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The Digital Sketchbook and the materiality of remote educational processes underpinned by Cultural-Historical Theory

Caderno Digital e a materialidade de processos educativos remotos ancorados na Teoria Histórico-Cultural

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ABSTRACT
In this article, we introduce and explore the concept of the Digital Sketchbook as a research and educational tool in remote and synchronous settings. We examine its theoretical and methodological convergence with dialectical materialism categories, aligning with the assumptions of Historical-Cultural Theory. Next, we analyze and discuss excerpts from Angelo's (2021) research demonstrating the use of this resource through the lens of the principles of movement and contradiction. These principles manifest in the research as the struggle of opposites through the dialectical pairs of the abstract and the concrete, as well as appearance and essence. Finally, we advocate for the Digital Sketchbook as a theoretical and methodological instrument for educational research and training processes in remote and synchronous models. We highlight its potential for future research on training processes mediated by digital technologies from the perspective of Historical-Cultural Theory in contemporary times and digital materiality.

Keywords: Digital Sketchbook. Online Teaching. Historical-Cultural Theory. Digital Materiality.

RESUMO
Nesse artigo, apresentamos e discutimos o conceito do Caderno Digital como recurso para a pesquisa e para a educação em modo remoto e síncrono, em sua convergência teórica e metodológica com categorias do materialismo dialético, em coerência com os pressupostos da Teoria Histórico-Cultural. Na sequência, analisamos excertos da pesquisa de Angelo (2021) que demonstram o uso desse recurso e os discutimos sob as lentes dos princípios movimento e contradição, sendo que esse se manifesta nessa pesquisa na luta de contrários por meio dos pares dialéticos abstrato/concreto e aparência/essência. Por fim, defendemos o Caderno Digital como um instrumento teórico-metodológico de pesquisa em Educação e para processos formativos em modelos remotos e síncronos. Destacamos seu potencial para futuros trabalhos que investiguem os processos formativos mediados por tecnologias digitais, sob a perspectiva da Teoria Histórico-Cultural de formação humana na contemporaneidade e na materialidade digital.

Palavras-chave: Caderno Digital. Ensino Remoto. Teoria Histórico-Cultural. Materialidade Digital.

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1 Introduction

The discussion about the presence of digital technologies (DT) in teaching and learning processes is real. However, experience has shown us that the use of these resources has different qualities. It seems to us that the debate over including technology in teaching and learning is already outdated.

A more relevant question is how to use technology to promote human development without subjecting it to forms and methods that render the experiences and paths of its development invisible. Authors such as Antunes (2020, p. 14) have noted the rapid expansion of automated technological and digital processes that directly impact the organization and value of "living work."

Thus, we understand digital technologies as sociocultural artifacts that mediate work in the contemporary world, directly impacting behavior and, consequently, human education.

In a society integrated into productive processes mediated by digital materiality, we emphasize the importance of theoretical and methodological research on collective teaching and learning environments aided by digital instruments that facilitate the collective sharing of cultural meanings to develop theoretical thinking in a digital technology context (Angelo, 2021, p. 63).

In this article, we introduce and discuss the concept of the Digital Sketchbook as a research and educational resource in remote and synchronous settings, focusing on its theoretical and methodological convergence with dialectical materialist categories. Next, we analyze and discuss excerpts from Angelo's (2021) research demonstrating the use of this resource through the lens of the categories of movement and contradiction. These categories manifest in the research as the struggle of opposites through the dialectical pairs of the *abstract and the concrete,* as well as *appearance and essence*. Lastly, we present our concluding remarks, defending the use of the Digital Sketchbook as a theoretical and methodological tool for remote and synchronous research and education from a historical and cultural perspective.

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2 Human Labor, Tools, and Digital Technologies

For the discussion on the role of digital technologies in educational processes, we take the historical-cultural perspective as a reference point. This perspective is anchored in a historical-dialectical materialist understanding of human development.

Formulated in the early 20th century by Soviet psychologists L. S. Vigotski, A. N. Leontiev, and A. R. Luria (Martins, 2013, p. 44), this perspective is based on the centrality of the transformation of reality through the category of work and is characterized as a theory of the development of cultural forms of behavior (Elkonin, 2023, p. According to Elkonin (2023, p. 161), Vygotsky suggested that while mastery of nature occurs through work tools, mastery of behavior "occurs based on special tools resulting from work and culture, such as language and numerical signs". In Vigotsky's words:

> Marx wrote that the use and creation of tools, although present in some animal species, is a defining characteristic of human labor. For this reason, Franklin defines humans as tool-making animals (Vygotsky; Luria, 1996, p. 90).

