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The Study Activity and the development of theoretical thinking in science classes

A Atividade de Estudo e o desenvolvimento do pensamento teórico em aulas de Ciências

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ABSTRACT

How does a student learn and how does the development of theoretical thinking occur in science classes? These are questions that concern teachers who work in elementary school, becoming a great challenge for the organization of teaching. We analyze how the development of theoretical thinking occurs in 8th grade students of a public school in the city of Itabuna (BA), based on a Study Activity, linking Science teaching with the Cultural-Historical Theory and the Theory of Developmental Teaching. From a participant research, of a cultural-historical nature, we established relations between Study Activity and the development of theoretical thinking. The analyses were based on four categories, considering meaning processes: the degree of abstraction and generality relations; the guided participation; the cultural amplifiers and mediated action; and the meaning processes in the form of mental models. In the Activity, breathing was the nuclear concept/theme, organized from five mental actions: formation of the theoretical basis; mental analysis of the process; formation of the theoretical stance; exploration of the

RESUMO

Como um estudante aprende e como ocorre o desenvolvimento do pensamento teórico em aulas de Ciências? São questões que inquietam professores que atuam no Ensino Fundamental, tornando-se um grande desafio para a organização do ensino. Analisamos como ocorre o desenvolvimento do pensamento teórico de estudantes do oitavo ano de uma escola pública do município de Itabuna (BA), tomando-se por base uma Atividade de Estudo, vinculando ensino de Ciências com a Teoria Histórico-Cultural e a Teoria do Ensino Desenvolvimental. A partir de uma pesquisa participante, de natureza histórico-cultural, estabelecemos relações entre Atividade de Estudo e o desenvolvimento de pensamento teórico. As análises partiram de quatro categorias, considerando-se processos de significação: o grau de abstração e as relações de generalidade; a participação orientada; os amplificadores culturais e ação mediada e os processos de significação na forma de modelos mentais. Na Atividade, a respiração foi o conceito nuclear/tema, organizada a partir de cinco ações mentais: formação da base teórica; análise mental do processo; formação da

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situated and concrete knowledge and qualitative examination of the foundations of the actions, enabling the emergence of Development Zones and the constitution of a theoretical stance towards reality. It was found that students were able to establish more elaborate mental representations, beyond the action of reproducing them through mental models (such as school productions), when asked by the operations/challenges. The work with more complex knowledge systems pointed to autonomous and creative transit in the use of concepts, in relations of generality, manifesting theoretical thinking by the students.

Keywords: Study activity. Science teaching. Theoretical thinking.

postura teórica; exploração do conhecimento situado e concreto e exame qualitativo dos fundamentos das ações, possibilitando o surgimento de Zonas de Desenvolvimento e a constituição de uma postura teórica em relação à realidade. Constatou-se que os estudantes conseguiram estabelecer representações mentais mais elaboradas, além da ação de reproduzi-las por meio de modelos mentais (como produções escolares), quando solicitados pelas operações/desafios. O trabalho com sistemas de conhecimentos mais complexos apontou para o trânsito autônomo e criativo na utilização dos conceitos, em relações de generalidade, manifestando pensamento teórico pelos estudantes.

Palavras-chave: Atividade de Estudo. Ensino de Ciências. Pensamento teórico.

1 Introduction

How do students learn and how does theoretical thinking develop in science classes? These are questions that concern teachers working in elementary education who take on the challenge of organizing teaching activities that effectively contribute to human development. These questions challenge the very meaning that the school institution has for the community in which it is located and for the individuals who coexist within it. The broader questions that give rise to this text led to a research project with the general objective of analyzing the process of developing theoretical thinking in elementary school students in science classes, based on a study activity on the theme of "breathing."

The environment for this investigation was defined with reference to the context of public schools in the city of Itabuna (BA), which offer the final years of elementary school, added to the researcher's personal experience in teaching Natural Sciences. In the context of the discussion on what, why, and how to teach our students, we refer to the Bahia Curriculum Reference Document (BAHIA, 2018), which is based on the normative guidelines of the National Common Core Curriculum (Base Nacional Comum Curricular - BNCC). The

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document seeks to reframe and contextualize teaching proposals in order to take into account the unique characteristics of identity territories (in the case of Itabuna, the municipality is located in the Southern Coastal Territory).

We highlight the importance of Natural Sciences content for the human development of our students, as well as the historical neglect of public policies in the training of teachers who teach this curricular component. Our understanding of the importance of science education in basic education is in line with that of Prá and Tomio (2014, p. 179, emphasis added), when they argue about science education and its role in the development of what they call "a way of knowing the world":

> [...] in the current historical and social context and in our culture, those who have less opportunity to access, understand, use, and critique scientific and technological knowledge in their lives compromise the exercise of their citizenship and favor their exclusion from various social groups. With this, *we understand that school science education plays a significant role in the appropriation of culture by individuals by helping them to develop ways of thinking/explaining that allow them to make use of the signs and instruments necessary for participation in a techno-scientific society.*

Our proposal was to investigate the learning of students in an eighth-grade class at a public school, focusing on the students' Zones of Development and paying attention to the unit "meaning creation/learning leading to development" as a historical (genetic) process of a Study Activity. Knowledge of the psychological processes associated with learning and development in science classes was made possible by two theoretical approaches belonging to the historical-cultural school: Historical-Cultural Theory (in Vigotski) and Developmental Teaching Theory (in Davidov).

