Sociedade Brasileira de Educação Matemática

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Interdisciplinarity with digital mathematical cartoons during Emergency Remote Teaching in Elementary School

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Abstract: The objective of this article is to analyze how the minicyclones of expansive learning occurred during the development of mathematical tasks that involve the production of digital mathematical cartoons with 6th students at an elementary school in the interior of Brazil during the pandemic, Covid-19. 19. Thus, we base ourselves on the humans-with-media system and on qualitative research, whose sources and data production instruments were: field notes, questionnaires, audiovisual recordings, and student handouts. We analyzed the data through the method of analytical induction considering the analytical tool of minicyclones of expansive learning. The results indicated that minicyclones of expansive learning occur with expansion movements — questioning, criticism, and relationships between mathematics and society — at certain times and retraction movements — structured tasks and ready-made answers — at others. We conclude that thinking about approaches to break with the stable pattern of teaching and learning mathematics is something complex.

Keywords: Cartoons. Mathematics Teaching. Digital Technologies. Pandemic.

Intercomponente curricularriedad con cartoons matemáticos digitales durante la Enseñanza Remota de Emergencia en la Escuela Básica

Resumen: Este artículo tiene como objetivo analizar cómo ocurrieron los miniciclones de aprendizaje expansivo durante el desarrollo de tareas matemáticas que involucran la producción de dibujos digitales matemáticos con estudiantes de una escuela primaria en el interior de Brasil durante la pandemia, Covid-19. Así, nos basamos en el sistema de seres-humanos-con-medios y en la investigación cualitativa, con fuentes e instrumentos para la producción de datos: notas de campo, cuestionarios, grabaciones audiovisuales y apostilas. Analizamos los datos a través del método de inducción analítica a la luz de la herramienta analítica de miniciclones de aprendizaje expansivo. Los resultados indicaron que los miniciclones de aprendizaje expansivo ocurren con movimientos de expansión — cuestionamiento, crítica y relaciones entre las matemáticas y la sociedade — en ciertos momentos y movimientos de retracción — tareas estructuradas y respuestas preparadas — en otros. Concluimos que pensar en enfoques para romper con el patrón estable de enseñanza y aprendizaje de las matemáticas es algo complejo.

Palabras clave: Cartoons. Enseñanza de las Matemáticas. Tecnologías Digitales. Pandemia.

Interdisciplinaridade com cartoons matemáticos digitais durante o Ensino Remoto Emergencial no Ensino Fundamental

Resumo: Este artigo objetiva analisar como ocorreram os miniciclones de aprendizagem

expansiva durante o desenvolvimento de tarefas matemáticas que envolvem a produção de cartoons matemáticos digitais com alunos do ensino fundamental de uma escola do interior do Brasil durante a pandemia da Covid-19. Para tal, fundamentamo-nos no sistema seres-humanos-com-mídias e na pesquisa qualitativa, cujas fontes e instrumentos de produção de dados foram: notas de campo, questionários, gravações audiovisuais e apostilas. Analisamos os dados mediante método de indução analítica à luz da ferramenta analítica dos miniciclones de aprendizagem expansiva. Os resultados indicaram que os miniciclones de aprendizagem expansiva ocorrem com movimentos de expansão — questionamentos, críticas e relações entre a matemática e a sociedade — em determinados momentos e movimentos de retração — tarefas estruturadas e respostas prontas — em outros. Concluímos que pensar em abordagens para romper com o padrão estável de ensino e aprendizagem da matemática é algo complexo.

Palavras-chave: Cartoons. Ensino de Matemática. Tecnologias Digitais. Pandemia.

1 Introduction

The SARS-CoV-2 virus, which causes the disease Covid-19, caused an unprecedented pandemic in 2020-2021, and with it leveraged a worldwide "revolution" in all spheres of society. During this period, Digital Technologies (TD) were presented as one of the only safe alternatives for our survival (Borba, Souto & Canedo Jr, 2022). However, many of them did not meet the social, economic, cultural and educational needs that emerged with the pandemic. Thus, it was necessary to develop and/or improve them quickly. With this process, several changes emerged in the ways of living in society (social distancing), of relating to each other, of our professional practices, in short, of our ways of teaching and learning. The mentioned authors and other authors (e.g. Borba, 2021; Cunha, Borba & Souto, 2022) highlight that such movements were of reciprocal transformations and leveraged by the agency of the SARS-CoV-2 virus.

