the connection with more general concepts allows the phenomena to be understood in their totality, not as isolated concepts whose learning must start anew with each new concept.

When we observe the content presented in Figures 1 and 2, we revisit the questions we consider necessary to ask of all curricular content before planning teaching actions: What links are there between this teaching content and human activity? How did this knowledge arise and to which historical need is it linked? What problems related to human existence has this content helped and still helps to answer? Seeking answers to these questions directs us towards the analysis of the logical-historical aspect of this content.

### 3.2 The Content "Changes in the Physical State of Water" Based on the Analysis of the Logical-Historical Aspect



In the content "changes in the physical states of water," we seek its link with objective reality, that is, its connection with the phenomena we experience, whose intelligibility occurs through the study of this content. We also analyze what is the nuclear of the concept, i.e., the essence that allows understanding the laws of this phenomenon, in this case, the changes of state.

In searching for the nuclear aspect of the changes in the physical state of water, we start from the premise that the concept, as teaching content, is the expression of the result of an objectal-practical activity, making this content the mediator in new human relationships with the phenomenon in question. We look for a general principle capable of explaining and deducing different situations and problems faced by humanity in the struggle for the localization, acquisition, conservation, and storage of water.

Observation of the physical state changes of water has certainly been present for a long time in human history. Observations of these changes occurring in nature (water heated by the sun, melting glaciers, hail, snow, among others) as well as those present in some everyday situations (droplets formed on the inside of a lid after boiling liquids; faster boiling of water if the container over the fire is covered, etc.) are common in human daily life, even before any formal knowledge about these phenomena existed.

However, it was knowledge about the means to alter the physical state of water that allowed humans to control this process. Understanding how this phenomenon is produced by nature itself (natural phenomenon) enabled human intervention in it, that is, made the changes in the physical state of water a cultural production of humanity.

This knowledge has enabled the creation of technologies that maintain or artificially produce changes in the physical states of water. Thus, knowledge about how to freeze water leads to mastery of ways to freeze food and the production of technologies that enable this action. Producing steam on a small scale has, over time, led to the creation of steam engines, as well as machines to produce steam itself. Moreover, knowledge about ways and

means to control steam has generated methods and technologies that allow for faster cooking.

We consider that understanding the effects of temperature and pressure on water was the central knowledge humans achieved to master this phenomenon. Based on the arguments presented by Kopnin (1978), we understand that this comprehension becomes possible when we analyze the most developed ways humans have dealt with this phenomenon, linked to the history of humanity's relationship with this knowledge. This analysis, however, is not a historical analysis centered on names, dates, and places, but seeks the logical form of knowledge development reflected in the historical process.

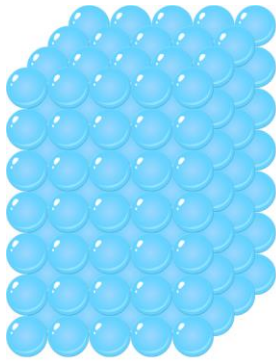
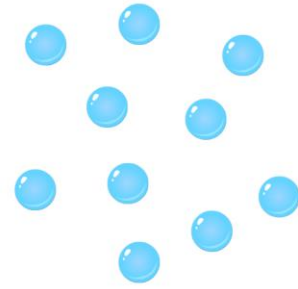
For the physical states of water to be understood beyond their immediate appearance, which can be grasped in extra-curricular interactions, it is necessary for students to understand what matter is composed of<sup>9</sup>.

Thus, it is possible for children to understand that all things are made up of very small units, which we cannot see. These units are atoms and molecules. In the case of water, the way its molecules are "organized" determines whether the water is in a solid, liquid, or gaseous state (Figure 4).

Figure 4 – Organization of Molecules: Solid, Liquid, and Gaseous States

---

<sup>9</sup> The concept of the atom can be introduced through an imaginary experiment. Imagine that we take a stone or a brick and break it into smaller parts. Then, we take one of these parts and break it again. If we continue this process indefinitely, we will arrive at a part that can no longer be divided. This indivisible part is the atom. Atoms are the indivisible parts of chemical elements such as hydrogen, oxygen, nitrogen, and carbon (represented by the letters H, O, N, and C, respectively). Chemical elements are rarely isolated but combined with each other to form molecules that make up the substances we know. Water, for example, is composed of two hydrogen atoms and one oxygen atom.

**SÓLIDO****LÍQUIDO****GASOSO**

Source: GEPAE Collection.