Thus, external instruments assist in the transformation and manipulation of material objects in human work, while internal instruments turn inward toward an individual's own behavior (Vygotsky, 1996). According to this thesis, fundamental changes in the psyche occurred throughout the history of human development through the use of instruments in human activity. In other words, the sociogenesis of higher psychic functions is a direct result of work and communication activities between individuals (Leontiev, 1994, as cited in Davidov, 2023, p. 299).

To genetically investigate the development of the psyche, therefore, Vigotski emphasizes the importance of "studying all phenomena as processes of change" and the "scientist's task of reconstructing the origin and course of behavior and consciousness development" (Cole, 2007, p. XXV). According to this theory,

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researchers must trace the historical and logical development of their relationships as well as the qualitative changes from elementary to higher psychological processes based on the study of human activity (Cole, 2007, p. XXV).

From a methodological perspective, according to Vygotsky (2021, p. 3), we should not investigate human behavior in a "fragmented" way by breaking it down into elements or components. Rather, we should study it as a "structure in its entirety."

The authors of the Historical-Cultural Theory emphasize the concept of mediation as a fundamental aspect of human social nature. This concept is fundamental to understanding the genesis of higher psychological functions. The central research problem based on this theory is "clarifying the origin and structure of mediated processes" (Elkonin, 2023, p. 163). Mediations provide the instruments through which we understand sociocultural development as a broad chain of instrumental mediations and appropriation processes (Leontiev, 1984, p. 81*).*

According to Vygotsky (2021) and Leontiev (2004), this process begins interpsychically (social stage) and becomes intrapsychic (psychological stage) when the collective (inter) is appropriated by the individual (intra). Leontiev (2004, p. 165) emphasizes that the "mediating node" can be not only the word but also the "material medium (an instrument), socially elaborated verbal concepts, or any other sign." In Leontiev's words:

> Since activity can only occur through external expression, it was assumed that external processes were subsequently transformed into internal, intellectual processes. However, the ideas put forward by L.S. Vigotski at the time do not constitute a complete psychological system. They express more of an approach to the problem than a solution (Leontiev, 2004, p. 166).

Assuming the dialectical relationship between internal and external instruments as mediators of human behavior, we developed a study based on these theses that investigated evidence of the development of theoretical thinking among mathematics teachers in the early years from a continuing training perspective, adopting digital technologies as external instruments (Angelo, 2021). Specifically,

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we sought to understand the genesis and development of psychic processes mediated by digital technologies, considering contemporary and cultural forms of expression and communication.

For this reason, we developed the Digital Sketchbook concept (Angelo, 2021; Angelo; Moretti, 2022, 2023) as a theoretical and methodological instrument used in developing the formative experiment (Cedro; Moura, 2016) with early-years teachers in remote training due to the Coronavirus Disease (Covid-19) pandemic. In this context, the Digital Sketchbook proved essential in organizing technological artifacts, including digital games, and objectifying semiotic records that reveal the movement of teachers' thoughts. This unity of thought and language is produced in human activity.

We start from the assumption that, as mediators of human thought, digital technologies should help create "conditions for collective work involving communication, voice, and the sharing of symbolic and image records" (Angelo, 2021, p. 76). Thus, intentionally organizing communication and actions with digital technology is in line with the appropriation process, moving from the interpsychic (collective) to the intrapsychic (individual).

Beyond digital technological artifacts, we consider the essence of the Digital Sketchbook to be the dialectical unity between its digital materiality and the theoretical principles that govern the development of instruments, actions, and analyses.

To this end, we relate some categories of dialectical materialism to the Digital Sketchbook in a scientific and creative exercise. In the words of Kopnin (1972, p. 276), "the creative process is the synthesis of knowledge, which operates because of categories," and "through them, there is the reproduction of all the complexity of the movement of thought in the sense of new scientific results" (Kopnin, 1972, p. 277).

In this context, laws and categories are the content of the materialist dialectical method (Kopnin, 1978, p. 103). For Kopnin, the basic laws of the method are: 1) Law of the transformation and struggle of opposites; 2) Law of quantitative and qualitative transformation; and 3) Law of the negation of negation. These laws

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are fundamental and complement each other, occupying the dialectical conception of the development not only of the material world, but also of human knowledge (Kopnin, 1978, p. 103; Kopnin; Blauberg; Pantin, 1972, p. 49).

However, dialectics is not exhausted by these laws; the multiple variety of reality is found in categories (Rosental, 1951, p. 167). Categories are general terms that reflect our objective world in motion and, as such, are "forms of thought and, as such, must be incorporated into concepts" (Kopnin, 1978, p. 105). In the words of Kopnin (1978, p. 107):

> The most general and important laws governing the movement of phenomena in the world are reflected in the form of categories. The emergence of categories is proof of the maturity and richness of human thought and of its immense success in interpreting the external world (Kopnin, 1978, p. 107).

Despite the essential search for categories that allow us to understand dialectical logic, this search itself borders on contradiction, and some authors have understood that "the principles of dialectics lend themselves poorly to any codification" (Konder, 2000, p. 60).