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2 Methodology

In order to clarify the organization of research with elementary school students who, together with their teacher-researcher, learn and develop, we opted to create a space for reflection and discussion based on the five mental actions described by Davidov (1986) that characterize a Study Activity. Therefore, this is a qualitative, participatory research based on the historical-genetic method (VIGOTSKI, 2004b), that is, with a focus on the historical and dialectical genesis of events. The participatory research is limited to the historical plane of microgenesis, where Activities (teaching and studying) will be dialectically united in a specific historical-cultural context that highlights, above all, the concept of productive or practical activity: a school in the municipality of Itabuna (BA) and a classroom bringing together a research professor and his 12 eighth-grade teenage students.

Vigotski (2004b, p. 373 - 374) gave historical (genetic) importance to methodology and analysis in research, making an important observation: "the strength of analysis lies in abstraction." Thus, much more than the students' mistakes and successes in their Study Activity will be considered, since we are interested in identifying and analyzing historical paths and processes of subjectivation, in and through practical activity. Therefore, during the classes, the students and their teacher-researcher made explicit a relationship between learning and development that is based, above all, on the joint participation of reciprocities: teacher ↔ students and students ↔ students, united around scientific knowledge. This participation expresses the social and mediated nature of behavior. (VIGOTSKI, 2001).

In the research, knowledge of the daily routine of the class, with its participants in interactive dynamics, was recorded on video, allowing for a careful look not only at the events, but, above all, at the way in which they occurred. Different mental models (DAVIDOV, 1986) were also used in the analytical process, in the form of written exercises, photographic records, and other products resulting from the Activity, aiming at a more detailed data

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collection, with indicators of the levels of thought organization that students operated in the process of developing theoretical thinking.

We understand that video recordings enable attention to detail, contemplating the perspective of students and their teacher in mediated interactive processes, with the attempt to distinguish worldviews, desires, and attitudes, in short, understandings. We emphasize here the importance of paying due attention to the historical perspective of processes that change successively, as Vigotski (2004b) referred to in relation to research on human psychological functioning: the focus on social genesis and transformations in the course of events in complex interactive processes.

In Research Activity[3], we list, a priori, four categories of analysis to identify and understand, in the interactive dynamics of a Study Activity, the emergence of meaning processes, that is, how students qualitatively operated the relationship between thought and language:

a) *the degree of abstraction and general relationships* (knowledge related to the topic of the Study Activity, in the form of scientific concepts, premises, laws, etc.);
b) *guided participation* (interactions between teachers and students and among students themselves, with an emphasis on dialogic interactions);
c) *cultural amplifiers and mediated action* (the use of resources and methodologies);
d) *meaning processes in the form of mental models* (students' intellectual and affective production, materialized in the form of texts, posters, videos, dialogues, etc.).

Our choice to use representatives from the historical-cultural school is justified by the fact that the classroom is a social and cultural environment,

[3] All ethical procedures were observed and submitted in advance to the University Ethics Committee, receiving approval by Opinion No. 4,788,174.

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marked by interpersonal intertwining, mediated by knowledge, in an intense movement of meaning construction. Vygotsky (2001) understands learning as a driver of development, based on Zones of Development that have been established in the historical path constituted by mental actions, towards more elaborate knowledge systems that would be difficult to establish without the effective action of the teacher. For Vigotski (2017), the process of internalizing these systems is, in fact, a formative element of what we call theoretical thinking.

It is worth noting at this point that classes in the State Network were suspended in March 2020 due to the Covid-19 pandemic caused by the SARS-CoV-2 virus, and were later resumed in 2021 in a remote format, with the support of technological resources, including synchronous and asynchronous moments, according to the students' possibilities[4]. The Bahia State School System provided teachers and students with access to an institutional email account, E-Nova, set up by the Department of Education, which resulted in the provision of an account for each of the individuals working in public education in Bahia, with the possibility of using Google tools.

Based on the available resources and students' access possibilities, the school determined that synchronous classes would take place through the Google Meet digital platform, a video call tool that allowed real-time interaction between participants. In addition to this, it was also determined that the WhatsApp application would be used for asynchronous communication between students, teachers, and other members of the school community.

3 The Activity of Study, Mental Actions, and Their Meanings

Davidov, inspired by Historical-Cultural Theory and Activity Theory, researched and organized a vast body of knowledge, composing what we now know as Developmental Teaching Theory.

[4] The students participating in the research used nicknames instead of their real names. This initiative was justified in order to protect their identities.

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In this sense, his epistemology is also based on historical-dialectical materialism, since his work expresses the relationship between the subject and their external reality, mediated by (work) Activity, which produces changes in both that reality and the subject.

The theoretical focus is on the unity of "teaching and studying" aimed at qualitative changes (cognitive and affective), especially with regard to the development of (theoretical) thinking by students.

For Davidov, "the most central issue in educational psychology is the relationship between education and development, explained by the general law of the genesis of the child's psychic functions in interaction with adults and peers in the teaching and learning process at school." (LIBÂNEO; FREIT)

AS, 2013, p. 324). The authors complete their arguments by stating that Davidov attributes to teaching "[...] a major role in student development, through the structuring of their study activity and with a focus on theoretical knowledge and theoretical generalizations." In Developmental Teaching Theory, the concepts of "Study Activity" and "theoretical thinking" are fundamental and place students as full subjects of their Activity. This was an important issue developed throughout Davidov's work. With regard to learning, the author distinguished it as a fundamental activity of human development, confirming its most important necessity: the mastery of theoretical knowledge in the form of concepts, that is, the mastery of cultural psychological instruments (in our context, scientific culture).

In Davidov's terms (1986), students appropriate more elaborate forms of human thought through concepts. (LIBÂNEO, 2004). Supported by Vigotski, the author states that a Study Activity enables the emergence of important psychological formations (neoformations) by students, such as the development of theoretical thinking and personality, referred to by Davidov (1999, p. 3) as "creative personality":

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> For us, a person's personality is manifested in their creations. Therefore, teaching students the necessity of studying and their ability to do so contributes to the development of their personality.