For this reason, when water molecules are close together, their interaction is greater and they do not move; thus, the water remains with a defined shape and volume, like ice or snow. When the molecules are more spread apart and the interaction is less, the water takes a liquid form, not having a defined shape like in the solid state. Besides being transparent, as the molecules are separated, its shape varies; it adapts to the container it's in (the shape of a glass, bottle, or riverbed). When the particles are well separated, the water, in addition to not having a defined shape, is not visible—it is in the gaseous state.

This explanation aims to demonstrate that the concepts of atoms and molecules as components of matter are essential in the system of concepts that explains the different states of water. Obviously, we are not advocating for a formal conceptualization of molecules, atoms, protons, neutrons, and electrons at this stage of education, but rather to provoke in children the reflection that there are things in nature that cannot be seen, that are minute, others that are microscopic, but together compose what we see and feel.

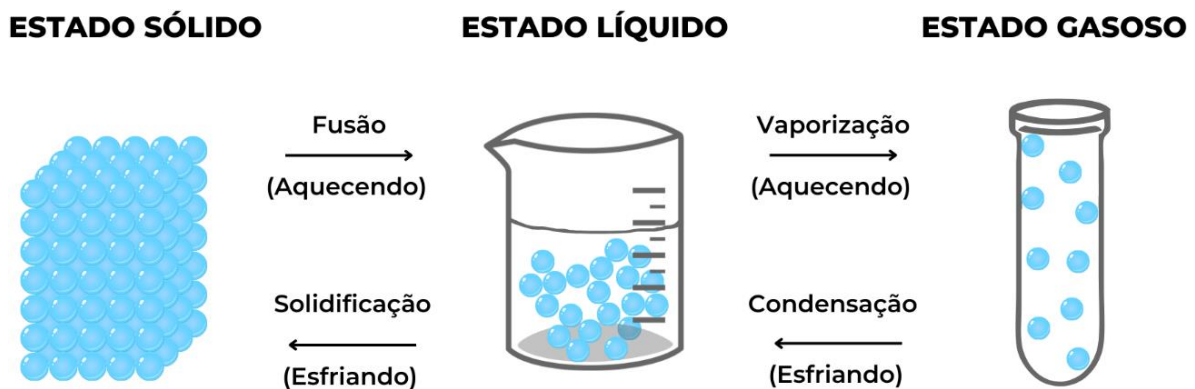
Without the concepts of atom and molecule being introduced to students, even in a simplified manner, their relationship with the different states of water remains at the empirical level, altering very little the content they already bring from everyday learning.

For the changes in the physical states of water to occur, a change in temperature and pressure is essential<sup>10</sup>; these terms were not mentioned, much less worked on in the didactic unit of the book analyzed by Bacaro and Sforini (2021). By providing energy in the form of heat to the molecules that are joined side by side (solid), they begin to agitate and move apart, thus forming the liquid state. Similarly, with an increase in temperature, the molecules move even further apart, transforming into the gaseous state.

The link between the concept of matter and the idea of transformation is essential to perceive the movement between the physical states of water. As all matter is mutable, that is, it is always undergoing transformations, even if some are imperceptible to the naked eye, water also undergoes transformations.

With this discussion, we want to emphasize that the concepts of solidification, melting, vaporization, and condensation have a common axis: the increase or decrease in temperature (Figure 5).

Figure 5 – Changes in the Physical States of Matter



Source: GEPAE Collection.

Another factor related to the state changes of water is pressure. In the textbook analyzed by Sforini and Bacaro (2022), it is explained that ice melts when temperatures rise above 0°C. However, besides the fact that ice never

<sup>10</sup> Considering that, in the learning contents and objectives for the early years of elementary school, the concept of pressure is not a topic of knowledge, we will discuss the physical state changes of water taking into account only the concept of temperature.

reaches temperatures above 0°C, it is not mentioned that this warming occurs at an ideal pressure, namely at 1 atm<sup>11</sup>, and that with an increase in pressure, the temperature can vary. This becomes clearer when thinking about an ice rink. In this case, the water is in a solid state, at 1 atm, and it will melt when it reaches temperatures above 0°C; however, with the increase in pressure that the skate blades exert on the ice, a layer of water forms under the blades allowing the skates to glide on the ice. This is because the blades are sharpened to reduce the contact area and increase the pressure and force on a specific point of the surface.