Particularly, in Education, it was necessary to reorganize teaching practices, adapt teaching methodologies for the so-called Emergency Remote Teaching (ERE), train teachers for the pedagogical use of different virtual learning environments, social networks and other associated technologies and, at the same time, train them to deal with economic inequalities that restricted or made it impossible to use any type of TD. In Mathematics Education it was no different, chronologically this period is associated with the fifth phase of Digital Technologies (Borba et. al., 2022) because, even with all the social and economic adversities, the scope that the inclusion of TD reached had never before been obtained by any type of government program or educational public policy.

In the interior of Brazil, in rural schools, like the one that participated in the research that gave rise to this article, the challenges seem to take on greater dimensions. This is because internet access was unusual before the pandemic, and TDs, in general, were not part of teaching practices. Thus, the teaching and learning processes were restricted to the closed classroom in parallelepiped format with the use of non-digital technologies such as pencil, paper, blackboard, and other materials.

Even with all these challenges and impossibilities, teachers did not give up, on the contrary, they sought training, concerned themselves with "how to teach with digital technologies" and understanding "how students can learn with them". A complex process that needed to be put into practice on an emergency basis, after all: we "slept" on-site teachers and "woke up" ERE teachers (without even knowing exactly what that nomenclature meant).

In these movements of profound necessary and dialectical transformations, we were impelled, as teachers, to reorganize our practice to contribute to our students' learning and,

simultaneously, as researchers, to seek understandings about how learning occurred with TD in that period. In this way, we plan and execute a study proposal with the use of TD in a field school with restricted access to the internet. In 2020, we developed an interdisciplinary project (Intertoons: Interdisciplinaridade-com-cartoons - Mathematics, Portuguese, Arts, Sciences and Informatics) with 6th and 7th-grade students from the União da Chapada State School, in the municipality of Campo Novo do Parecis — MT. The cartoons developed in the Intertoons project are of the "digital mathematical cartoons" type — audiovisual productions — drawings, collages, or modeling — animated by digital means (software, applications etc.) aimed at communicating mathematical ideas (Souto, 2016).

We performed a clipping of the data produced during the Intertoons project, specifically in solving mathematical tasks to achieve the objective of analyzing how the minicyclones of expansive learning occurred. To do so, we base ourselves on the Humans-With-Media System, which can be considered a fusion of the ideas of the Humans-With-Media construct and the concepts of Activity Theory. Methodologically, this research is qualitative, Borba & Araújo (2019), and the sources and data production instruments were: field notes produced during participant observation, questionnaires, audiovisual recordings and records of students' handouts. Data were analyzed using the analytical induction method and in light of the analytical tool of minicyclones of expansive learning (Souto, 2013).

To reach the proposed objective, this article is organized as follows: initially, we discuss the theoretical framework, then we present methodological aspects, followed by the analytical appreciation of the data and, finally, the final considerations, followed by the references used here.

2 The Humans-With-Media System

The first ideas on how the frameworks of the Activity Theory (TA), proposed by Engeström (1987), and the construct Humans-With-Media (S-H-C-M), elaborated by (Borba, 1993, 1999; Borba; Villarreal, 2005), can harmonize and develop was carried out by Souto (2013). From these contributions were born the first concepts of the theoretical-methodological perspective – Humans-With-Media System – which was proposed, discussed and improved by Souto (2013; 2015), Souto and Araújo (2013), Souto and Borba (2013; 2016, 2018), which is fundamentally marked by the anthropomorphic characteristics of TD.