Also drawing on Leontiev, Davidov (1986) incorporates assumptions and concepts from Activity Theory into his theory and adapts them to the theoretical elaboration of Teaching Activity and the development of theoretical thinking: its object, necessity, motive, actions and operations, and underlying conditions. In addition, he also inserts an important psychological component related to emotions: the relationship between need and desire, characterizing an emotional condition for Activity. In this way, he links two psychological possibilities related to learning: affections and cognition, approaching the understandings already elaborated by Vigotski (2001) on the role of higher emotions. Thus, Davidov pays special attention to the meanings that students give to school, knowledge, the role of teachers, and the very act of studying something. In fact, meaning links students to their reality (their experiences in the world).

The author proposes, based on its historical and developmental nature, the organization of Activity based on five mental actions (DAVIDOV, 1986), which have distinct characteristics in terms of the complexities of the operations to be proposed, as well as the conditions present in the environment. We can also state that, in each mental action, there is a development of ways of thinking about the object being studied. The stages, therefore, are as follows:

1. First mental action: The formation of the theoretical basis.
2. Second mental action: The mental analysis of the process.
3. Third mental action: The formation of the theoretical stance.
4. Fourth mental action: The exploration of knowledge.
5. Fifth mental action: The qualitative examination of the theoretical foundations.

In Figure 1, we specify the five mental actions and the emergence of neoformations (which we will discuss later).

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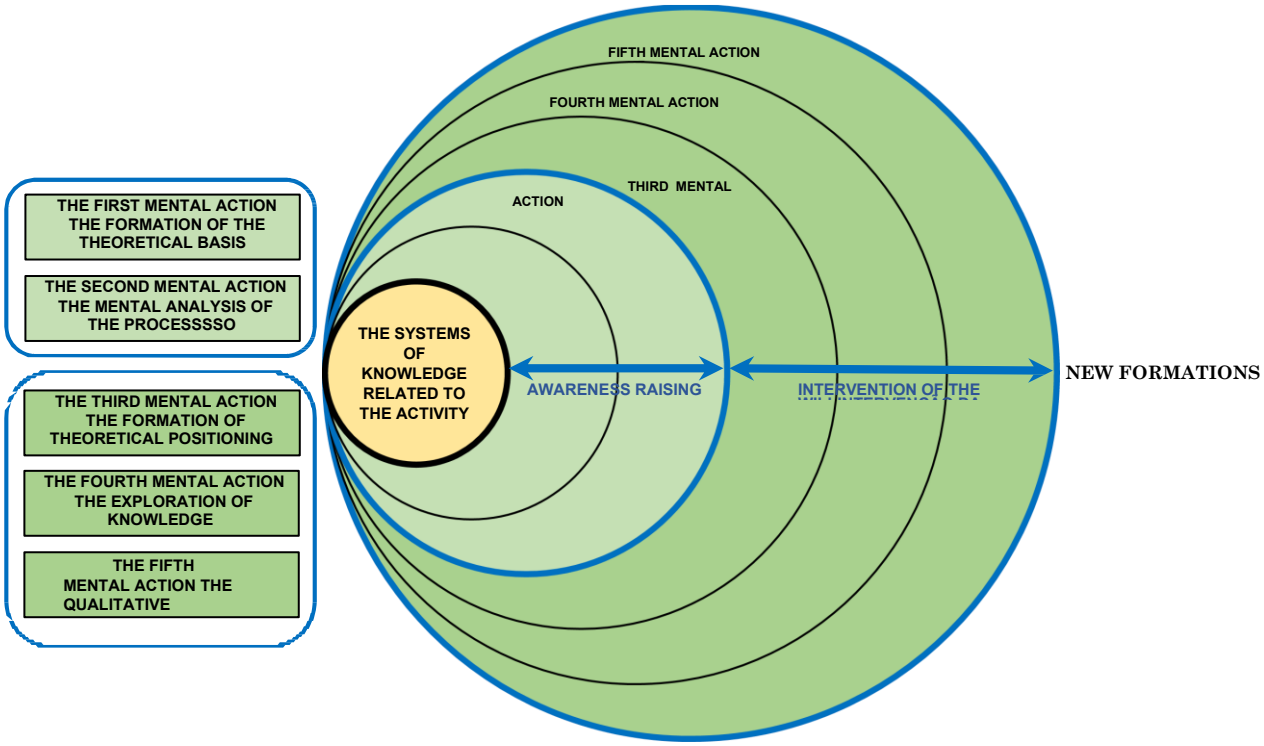
Figure 1—The mental actions predicted by Davidov and the development of neoformations



Source: Illustration prepared by the authors

This historical organization has a decisive meaning: in every mental action, students always establish relationships with scientific knowledge. However, these relationships follow a growing complexity as they learn, develop, and deal with the knowledge system of the Activity itself, that is, as they develop conceptual thinking, or theoretical-scientific thinking, as Davidov (1986) advocates. But there is another important meaning: the pedagogical role of challenges (as problem situations), which they must solve along the way. Challenges evoke an important condition already presented above: a Study Activity needs to have a creative/transformative principle. We understand that challenges provide this (psychological) condition and that it is closely related to the dialectic of "imagination and creation" announced by Vigotski (2009).