Indeed, water freezes at 0°C and boils at 100°C, but there are some cases where this heating or cooling can be controlled by increasing or decreasing the pressure. This demonstrates the relationship between temperature, pressure, and the physical states of water. Just as we believe it is not necessary to formally define molecules, atoms, protons, neutrons, and electrons to explain the concept of a particle, we also argue that, at this stage of schooling, there is no reason to worry about the formal definition of atmospheric pressure, centimeters of mercury, etc. At this time, it is important to lead the student to understand the laws of this phenomenon, namely the understanding that the drivers of the changes in the physical states of water are variations in temperature and pressure, and that it was this knowledge (and not the names given to the changes) that allowed humans to intervene in this process, creating technologies for this purpose.

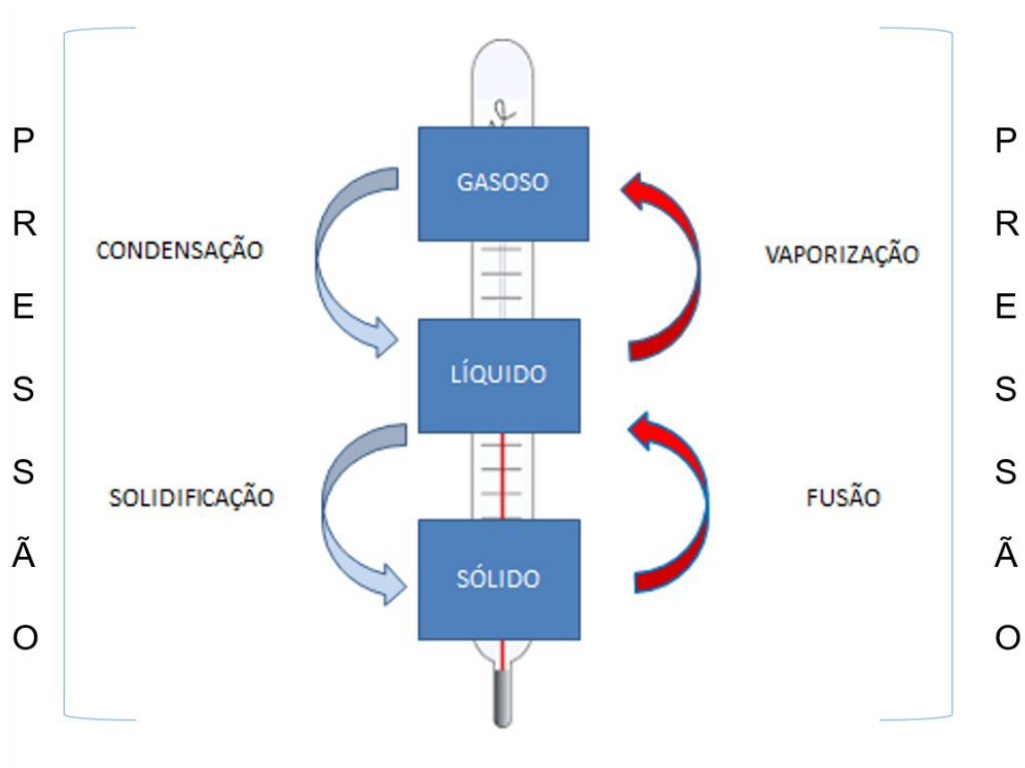
Thus, through the study of the content, we identify that around the knowledge of temperature and pressure should be articulated the concepts more directly linked to the changes in the states of water, such as solid, liquid, gas, condensation, vaporization, solidification, and melting. We consider these to be essential links for this content to be understood and not just tied to verbal definitions (nominalism) and examples of a specific aspect linked to each word

---

<sup>11</sup> “atm” - atmospheric pressure, is a unit of pressure commonly used. This measure has been adopted by the International System of Units.

(associationalism). To highlight these essential links, we have created the model shown in Figure 6.