> Since dialectics involves the analysis of contradictions in motion, attempting to establish fixed, predefined categories of analysis for the dialectical method of investigation would in itself constitute a paradox (Moretti; Martins; Souza, 2017, p. 29-30).

In this sense, the principles outlined by Kopnin (1978) serve as a foundation for authors dedicated to studying materialist dialectics. In the context of educational processes, for example, Gadotti (1990) argues that this movement can be understood through dialectical principles such as totality, movement, qualitative change, and contradiction. This is undoubtedly a broad and profound topic. For the purposes of this article, we will assume these dialectical principles.

To address "historically situated and imminently contradictory educational processes," dialectical materialist theory starts from "an analysis of objective reality through its contradictory aspects in the totality of its movement and in the search to reveal the essence of the object" (Moretti; Martins; Souza, 2017, p. 28).

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Based on this understanding and the need to objectify it in a context of remote and synchronous teaching, we developed the Digital Sketchbook proposal. We took on the challenge of searching for movement and highlighting dialectical pairs. In our case, we chose the pairs *abstract/concrete* and *appearance/essence*. Next, we will discuss the concept of the Digital Sketchbook.

3. The historical-cultural concept of the Digital Sketchbook

The Digital Sketchbook was developed in response to the need for teachers to conduct research and receive training remotely and synchronously. This approach aligns with the principles of Historical-Cultural Theory (Vygotsky, 1996, 2021) and the concepts of historical-dialectical materialism (Kopnin, 1972, 1978; Gadotti, 1990; Konder, 2000; Rosental, 1951; Rosental; Straks, 1960). In our research context, the sketchbook allowed us to study the processes of conceptual appropriation mediated by technology in its instrumental dialectical unity (external/internal and human/machine).

The Digital Sketchbook is a theoretical-methodological tool that organizes and creates a virtual environment for collective, collaborative, remote, and synchronous work. It was developed to address the researcher's need to qualify certain digital technologies as mediators of human thought in a formative experiment (Angelo, 2021; Angelo; Moretti, 2022, 2023). This experiment was conducted with teachers undergoing continuing education during the Coronavirus Disease (Covid-19) Pandemic.

We conceived the Digital Sketchbook in its dual dimensions. The first dimension is methodological and understands the Digital Sketchbook as a resource for remote research and education. The second dimension is theoretical and is produced in dialectical unity with the first dimension. It reveals the Digital Sketchbook's convergence with the assumptions of Historical-Cultural Theory and human activity. Figure 1 below schematically illustrates a general scheme of the dimensions proposed by the Digital Sketchbook.

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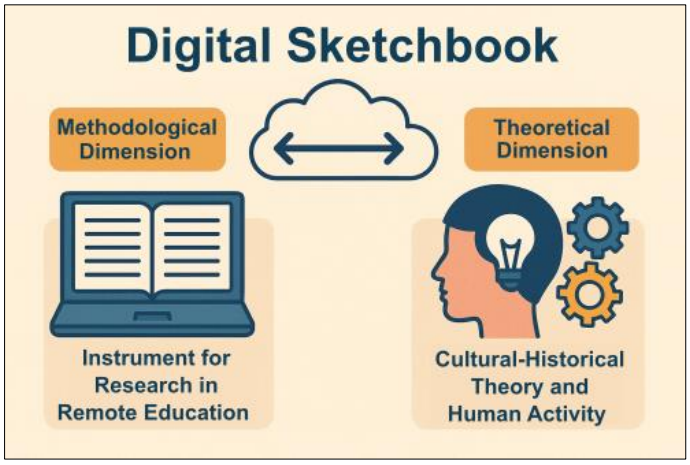
Figure 1- Representation of the dimensions of the Digital Sketchbook



Source: generated with ChaptGPT.

The Digital Sketchbook is a concept that ensures conditions for producing collective and collaborative work in a digital technological context, with the aim of developing participants' theoretical thinking during training. As a theoretical and methodological tool, the Digital Sketchbook is more than just a digital version of a physical sketchbook; it is a tool that guides the organization of mediation in digital materiality. Figure 2 illustrates the theoretical and methodological dimensions of the collective activity with the Digital Sketchbook.

Figure 2 - Schematic representation of the Digital Sketchbook

Source: authors, generated by Gemini and adapted with Inkscape.

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For our research, we understand digital materiality as the "material substrate" of virtuality, comprising work, resources, and materials — in other words, everything belonging to digital culture, even if it is "immaterial" (Casemajor, 2015, p. 13).

From this perspective, we established two principles that intentionally organize and qualify technological artifacts for the development of our research with the Digital Sketchbook as a theoretical-methodological instrument. The first principle is the appropriation of the use of digital technology through its rules or technical procedures (Angelo, 2021). The culture of digital materiality can only be entered through technology, which is a technological imperative of contemporary society. The second principle involves creating a collective space organized with digital technologies to develop theoretical thinking based on Historical-Cultural Theory assumptions (Rubtsov, 1992).