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3.1 The first action: establishing the theoretical basis of the study, as a step toward raising awareness

In the first action, two important psychological-pedagogical issues arose: the identification (and awareness) of two systems of knowledge: prior knowledge, including spontaneous knowledge and the universal relationship of the object, with its most general characteristics, or the universal relationship that reflected the theme, that is, the fundamental scientific concepts for the study. In other words, this means the student's journey through the genetic basis and source of all general and particular forms, that is, their theory (LIBÂNEO; FREITAS, 2013).

The presentation of the conceptual field of the theme, or the formation of the theoretical basis, involved the definition of the core concept (the one that reflected the theme), as well as the associated concepts. With these, students were challenged to develop more comprehensive starting questions relevant to the study and related to the core concept: “What do we want to know?”, “Why is this important?”, among others. These questions were revisited in the fifth mental action, as we will see later.

In the first mental action, students become aware that they already have a system of knowledge (i.e., ways of thinking about the theme) and that there is also a more complex system, which is the object of study. Thus, first, they were urged to pay attention to the relevant abstractions (especially the concepts that establish relationships with the core concept, or a deeper understanding of the concepts and their relationships with each other, constituting what Vigotski (2001, p. 295) perceives as a system of concepts or a field of cultural meanings, with their relations of generality:

> We have discovered that awareness of concepts is achieved through the formation of a system of concepts based on certain reciprocal relationships of generality, and that such awareness of concepts renders them arbitrary. And it is by their very nature that scientific concepts are the gateways through which awareness penetrates the realm of concepts [...].

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From the point of view of teaching organization—delving into knowledge systems, that is, understanding the theoretical basis of the study—meant recognizing its core concept, as well as the concepts associated with it. In our planning, we defined the concept of "breathing" and, from there, derived the other concepts.

Subsequently, there were developments for more specific content, such as the parts that make up the respiratory system and their functions, the phenomenon of exhalation and inhalation and gas exchange, etc. It ended with diseases associated with human respiration, such as influenza, the SARS-CoV-2 virus and acute respiratory infection, tuberculosis, pneumonia, and emphysema. Thus, a system of knowledge was proposed that we consider important for guiding students toward a more elaborate understanding of the concept of "breathing." A central question was established as a starting point: "Why is breathing important for life?" From there, the scientific knowledge system of the Activity was organized, establishing the theoretical and conceptual basis for its implementation.

We know that the process of theoretical elaboration involves individual, non-linear psychological movements that occur according to the singularities of each student. However, after the research, we observed that teachers who are aware of how this process occurs can think about and organize their teaching activities in a way that favors these elaborations. This was our starting point for organizing the Study Activity: to propose situations of a pedagogical-psychological nature so that students could exercise their mental elaborations, individually or collectively, as well as to ensure communicative spaces to expose their mental models and, at the same time, interact with their peers and the teacher. Asynchronous activities, such as group posts, allowed students to interact through dialogue, according to their individual time and connectivity possibilities. Our intention was to conduct, in the interactive process that characterized the Activity, an analysis that would consider:

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a) The relationship between the Study Activity topic and the students' sociocultural context.

b) Engagement related to the Activity and the resulting connection with its scientific concepts.

c) The impact of the response on the community.

d) And, based on the questions, begin selecting the study materials and strategies necessary for developing mental actions.

Given the contingencies imposed by the pandemic and the material and technical conditions of the students and teacher, classes were often characterized by dialogued exposure for discussion of the knowledge involved, such as questions about the use of breathing and its importance for sustaining life, the functions of the organs of the respiratory system, etc. As far as possible, activities were proposed that involved the organization of working groups for handling materials and written records.

When referring to the learning of concepts, Vigotski (2001, p. 237, emphasis added) provides us with an important guideline: "[...] *it always arises in the process of solving a problem that is posed to the adolescent's thinking.* Only as a result of solving this problem does the concept arise." Here, it is pertinent to say that, for Davidov (1988), the process of forming theoretical thinking does not disregard the function that the five senses have in this process. Therefore, in the first mental action, explorations (such as practical activities, watching videos, reading texts, using concrete materials, etc.) had a significant influence on the processes of theoretical thinking formation. Notably, the tasks resulting from the five mental actions needed to be organized based on the understanding that theoretical thinking is based on real data, in the form of sensory knowledge. (DAVIDOV, 1988).

In the first mental action, during the meetings, students were guided to learn about abstractions relevant to the topic, that is, we sought to draw

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attention to concepts that formed relationships with our core concept: "breathing" and also how they established relationships with each other, forming what Vigotski (2001) perceives as a system of concepts, with their relationships of generality:

> We have discovered that awareness of concepts is achieved through the formation of a system of concepts based on certain reciprocal relationships of generality, and that such awareness of concepts renders them arbitrary. And it is by their very nature that *scientific concepts are the gateways through which awareness penetrates the realm of concepts* [...]. (VIGOTSKI, 2001, p. 295, emphasis added).

According to Vigotski, scientific concepts allow students to establish a new and specific relationship with the objects of knowledge, and this happens, above all, through the hierarchical links that concepts constitute among themselves. Therefore, awareness manifests itself before anything else and comes into existence, according to Vigotski (2004a; 2001), as thought, which is characterized as a neoformation, that is, a new structure of generalizations. (VIGOTSKI, 2001). From a psychological point of view, conscious perception leads to voluntary control, which Vigotski refers to as arbitrariness. It is worth noting that the functional structure of consciousness develops and, in turn, expands the possibility for new learning to take place. This is an aspect related to human development that gives pedagogical meaning to a Study Activity with its mental actions.