Figure 6 - Model of the Concept 'Physical State Transformations of Water'



Source: GEPAE-UEM Collection - Study and Research Group on Teaching Activity

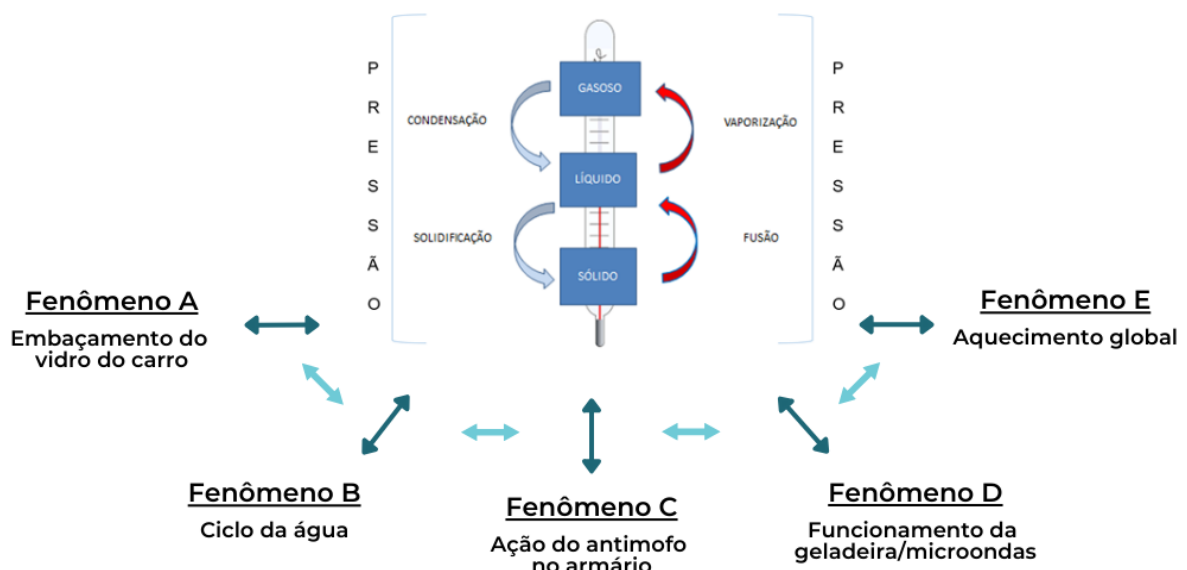
So far, we have highlighted the links between this curricular content and human activity, how this knowledge originated, and the historical needs it is

connected to. But what problems related to human existence has this content helped and continues to help address?

To answer this question, once again, we feel the need to seek the core of the concept and not just select isolated examples of the presence of changes in the physical states of water (melting glaciers, clothes drying on a line, foggy mirrors, water droplets on the lid of a boiling pot, melting ice, etc.). Temperature and pressure, as nuclear concepts, are organized in a system that allows establishing a relationship with representations of reality, internally connected. This internal connection is what makes it possible to unite in the same conceptual system the different states in which water can be found in the world.

Armed with this knowledge, students can establish essential links between the various and contradictory phenomena in which the physical state changes of water occur. That is, various phenomena, different in appearance, can be understood through the same concept, from situations close to the student's daily life to more complex phenomena, as shown in Figure 7.

Figure 7 - Intelligibility of Phenomena



Source: GEPAE-UEM Collection - Study and Research Group on Teaching Activity

Ultimately, the relationship between the core of the concept and the various objects and different phenomena is what we consider to be the content to be taught, not just the verbal definition of isolated concepts.

#### 4 Conclusions

Teaching that aims to promote the development of students' thinking achieves this goal as long as it facilitates conceptual learning. However, for this learning to be possible, teaching must be organized in such a way as to ensure the movement of thought towards the analysis of the essential properties of the studied object and its connections, constituting the core of the studied concept. This action makes it possible for students to gain new understandings about the phenomena of reality and not just the knowledge of scientific nomenclature.

Thus, for the preparation of teaching planning, before defining the texts to be used, the tasks to be proposed to students, it is essential to analyze the content, in order to identify it as a symbolic instrument. Knowing the origin and development of the concept in history, guided by dialectical logic, helps us understand its essence as an instrument of human activity.

The quest for knowledge about the origin of the concept is an action of the teacher to organize their teaching. It is not about finding a formal history of the concept to be transmitted to the student, but rather a means for the teacher to have a deeper understanding of their teaching object. In this way, the teacher becomes capable of developing teaching actions that allow inserting students in situations similar to those that generated the need to develop the concept, leading them to act with the concepts as symbolic instruments, ensuring greater intelligibility for the student about the objective world and its phenomena. Finally, the logical-historical analysis changes the way content and teaching are conceived.