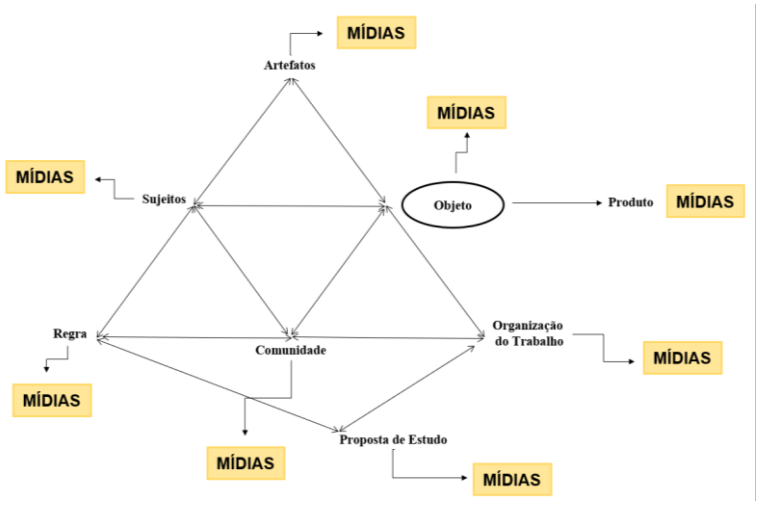
In a Humans-With-Media System, hyphens are used to highlight the formation of an inseparable collective that moves and metamorphoses when producing knowledge. In Figure 1, we represent the triangular diagram of this system, which was inspired by TA, but with some aspects that differentiate it due to the influences of the S-H-C-M construct.

In the diagram in Figure 1, the representation of the SS-H-C-M suggests that all elements of this system are interconnected and have the participation of media (or technologies) in all its vertices, that is, they are intertwined, impregnated in the system in the same way as humans actors, influencing them as a whole. This interpretation has the epistemological traits of the humans-with-media construct (Borba & Villarreal, 2005). Differing, to a certain extent, from the TA concepts because, as stated by Engeström (1987), the media influence the system to the extent that they play the role of mediating artifacts, with, in this regard, a hierarchical separation between humans and non-humans actors in the learning.

On the other hand, in harmony with what Engeström (1987) proposes, to understand the relationships that are established in this type of SS-H-C-M system, Souto (2013) highlights that it is fundamental to consider its historicity. Both from a local point of view and from a broader perspective, a historicity structurally built over the years that takes into account, mainly, the

way we have been teaching and learning mathematics.

Figure 1: Humans-With-Media System



Source: Own elaboration based on Souto (2013, 2014) and Costa (2017, 2020)

These different amplitudes of historicity can be implicitly presented (in the proposed tasks with closed and unique answers; in the lack of establishing relationships between algebraic and geometric representations in problems without connections with the lived reality or with social, economic, or cultural issues, or that is, in the encapsulated form that we have presented mathematics to our students). In the same way, they can also echo the voices of the research participants, which, according to TA, would be the multivocality of the system. However, Borba et al. (2022) points out that for the SS-H-C-M it is also necessary to consider as "voices" the multimodal forms used to communicate a mathematical idea, such as videos, gestures, movements, music, sounds, images, algebraic, graphic, tabular representations, facial expressions, among other modalities.

The symbiosis between the different amplitudes of historicity and the multiple forms that represent the "echoing voices" of the SS-H-C-M (Figure 1) can generate at least two situations: revealing tensions accumulated in the system or identifying conflicts, dilemmas and local tensions, in both cases there are influences on the learning process. In the light of TA, these situations can culminate in internal contradictions, which, in turn, can leverage expansive learning, which is presented by Engeström (1987), at least in three ways: as the reconceptualization of the object of the activity to embrace a wider horizon than in the former mode of activity; as continuous movements of construction and resolution of tensions; and as movements of reorchestration of the multivocality of the activity system. It is possible to observe a more relational character (concerning the elements of the system, mainly the object and the other principles — historicity, multivocality and internal contradictions) than something more deterministic.

In the context of Mathematics Education, Souto (2013, p. 234) reinterprets learning situations in Mathematics classrooms (of any type or modality), including the concept of collectivity, proposed by Borba (1999) and Borba & Villareal (2005). In this bias, learning (or expansive transformation) can be understood as:

> [...] movements in a system of collective activity in which humans-with-technologies seek, in a critical way, a way that had not been, in other situations, thought by them to understand and/or reconstruct understandings about a certain problem or content mathematician (SOUTO, 2013, p. 234)

This definition by Souto (2013) is closely linked to the representation of Figure 1. For the author, expansive learning is related to how a given element of the S-H-C-M system moves between the different vertices of the triangular representation and starts to play different roles. Thus, these transformations can generate qualitative changes in Mathematics learning, as the participation of TD can cause reorganizations in thought and reciprocal transformations in the ways of proposing 'doing' Mathematics (Costa, 2017).