During the tasks required in the first action, it was recommended that short written summaries be prepared that already included the use of the concepts from the theoretical basis. This recommendation was intended not only to explain the system of relevant knowledge, but also its relationship with real (cultural) contexts that were understandable to the students, with the text presented by Clara:

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> *To ensure **breathing**, the body performs two **respiratory movements**: inhalation, which is the intake of air into the lungs, and **exhalation**, which is the elimination of **carbon dioxide**. Pulmonary respiration is a process in which air enters our lungs and is subsequently eliminated.*

When referring to awareness, Davidov (2017, p. 219) asserts that conscious character is truly enabled only when: "[...] students do not receive ready-made knowledge, if they themselves reveal the conditions of its origin." This is possible when students "[...] perform those specific transformations of objects, thanks to which, in their own school practice, they model and recreate the internal properties of the object, which become the content of the concept." This is what Davidov (1986) refers to as the formation of a genetic basis that enables subsequent mental actions. That is, students manifest "[...] the general content of a certain concept, as a basis for the subsequent identification of its particular manifestations." (DAVIDOV, 2017, p. 220). Like Vigotski, Davidov (1986) interprets the concept as a reflection of reality and, at the same time, a procedure of the mental operation that led to its construction. In the third week of the Activity, everyone was very active on the WhatsApp group, posting images of their work, in some cases also highlighting the help of family members who served as models for their drawings. From the third week onwards, therefore, there were elements for us to move on to the second action.

3.2 The second action: mental analysis of the process

This action was characterized by the development of a model representing the universal relationship and its internal connections (the production of a video about smoking), which materialized in a result (a model) that highlighted a way of thinking—a system of knowledge already formed by the student as a consequence of the first action, when the theoretical basis was established. Davidov (1988, p. 134) conceives of a model as follows: "[...] a system represented mentally or realized materially that, reflecting or reproducing the object of investigation, is capable of replacing it so that its

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study provides new information about this object." Regarding the development of new formations, we recall that, in the second mental action, we are still in the stage of awareness. Thus, when we asked students to develop a representative mental model, they should have represented not only the concepts and their definitions, but above all a relationship of generality (VIGOTSKI, 2001), a system of knowledge in terms of understanding.

The task was to create a video, considering the concepts of the study and how they help in understanding a certain aspect of daily life: smoking is a recurring practice in the region. From a psychological-pedagogical point of view, Davidov (1988, p. 128) states: "Having a concept about an object means knowing how to mentally reproduce its content, to construct it. The mental action of constructing and transforming the object constitutes the act of understanding and explaining it, the discovery of its essence." At this stage of the activity, students enter the knowledge system—but in a relationship of generalities, explaining it in the form of language, an exercise of a psychological nature called metathinking (VIGOTSKI, 2001), that is, students manifest degrees of consciousness, not only in relation to the object of study, but above all in relation to the scientific concepts that constitute it, already as thought. They did this by planning and producing an informative video. For Vigotski (2001, p. 275), "becoming aware of some operation means transferring it [knowledge] from the plane of action to the plane of language, that is, recreating it in the imagination so that it can be expressed in words."

As mentioned, in the second action, the manifestation of thought via language predominated. In the process of making the video, they were also guided in the preparation of a written script so that they could organize the necessary scientific knowledge and the way it would be disseminated: orally or through written and illustrated messages. In this sense, we believe that authorial writing became an important condition of the task announced for this stage of the Study Activity.

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From a psychological point of view, Vigotski (2004a, p. 185) states: "[…] as the word grows in consciousness, it modifies all its relationships and all its processes […], the very meaning of the word evolves as a function of the change in consciousness." What are the meanings of this statement? The opportunity to think (and subsequently act) based on knowledge systems or reference systems that are different from their own. Therefore, the video defined a relationship between the student (author) and their theme, in which concepts mediated an interaction with the world (a learning relationship), mainly because they were already able to express, for example, critical thinking, an aspect that we will address in the next mental action. In this operation/challenge, there was a dialectical approach which, according to Vigotski and Davidov, related thought and language, a psychological determinant that points to a way of learning: students already consciously and arbitrarily employ both spontaneous and scientific knowledge systems. Here, we highlight the students' authorial protagonism. We identified this creative protagonism in the solutions developed by the students, both in terms of the use of available technological resources for the development of materials and in the use of the knowledge system, with concepts related to breathing. That is, in the second mental action, we took into account the degree of generalization acquired. In this sense, the video on smoking (as a mental model) became the reason for the formation of meaning for the students.

3.3 The third action: the formation of theoretical stance

In the third stage, the mental model was transformed, that is, the properties of the universal relationship were experienced in their concrete aspect and not just in the abstract. According to Davidov (1986), the analysis of the essential genetic relationships of the object and concerning the subject of the study enables students to understand the essence of this object, that is, its theoretical foundations. In this way, they develop ways of thinking about the object, of problematizing, investigating, as well as identifying and

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distinguishing connections. Davidov calls this developmental condition a theoretical stance: they employ already known forms of generalization, but in this mental action, they operate from a specific episode. It is important to remember that, from the third mental action onwards, in terms of neoformations, we identify the domain of the concept. The internal hierarchical system of interrelationships comprises the sphere in which awareness—its generalization and mastery—arises for the first time. The intention of the action was for them to establish a theoretical perspective, since they had already experienced a historical journey by experiencing the first and second mental actions, based on a system of scientific knowledge. We return once again to Vigotski (2003, p. 160), who helps us with this important question: "Explaining something scientifically means nothing more than discovering its connection with other phenomena and integrating the new knowledge into the fabric and system that is already known […]."

Here, the challenge intensified the establishment of what Vigotski (2001, p. 368) calls relations of generality: "the independence of the concept in relation to the word, its meaning, and its expression is expanded, and there is an increasing freedom of semantic operations in themselves and in their verbal expression." The operation/challenge proposed for this stage was a "News Board," containing different reports related to the pandemic and its effects on the geographical region where the school is located (Figure 2). Based on the application of the command shown in Figure 2, the intent was to have students make connections, identify meanings or even contradictions through reading, and mobilize a relationship between (conceptual) thought and language in a subsequent Conversation Circle via the app.