Implicaciones del análisis del contenido de enseñanza en su aspecto lógico-histórico para la definición de acciones didácticas



**RESUMEN**

Este ensayo tiene como objetivo presentar cómo el análisis del movimiento lógico-histórico del contenido a enseñar instrumentaliza teóricamente al profesor en la definición de las acciones de enseñanza que buscan el desarrollo del pensamiento teórico de los estudiantes. El manuscrito se fundamenta en la Lógica Dialéctica, la Teoría Histórico-Cultural y la Teoría del Enseñanza Desarrolladora. Para comprender las implicaciones de este análisis en la definición de las acciones de enseñanza, se presenta como ejemplo un ejercicio de análisis del contenido de los cambios de estado físico del agua, del componente curricular Ciencias de la Naturaleza. El análisis del movimiento lógico-histórico permite identificar lo que es crucial para la comprensión del sistema conceptual objeto de enseñanza, así como reconocer los diversos objetos y fenómenos que pueden ganar inteligibilidad mediante su apropiación. Este análisis cambia la forma de concebir el contenido y la forma de enseñanza.

**Palabras clave:** Enseñanza; Aprendizaje Conceptual; Didáctica.

**References**

BACARO, B. L.; SFORNI, M. S. de F. Aprendizagem conceitual e desenvolvimento do pensamento: análise do potencial formativo do ensino proposto em um livro didático. *Revista Vidya*, v. 41, n. 2, p. 149-167, jul./dez., 2021 - Santa Maria, 2021. Disponível em: <https://periodicos.ufn.edu.br/index.php/VIDYA/article/view/3879>. Acesso em: 9 jun. 2023. DOI: <https://doi.org/10.37781/vidya.v41i2.3879>.

BAKRI, M. S. *Projeto Buriti: ciências: ensino fundamental: anos iniciais / organizadora* Editora Moderna; 3. ed. São Paulo: Moderna, 2014.

BRASIL. Ministério da Educação. Base Nacional Comum Curricular (Terceira Versão). *Ministério da Educação*, Brasília, DF: MEC, 2017. Disponível em: [http://basenacionalcomum.mec.gov.br/images/BNCC\\_EI\\_EF\\_110518\\_versaofinal\\_site.pdf](http://basenacionalcomum.mec.gov.br/images/BNCC_EI_EF_110518_versaofinal_site.pdf). Acesso em: 02 de out. 2021.

DAVÍDOV, V. V. *La enseñanza escolar y el desarrollo psíquico: investigación psicológica teórica y experimental*. Moscu: Editorial Progreso, 1988.

DAVYDOV, V. V. Análise dos princípios didáticos da escola tradicional e dos possíveis princípios do ensino em um futuro próximo. In: LONGAREZI, A. M.; PUENTES, R. V. (org.). *Antologia: Livro 1*. Uberlândia, MG: EDUFU, 2017. p. 211-223.

KOPNIN, P.V. *A dialética como lógica e teoria do conhecimento*. Rio de Janeiro: Civilização Brasileira, 1978.

LEONTIEV, A. N. *O desenvolvimento do psiquismo*. 2ª ed. São Paulo: Centauro, 2004.

LURIA, A. R. *Curso de psicologia geral*. 2. Ed. Rio de Janeiro: Civilização brasileira, 1991. v. 4.

MOURA, M. O. Prefácio. In. Sousa, M. C; PANOSSIAN, M. L.; CEDRO, W. L. *Conceitos algébricos: do movimento lógico-histórico à organização do ensino*. Campinas, SP: Mercado de Letras, 2014, p. 7-11.

SFORNI, M. S. de F. *Aprendizagem conceitual e organização do ensino: contribuições da teoria da atividade*. Araraquara: Junqueira & Marin, 2004.

SFORNI, M. S. de F.; BACARO, B. L. Aprendizagem de Conceitos Científicos e Desenvolvimento do Pensamento: um Olhar para o Livro Didático. *Revista de Ensino, Educação e Ciências Humanas*, v. 23, n. 3, p. 397–406, 2022. Disponível em: <https://revistaensinoeducacao.pgsscogna.com.br/ensino/article/view/9390>. Acesso em: 9 jun. 2023. DOI: <https://doi.org/10.17921/2447-8733.2022v23n3p397-406>.

VIGOTSKI, L. S. *A construção do pensamento e da linguagem*. SP: Martins Fontes, 2001.

VYGOTSKI, L. S. *Obras Escogidas: tomo IV*. Madrid: Machado Grupo de Distribucion, 2012.

Received in March 2024

Approved April 2024