Both principles relate to the Digital Sketchbook's dialectical unity (external/internal), which aims to create the conditions necessary for students to engage in collective activity within theoretically organized digital materiality. Thus,

> [...] the digital sketchbook enabled conditions for remote and synchronous meaning-making processes to occur, contributing to the production of empirical material for our research in Education. In other words, information and communication technologies (ICTs) organized for remote teaching and learning activities have been transformed and qualified as a digital sketchbook by the actions of the participants in training (Angelo 2021, p. 76).

Thus, the Digital Sketchbook enables the development of collective work plans in a digital format by creating conditions for the sharing of languages (oral, written, and symbolic) between subjects in a synchronous and remote manner. The Digital Sketchbook is understood as a conceptual set of technologies. Essentially, the Digital Sketchbook organizes and qualifies two types of technologies: one that mediates communication (voice and video) and another that facilitates collective interaction (production and sharing of symbols, images, and texts). Figure 3 below presents an image of the screen during a moment of collective work with technologies enabled as a Digital Sketchbook.

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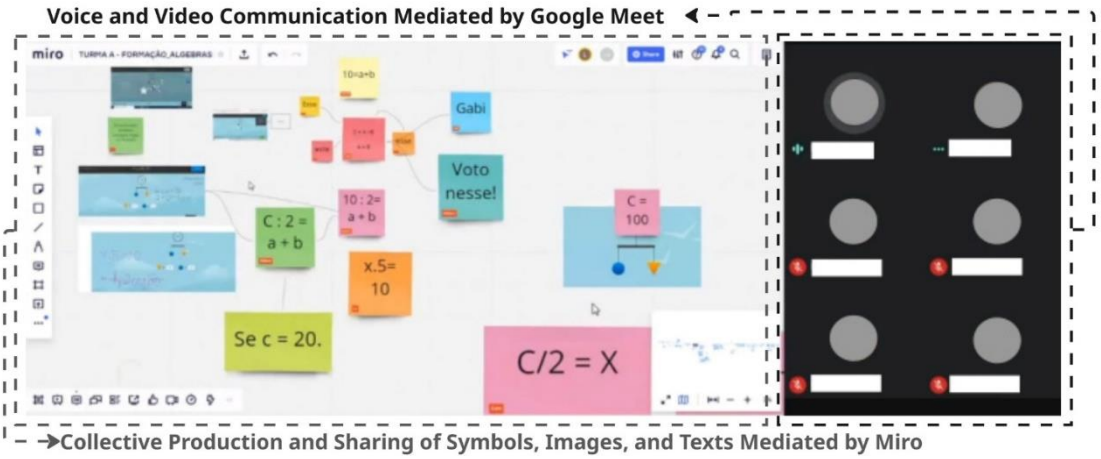
Figure 3 – Image of the Miro whiteboard together with Google Meet



Source: authors, image adapted with Miro.

Figure 3 highlights two main technological platforms. For the technological platform of collective interaction (production and sharing of symbols, writing, images, and texts), we chose the digital whiteboard Miro. This technological artifact's objective is theoretically aligned with the possibility of collective, synchronous interaction in language production (symbols, images, and texts). For voice/video communication, we chose Google Meet so teachers could share their thoughts on collective production. Finally, for research requirements, we chose OBS Studio to record meetings for data analysis (Angelo, 2021, p. 76). Below is a chart of the technologies that enable the materiality of the Digital Sketchbook when worked on together.

Chart 1: Technological Artifacts of the Digital Sketchbook

Concepts	**Description**	**Digital Tools**	**Access**
Communication	Video conferencing tool. Used for remote and synchronous meetings.	Google Meet	https://meet.google.com/
Individual and collective work through languages	Interactive virtual whiteboard for producing and sharing symbols, images, and videos.	Miro	https://miro.com/
Data production	Tool for recording audio and images on the computer screen.	OBS Studio	https://obsproject.com/pt-br/download

Source: Angelo, 2021, p. 77, adapted.