Aiming to favor understandings regarding expansive learning movements in an S-H-C-M system, Souto (2013), Souto and Borba (2016, 2018) and Borba, *et al*., (2022) propose an analytical tool: the minicyclones of transformations or expansive learning. Research such as those developed by Costa (2017); Saints (2022); Anschau and Souto (2022) have used this tool for data analysis with a focus on learning mathematics.

These minicyclones do not have rigid, pre-defined, or a priori established movements. However, Souto (2013), Souto and Borba (2016, 2018), Borba et. al. (2022) suggest that there are at least some indicators that can contribute to recognizing its emergence, development, and its completion.

According to Souto (2013), in general, the beginning of these minicyclones is observed based on their local historicity and the multiple "voices" of the learners and can be marked by doubts, questions, and criticisms regarding a stable pattern of Mathematics production and searches to break it. The beginning of a minicyclone can reveal initial dilemmas, conflicts, and tensions that can strengthen or stagnate it. If the latter occurs, there is a learning retraction process. But, if there is potentialization (thought reorganizations), the development of the system can gain new movements: rotation and translation.

As suggested by Borba *et al*., (2022), rotations can occur when learners assume the autonomy of the teaching and learning processes, suggesting script breaks that are ruptures, criticisms, interruptions, pauses, or reorganizations in/of the teacher's planning; or when they are faced with new rules, new forms of work organization and the inclusion of technologies that were not used until now (Borba, *et al*., 2022). Rotational movements are also characterized by the process of reciprocal molding (humans transform technologies and, at the same time, are transformed by them) (Borba, 1999). Rotations, as well as the onset of a minicyclone, are closely linked to local events (historicity), that is, events that take place within the activity system.

On the other hand, long-term structured historicity that accumulates external tensions that influence the system characterizes translational movements. In line with Borba *et al*. (2022), such translations can contribute to the disruption of patterns of mathematical knowledge production or at least to the destabilization of reproductive beliefs or encapsulated practices already rooted in our practices. Historically accumulated tensions resulting from social, economic, cultural or other system factors are identified in the translations.

The completion of a minicyclone can be observed at the moment of "construction of justification for a solution produced with multimodal and intermediate connections that had not been thought of until then by the subjects of the activity and that, with this, results in new forms of expression of mathematical thinking" (BORBA *et al*., 2022, p. 100). In summary, the Humans-With-Media System, together with minicyclones of expansive learning, contributes to promoting understanding about the mathematics learning process as discussed in this article.

3 Methodological aspects of the research

We consider this research qualitative, because according to Borba and Araújo (2019, p.

25), “research carried out according to the qualitative approach provides us with more descriptive information, which excels in the meaning given to the actions”. These characteristics are in line with the aspects of this research, given that it emphasizes the understanding of learning with description and analysis of data focusing on the actions, voices and other manifestations of the different actors participating in the research.

Regarding the context of data production, they were generated at the União da Chapada State School, located in the municipality of Campo Novo do Parecis — MT, in the year 2020 during the Covid -19 pandemic. Students in the 6th and 7th grades of elementary school were invited to participate voluntarily in the Intertoons project in the reverse shift of classes. The project was developed completely online, with 15 (fifteen) meetings in the Microsoft Teams platform environment and support of interactions made possible by the WhatsApp application.

We consider this investigation qualitative, because according to Borba & Araújo (2019, p.25), "the investigation carried out according to the qualitative approach provides us with more descriptive information, which stands out in the meaning that is given to the actions". online with the aspects of this investigation, as it emphasizes the understanding of learning with description and analysis of data focusing on the actions, voices and other manifestations of the different actors who participate in the investigation.

During the after shift, students developed tasks related to difficulties and doubts in computing. At that time, students were invited to handle some editing applications, such as Zepeto, bitmoji, Avatar Maker, Benime, and Pics Arts. In the classes of the curricular components involved, the teachers prepared and developed with the students a workbook with tasks related to the theme of cartoons and the coronavirus.