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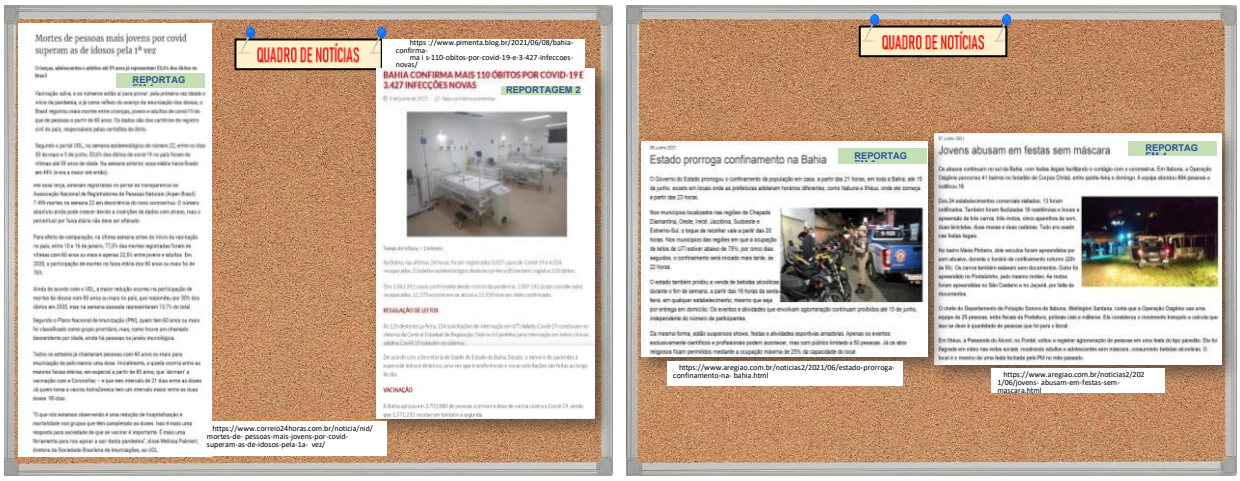
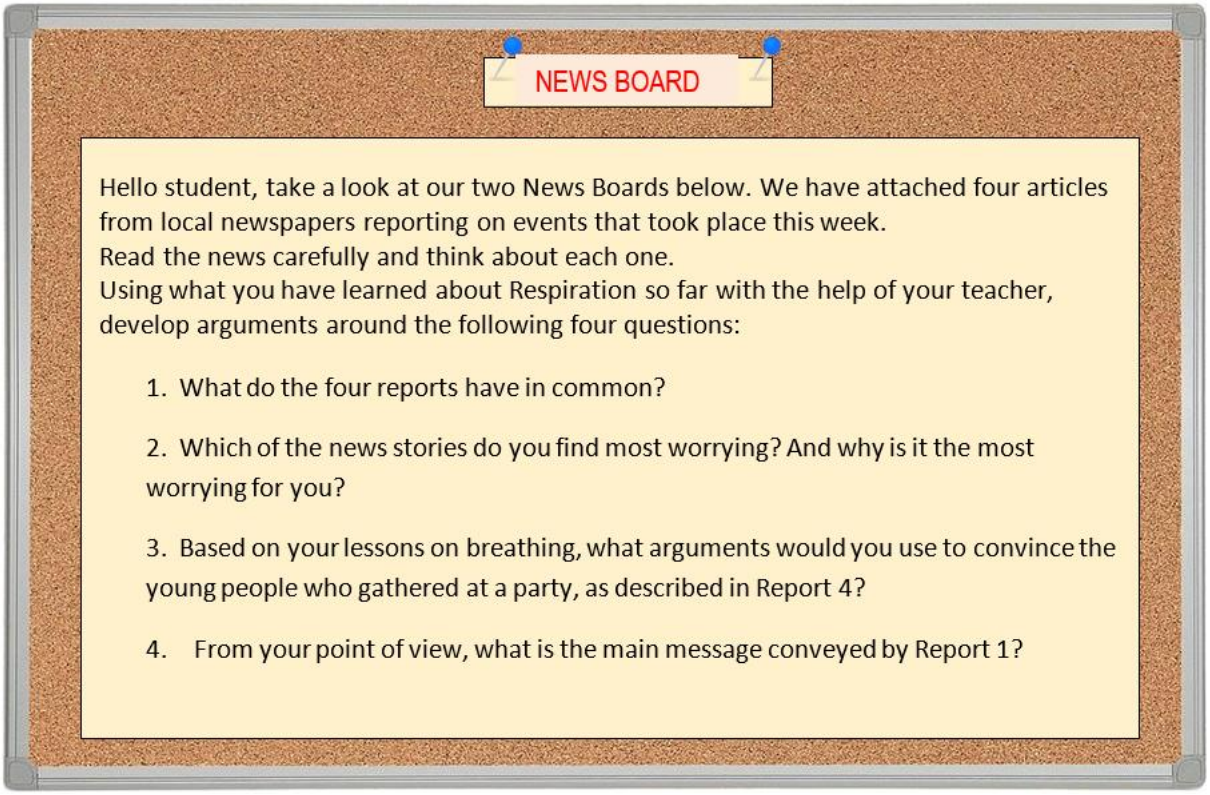
Figure 2 - The News Board



Source: Prepared by the authors

Figure 3 - Questions generating reflections based on theory



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Significant importance was attributed to reasoned dialogues, expressing a more complex discursive structure, different from that which students usually used, highlighting values and belief systems related to more scientific practice and thinking (with a theoretical stance). Thus, we remind teachers that they need to be attentive to the ways in which students organize their thinking and how they express and conduct it, encouraging and guiding them toward the correct use of the conceptual basis defined for the Activity.