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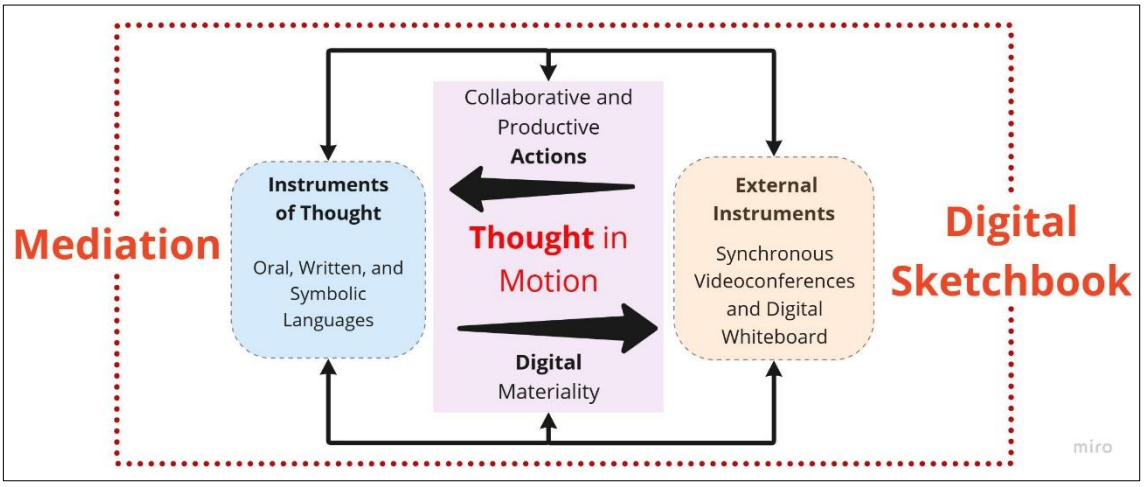
Chart 1 illustrates the hierarchy of digital technological artifacts in the Digital Sketchbook, beginning with general theoretical-methodological concepts and ending with the selection of an appropriate digital technological artifact. For this reason, the researcher developed a methodology to investigate the evolution of theoretical thinking, "provoking the emergence of the phenomenon under investigation and intervening in a way that follows the formation process in formative experiments" (Moretti, Martins; Souza, 2017, p. 43).

Tracking the formation process through the Digital Sketchbook enabled us to conduct a multimodal analysis of the formative process. This analysis considers symbolic production as a "dialectical whole," moving beyond the independent examination of each produced symbol (Moretti; Radford, 2021).

Figure 4 below represents a synthesis of the Digital Sketchbook concept as a theoretical and methodological instrument that unifies external and internal instruments in the context of the proposed collective activity.

Figure 4 – Summary of the Digital Sketchbook



Source: from the authors and created with Miro.

Figure 4 highlights the mediation of languages (oral, written, and symbolic) by inernal instruments/signs and actions (collaborative and productive) by external instruments/technologies (e.g., videoconferencing and digital whiteboards). Thus, movement is presented in a dialectical sense within digital materiality.

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We can only understand the possibility of studying the movement of subjects in the collective in formation by assuming external instruments (technologies) and internal instruments (languages, voice, etc.) as a dialectical unity.

> [...] The teachers' organization of actions aimed at ensuring communication is a prerequisite for carrying out this activity. This is achieved by creating conditions for planning individual actions within a collective work plan and enabling exchanges between different modes of action. This transforms them into a collective space (Moretti, 2007, p. 139).

At this point, we establish the conditions for mediation between subjects and instruments in digital materiality, which we conceptualize as an instrumental dialectical unit (external/internal) and refer to as a Digital Sketchbook. Within the scope of the research, we aim to facilitate the movement of the phenomenon under investigation, in this case, the development of teachers' theoretical thinking and analyze certain dialectical pairs.

Next, to broaden the theoretical understanding of the Digital Sketchbook as a theoretical and methodological instrument for research and training, we will discuss excerpts from the training experiment with teachers developed in the research (Angelo, 2021). We will relate the use of the Digital Sketchbook to principles of dialectics, such as *movement* and *contradiction*, which are manifested in dialectical pairs, such as *abstract/concrete* and *essence/appearance*.

4 Movement and dialectical categories in the Digital Sketchbook

As discussed throughout this text, the Digital Sketchbook was developed as a theoretical and methodological tool to support a formative experiment in a research project investigating the development of theoretical thinking among early childhood educators undergoing continuing education. This project used digital technologies and games in a remote, synchronous setting. The research project aimed to analyze evidence of a movement of theoretical thinking in a developmental process mediated by conceptual links belonging to algebraic knowledge in early childhood education (Angelo, 2021).

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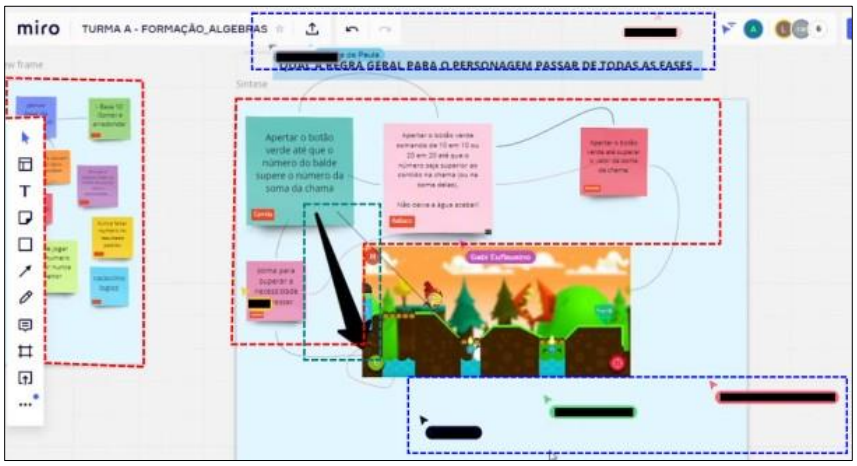
During the formative experiment meetings, the group of teachers' dynamics, supported by the Digital Sketchbook, can generally be described as follows: When faced with a learning trigger problem (Virgens, 2019), Teacher A makes an initial symbolic post (A1) to communicate and justify her contribution to the class. Then, another Teacher (B) publishes a post (B1) expressing her position on the same problem. This motivates a third Teacher (C) to respond with a statement (C1). These actions (A1, B1, and C1) are materialized and justified through the Digital Sketchbook and motivate other actions (A2, B2, and C2), whether through speech, text, or symbolic forms representing an interpretation of the proposed problem. The collective movement materialized through the Digital Sketchbook is illustrated below:

Figure 5 - Scene from the Digital Sketchbook

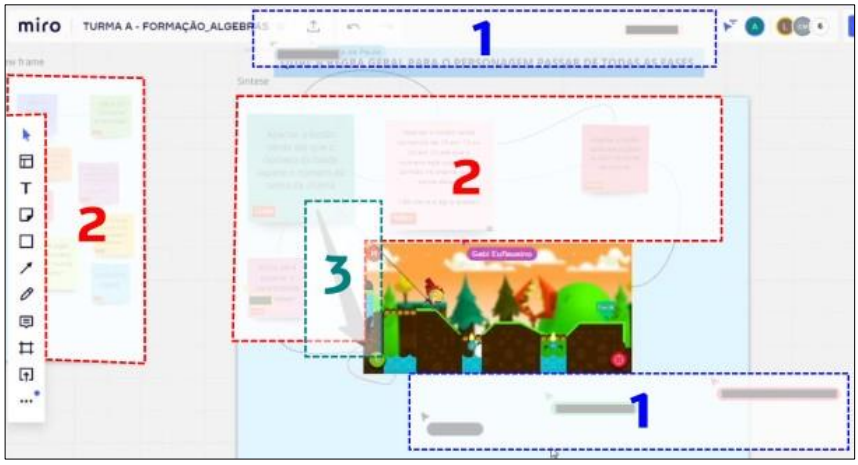


Source: from the authors and adapted with Miro.

Figure 5 highlights a scene from the collective movement of teacher mediated by the Digital Sketchbook. The blue, red, and green lines show the teachers' actions mediated by an organized set of technologies. This enables "the creation of the minimum conditions for communication, voice, and symbolic expression (Digital Sketchbook) for the production of new knowledge" (Angelo, 2021, p. 106). Figure 6 below provides a more detailed explanation of this same movement in the scene.

DOI: http://doi.org/10.14393/OBv9.e2025-23

Figure 6 - Scene from the Digital Sketchbook



Source: from the authors and adapted with Miro.

Figure 6 highlights the marked areas (1, 2, 3) and the teachers' actions (A, B, C, etc.) in various semiotic forms. These forms include indications of movement with the mouse (1), explanatory texts (2), and image production (3). These forms are in response to the triggering problem proposed in the training. With the trainer's guidance, the teachers produced a summary to develop a conceptual link to algebra, as proposed by the Learning Trigger Situation (LTS) (Angelo, 2021).

Analyzing the data with the Digital Sketchbook reveals that technology mediating actions in digital materiality was insufficient for developing theoretical thinking (Angelo, 2021). The trainer's mediating role, combined with the teachers' constant actions and evaluations in the collective training process, proved fundamental. This process is oriented toward the theoretical synthesis of the problem and "returns to ideas developed throughout the collective work through communication and voice, as well as the sharing of symbols and images via the Digital Sketchbook" (Angelo, 2021, p. 157). In the words of Angelo and Moretti,

> The researcher's intentional mediation promoted a movement toward conceptual connection, triggering a series of actions among the teachers. Specifically, the researcher focused on the teachers' proposed expressions and their meanings and significance throughout the symbolic construction process using the digital sketchbook (Angelo; Moretti, 2022, p. 12).