At this stage of the Study Activity, we recognized that they already had a conceptual basis related to the topic, although it was used in an incipient way and with the necessary supervision of the teacher. The subsequent implementation of a Conversation Circle, via an app, gave importance to reasoned dialogues, denoting a theoretical stance, which was a more complex discursive structure, different from that which students usually use, since they evidenced values and belief systems related to more scientific practice and thinking. Thus, we remind teachers that they need to be attentive to the ways in which students organize their thinking and how they express and conduct it, encouraging and guiding them toward the correct use of the conceptual basis defined for the activity.

When we say that students will "establish a theoretical view of the object of study," we are referring to the fact that they already have the ability to reconstruct it mentally. In other words, they are becoming subjects of culture.

3.4 The fourth action: the exploration of situated and concrete knowledge

In the fourth mental action, the most important challenge was to deal with specific contexts that could be understood in terms of an exploratory task. In this way, students were challenged to experience, even if in an embryonic form, the movements that characterize exploration in terms of searching for, organizing, and developing scientific knowledge. Therefore, the meaning-forming motives that generated interest stemmed from local issues, also generating the need for other operations such as (objective) planning, reading, careful observation, recording and organizing information, etc.

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It is important to mention that when students are challenged and in the process of organizing their thoughts, they engage in a kind of mental anticipation or, in Davidov's words, an ideal object representation (a project). This means that they establish a conscious purpose in relation to an exploration. Thus, in the fourth action, our goal is authorial protagonism in the exercise of creative autonomy, especially when students appropriated historical and cultural experiences already situated as scientific culture but transformed into each individual's thinking. In these terms, as the final product of the action, an Educational Primer showed, in addition to the knowledge involved, the historical path taken around tasks of a cultural nature.

The challenge proposed as an operation was to systematize information about breathing and diseases of the respiratory system, paying attention to essential and scientifically correct communications. In addition, the operation had a social nature: to develop material that could dialogue with people inside and outside the school, so students would need to use, in addition to the most accessible language of science, other languages that would draw attention to their reading. In this sense, for example, one team chose to explore comic books, since young people enjoy this format, encouraging reading. We highlight the use of the knowledge system in the form of dialogues between characters created by the students. The final product manifested the school discourse, which has qualitatively distinct forms of communication: concepts acting not only as means of communication, but mainly as objects of study.

3.5 The fifth action: qualitative examination of the theoretical foundations of the actions

The fifth action is characterized by the development and explanation of a critical examination of a conceptual nature, based on the four actions described above. The objective was to review the two knowledge systems (the spontaneous concepts and the theoretical bases of the study) that gave rise to the Activity, highlighting the central concepts and assumptions. This was a qualitative

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evaluation of the process, mediated by theoretical foundations.

Attention was also focused on the core concept of the study so that they could answer the original questions (what is breathing and why is it essential for life?), as well as argue (with a theoretical stance) about the nature of the answers. Our purpose was to lead them to an explanation of the essence of the object.

The task involved organizing and presenting a Conversation Circle based on a challenge set by the teacher, which led to the preparation of summaries related to each stage of the Study Activity (what did we learn from them? And how did we learn?). These summaries clarified what Davidov called a genetically initial, essential, and universal relationship, which determined the content of each mental action. That is, in the historical development of operations/tasks, students analyzed the experiences that enabled the use of the concepts of the theoretical basis introduced in the first mental action. We identified, in the dialogues, a more structured organization in the form of theoretical thinking: "I learned that pulmonary respiration is responsible for gas exchange between the organism and the environment. **Gas exchange, also called hematosis**, consists of the entry of oxygen and the exit of carbon dioxide from the organism." (Ana II) and "*Breathing is an automatic and* ***basically involuntary*** *process; breathing is the act of drawing oxygen in and then expelling carbon dioxide. It turned out short, but I think it's good."* (Cidreira). Or, in the words of Júpter, complemented by Ana II:

> *I agree with the girls, with what they said, that breathing is the basis of living beings and that without breathing we cannot exist.* ***Breathing is the process of exchanging oxygen for carbon dioxide with the environment, which allows us to survive****.*
> *Breathing is the main function, supplying our body with oxygen by performing gas exchange between our organism and the environment, removing the* ***gaseous product, carbon dioxide from cellular metabolism, which gas exchange performs through the pulmonary alveoli and the environment.***

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Jupiter further expands on his thinking as follows:

> *Breathing creates* ***the energy necessary for life; its main function is to supply our body with oxygen****. As* ***breathing is a vital process*** *for humans, we breathe because we need oxygen to keep our bodies functioning and to provide us with energy.*

At this stage of our analysis, we return to an issue that is essential to the historical-cultural perspective and concerns the theoretical proposition expressed by Vigotski regarding the concept of the Zone of Development: each mental action was characterized by leading students to new levels of thinking, both in quantitative terms, as they learned new concepts and/or procedures, but mainly in qualitative terms, when challenged to use them in general relationships, that is, scientific concepts forming a system that enabled understanding. We infer that this, even if in an incipient way in many situations, led to new ways of thinking and doing, and consequently, new ways of speaking, writing, and acting. It was the use of signs as a fundamental means of orientation and mastery of psychic processes.