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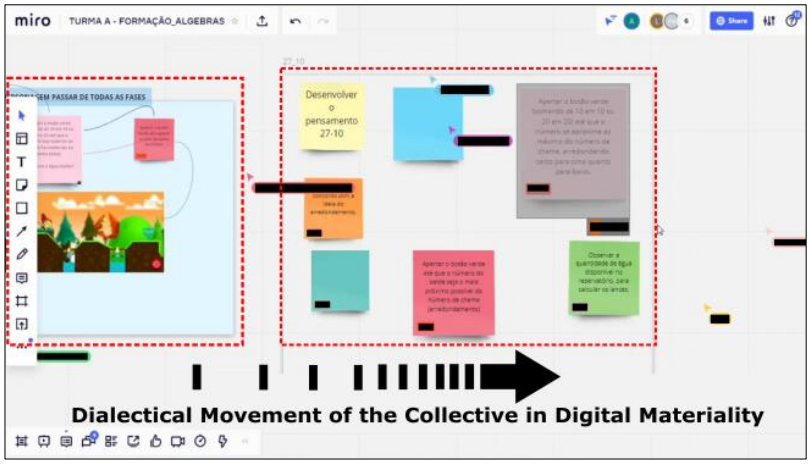
At this point, we observe the dialectical category of movement. This category is present in the collective of teachers in digital materiality, consisting both of differences (negations between the arguments of the teachers and the trainer) and of the common goal of seeking a theoretical synthesis of the mathematical problem (mediated by the trainer). The movement occurs collectively and is mediated by technologies in an external dialectical unity (technological artifacts) and an internal dialectical unity (languages, actions, speech, etc.). In the image below, we present another scene from the collective in digital materiality, illustrating a scene of movement in the face of the proposed mathematical and theoretical problem.

Figure 7 - Movement of the Collective in the Digital Sketchbook



Source: from the authors and adapted with Miro.

Figure 7 is a scene from the Digital Sketchbook that illustrates a dialectical dynamic. According to Barata-Moura (1997, p. 81), this dynamic is "not an abstract logical-formal identity that composes difference and excludes it, but rather a concrete identity that, in and through difference, is determined." Broadly speaking, at that moment, the group highlighted the mathematical characteristics of the situation, beginning the process of abstraction in a discursive and empirical way (Angelo, 2021, p. 97).

Throughout this process, the group, mediated by the trainer, identified the conceptual links between algebra and the solution to the proposed problem. In other words, they showed the group how to develop theoretical thinking based on

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the problem. The objective of this text is not to discuss the development of the teachers' theoretical thinking but to demonstrate the Digital Sketchbook's potential in structuring and guaranteeing collective, virtually mediated spaces.

Thus, although the following excerpt addresses the discussion of the algebraic link, we intend to share part of a dialogue between the teachers during this remote, synchronous collective work in our Digital Sketchbook research (Angelo, 2021).

> **Teacher A:** Let's change the idea from addition to multiplication. This post says "x + 10," but *I don't think it means* "plus," rather "times."
> **Teacher B:** Since we pressed so hard to get the number, *I think we are talking about multiplication.*
> **Teacher A:** Yes, I think the idea *is not a number plus* 10 but rather a number times 10. Do you think two unknowns is too much? For example, in this post, if *"x" times 10 equals "y,"* then we don't know because it's hypothetical. It would be like asking, "How many times do we press the button 10 times to turn on the fire?" (Angelo, 2021, p. 108, emphasis added).

In this excerpt from the dialogue, the teacher approached the conceptual nexus of algebra, "operations with unknown numbers," and returned to the Digital Sketchbook/Miro. They denied and reformulated them theoretically in search of a general synthesis of the problem. This indicates a dialectical movement grounded in the law of negation of negation (teachers´ expressions as *I don't think it means* and *is not a number plus*), the law of unity and struggle of opposites (*I think we are talking about multiplication*), and the transformation of a quantity of information, thoughts, and reflections into a quality of theoretical synthesis (the law of quantitative and qualitative transformation: *"x" times 10 equals "y"*).

We emphasize that the teachers' movement is from the general (mathematical theoretical content) to the particular, not a generalization of the particular (empirical). According to Davidov (1997), this path from concept to thing and from abstract to concrete is the genetic, historical, and logical development of theoretical concepts.

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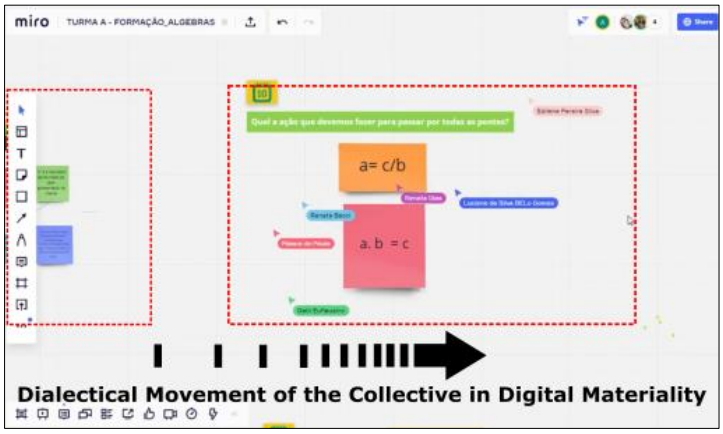
Therefore, this process reflects the dialectical relationship between the abstract and the concrete as categories that reflect a "change in cognitive image" in relation to the object (Kopnin, 1978, p. 154). In our understanding, the use of the Digital Sketchbook as a mediator of thought expression provided the conditions for expressing the collective in motion and, thus, for the sensory-concrete to undergo a qualitative change, reproducing it as a set of abstractions. This set of abstractions, as a negation of the sensory-concrete, manifests the law of negation of negation (Kopnin, 1978, p. 162).

Figure 8 shows a moment following Figure 7 that demonstrates this movement (indicated by the red dashed line), in which the collective defines an abstract and theoretical synthesis for the given problem.

Figure 8 - Movement of the collective in the Digital Sketchbook



Source: from the authors and adapted with Miro

Figure 8 shows the replacement of the sensory-concrete situation proposed by LTS with mathematical generalizations (abstract-theoretical expressions) developed through the collective activity of teachers in digital materiality, which is mediated by the Digital Sketchbook.

Replacing particular situations in the digital game (sensory-concrete) with mathematical expressions (abstract-theoretical) constitutes "a movement between degrees of knowledge about reality, demonstrating its contradiction and overcoming" in digital materiality (Angelo, 2021, p. 25). In other words, after grasping the essence of the digital game through mathematical language and its

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materialization in the Digital Sketchbook, the game was "discarded," overcoming its contradiction through the dialectical pair of appearance and essence in a mathematical synthesis.

With the semiotic records in the Digital Sketchbook, the group of teachers appropriated this process and became aware of the contrast between descriptive, empirical explanations and theoretical ones, or between phenomena and their essences (Angelo, 2021, p. 111).

4. Final considerations

In contemporary times, the formation of the subject necessarily involves some form of digital materiality. However, we must be cautious about taking this materiality as sufficient for the formation of scientific or theoretical thought. In response to the challenges of remote education and research, we developed a conceptual tool to support educational processes and scientific research based on Historical-Cultural Theory in remote contexts.

As a dialectical unity between external technological artifacts and internal languages and speech, we established an instrumental unity that cannot be understood in isolation. While there is no way to access digital materiality without technology, under certain conditions, there are potentialities that must be considered to promote human development.

In this sense, we conceptualize the Digital Sketchbook as a theoretical and methodological instrument that organizes technologies and favors collective movement in formations mediated by digital materiality. To deepen the analysis of the Digital Sketchbook in light of the dialectical materialist method underlying Historical-Cultural Theory, we propose an approach in which laws and categories manifest throughout use of the resource in a research project. This opens up possibilities for theorization based on practice itself.

Though the Digital Sketchbook was created during the pandemic out of necessity, it is a relevant tool for remote and synchronous educational processes. It aligns with the assumptions of Historical-Cultural Theory and the fundamental categories of dialectical materialism by creating conditions

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for formative processes to develop and be investigated as mediated and evolving processes. This reveals aspects of the unity of opposites and the negation of negation.

Thus, we advocate for the Digital Sketchbook presented in this article as a theoretical and methodological tool for educational research and formative processes in remote and synchronous models. It is also a potential reference for future work investigating formative processes mediated by digital technologies from the perspective of Historical-Cultural Theory. Through this work, we aim to contribute to an understanding of, and a theoretical and methodological deepening of, the dialectical materialist perspective on human formation in contemporary times and in digital materiality.

Cuaderno Digital y la Materialidad de los Procesos Educativos a Distancia desde la Teoría Histórico-Cultural

RESUMEN
En este artículo, presentamos y discutimos el concepto del Cuaderno Digital como recurso para la investigación y la educación en entornos remotos y sincrónicos, en su convergencia teórica y metodológica con categorías del materialismo dialéctico, en consonancia con los supuestos de la Teoría Histórico-Cultural. A continuación, analizamos fragmentos de la investigación de Angelo (2021) que demuestran el uso de este recurso y los discutimos desde la perspectiva de los principios de movimiento y contradicción, que se manifiestan en esta investigación en la lucha de opuestos a través de los pares dialécticos abstracto/concreto y apariencia/esencia. Finalmente, defendemos el Cuaderno Digital como herramienta teórica y metodológica para la investigación en Educación y para los procesos formativos en modelos remotos y sincrónicos. Destacamos su potencial para futuros trabajos que investiguen los procesos formativos mediados por las tecnologías digitales, desde la perspectiva de la Teoría Histórico-Cultural del desarrollo humano contemporáneo y la materialidad digital.

Palabras clave: Cuaderno Digital. Aprendizaje a Distancia. Teoría Histórico-Cultural. Materialidad digital.

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