4 With a view to finalization, some contributions to the organization of teaching

A fundamental aspect of all our arguments, built around Study Activity and its implications for the development of theoretical thinking, is present in a Vygotskian assertion that is essential for all teachers: "change" as a historical condition for human development. According to Davidov (1986), the main purpose of a Study Activity is to introduce students to more complex systems of knowledge, based on the experience of operations/challenges so that, over time, they begin to exercise a general (conceptual) approach to solving specific tasks. Therefore, we understand that students with theoretical thinking can act reflexively, and thus with intellectual autonomy, provided they are properly motivated, challenged, and guided to do so.

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Analyzing the Study Activity, as we propose it, we can say that it incorporated a historical understanding, insofar as the five mental actions (as "micro" historical plans) established relationships with each other. In addition, the actions followed the logic of "students placing themselves ahead of themselves," that is, students engaged around shared ideals in the process of internalizing culture and constantly challenged on how they could rework it, exercising their imagination and creativity. (VIGOTSKI, 2009). This occurred more intensely in the second mental action, when asked to make a video about smoking, and in the fourth mental action, in the preparation of the Primer. In the two final products, as mental models of the Activity, we highlight the authorial protagonism. We identified this creative protagonism in the solutions developed by the students, both in terms of the use of available technological resources for the development of materials and in the use of the knowledge system, with concepts.

In the Study Activity, when establishing the operations/challenges, the students experienced social creativity, because: "[...] a concept arises and takes shape in the course of a complex operation aimed at solving a problem [...]." (VIGOTSKI, 2001, p. 156). This is what we call the "degree of abstraction and relations of generality," related to the scientific concepts that were part of the knowledge system, with "breathing" as the core concept of the Activity. The degree of abstraction and the relations of generality, therefore, are related to verbal thinking, that is, how the student organizes their thinking (self-regulation) and expresses themselves in the form of language.

From a pedagogical point of view, it is important to note that by bringing students closer to knowledge systems through Study Activities, we enable them to experience, to some extent, the Activities that have been historically established and that we now call science. With this, our effort as teachers is focused on ensuring that students understand the true meanings of these forms of knowledge. (SCHROEDER; JAKOBOWSKI, 2020). In the process of conceptual elaboration, students, when dealing with these knowledge systems,

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develop new forms of understanding and, therefore, new possibilities for interactions between the student ↔ with themselves, the student ↔ with others, and the student ↔ with the world. In other words, they develop theoretical thinking. It is important to reaffirm, at this point, that the students' productions, resulting from the operations, constituted mental models that necessarily implied the organization and participation of thought and its expression as language, constituting what both Vigotski (2004b) and Davidov (1999) characterize as a complex cognitive activity. In this regard, we infer that, when dealing with the unity of thought and language, students act on social and historical factors (in the form of culture), as well as being transformed by their action.

We emphasize that mastery of the scientific concept as a definition and example is not sufficient. When students consciously use concepts as tools, they express an understanding and, with it, a position and an action (being and existing in the world). This is what we refer to as the development of theoretical thinking.

We assess that the students' development occurred to the extent that they experienced the five mental actions and, based on them, had to deal with different challenges. Thus, we highlight "*guided participation*," which referred to the interactive processes in the classroom: students and teacher and students among themselves. In these, participants enter into contexts of communication and articulate efforts around common knowledge and objectives (the meaning-forming motives of the Activity). Here we identify the plane of interpersonal relations, therefore the plane of intersubjectivities, complex and gradual, that the Study Activity made possible.

In this sense, we highlight an important condition associated with acting in a Zone of Development: cooperation between participants, understood as social "exchanges," since it involved students and their teacher engaged in specific sociocultural Activities. (SCHROEDER; JAKOBOWSKI, 2020). Here, we highlight the role of the teacher in collaborative Activities, who organized, challenged, observed, guided, supported, and evaluated. Assistance refers to joint productive

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activity, that is, social interactions of production, in the process of studying, learning, and developing.

When dealing with sociocultural content, we mention *"cultural amplifiers and mediated action."* Here, we highlight the cultural materials used (texts, videos, images, diagrams, websites). From a learning perspective, cultural amplifiers are complex systems that include signs representing reality; therefore, they deal with languages and also with expression in the form of models. We assessed that these resources contained specific forms of communication, therefore, the use of scientific language as sociocultural content. We reflected that teachers should not consider amplifiers only as facilitators of learning, but mainly as stimulators of development. It must also be said that there is a psychological-pedagogical determinant in this assertion: the relevance of what we are exposing as "mediated action," that is, how students access scientific culture and transform it into thought.

The issue presented here brings us to our last category of analysis: "*the processes of meaning in the form of mental models."* Here, we analyze learning as a social process based on the expression of thought in the form of languages, concretized in our Activity via written texts (especially those of an online nature), in the discursive interactions between participants (both in group posts and in online conversation circles), with the consequent exchange of ideas and ideals, in synchronous and asynchronous meetings or even outside them (in the case of videos and the Educational Booklet).

It is also important to reaffirm that the students' productions, resulting from the operations, constituted mental models that necessarily implied the organization and participation of thought and its expression as language, constituting what both Vigotski (2004b) and Davidov (1999) characterize as a complex cognitive activity.

In this regard, we infer that, when dealing with the unity of thought and language, students act on social and historical factors (in the form of culture), as well as being transformed by their action. Thus, they can be guided towards

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productive rather than reproductive knowledge. In terms of a science class, we can say that knowledge does not arise only in the form of results and solutions, but in the Activity, it arises as an authorial process, as students deal with exploratory contexts. Consequently, we can also say that the Study Activity can always have a deeply creative character. (SCHROEDER; JAKOBOWSKI, 2020).

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