In Portuguese, the concepts of the genres cartoon, comics and charge were deepened. In this curricular component, the writing of scripts and oral expressions was also oriented (pronunciation and spelling of words that the students had difficulties with). In Science, tasks were carried out on liquid and gel alcohol, homogeneous and heterogeneous mixtures and the artisanal manufacture of modeling clay for creating characters for stop motion-style video activities. In Arts, painting tasks with geometric figures, use of colors and shapes in the creation of drawings, scenarios and characters were carried out. Mathematics classes, the focus of the analysis in this article, were directed toward the development of graph analysis tasks, tables, graph construction, potencies, simulations and Fake News referring to Covid-19 data. With the development of these activities, the students produced their mathematical cartoons related to the topic of Covid-19.

The data production procedures and instruments were: questionnaires; interviews; field notes, prepared during participant observation; audiovisual recordings and records of student handouts. For data analysis, we performed analytical induction on the assumptions of Deslauries (2008), which states that analytical induction is a “mode of [production] and analysis, which aims to highlight the fundamental elements of a phenomenon, so that deduce, if possible, a universal explanation” (Deslauriers, 2008, p. 339).

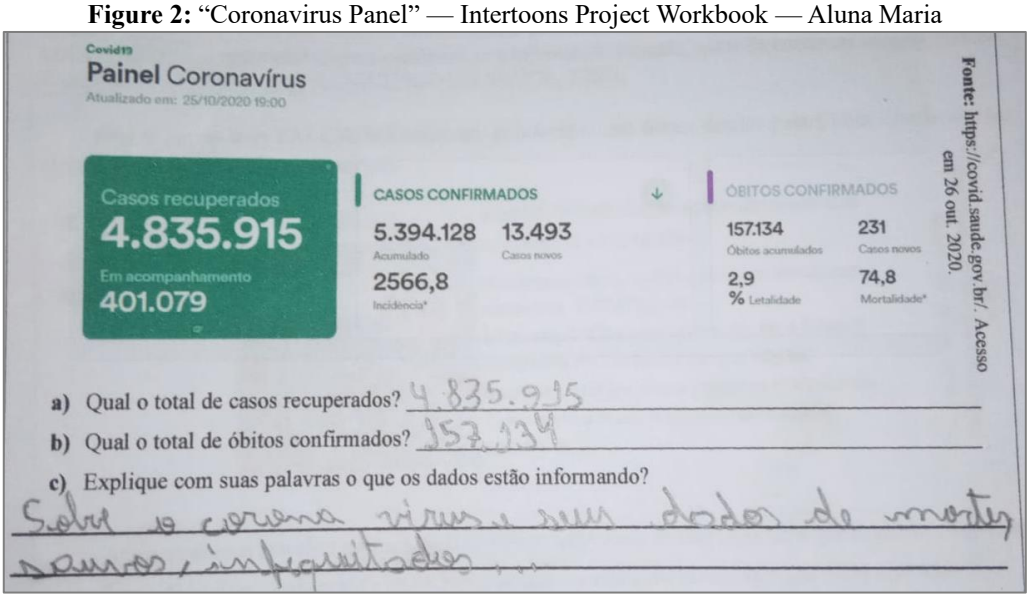
This analytical process, by Costa (2017), allows the researcher to move between the data produced, while practicing the induction method, to develop a descriptive model that encompasses all instances of the researched elements. In this process, two themes emerged, for this article we performed a cut in the data of the second theme: Mathematics learning movements during Emergency Remote teaching. After identifying this theme, we used the minicyclones of expansive learning (Souto, 2013). We also emphasize that the research participants signed the informed consent form, and for the analysis, pseudonyms were used to maintain the confidentiality of the participants. We also point out that this research is part of

the project Matemática e Cartoons na Educação Básica e Superior do Estado de Mato Grosso (M@ttoon), in Process n. 0206965/201, sponsored by the Fundação de Apoio à Pesquisa do Estado de Mato Grosso — Fapemat.

4 Mathematics Learning Movements

In the booklet of the "Intertoons" project, there were several tasks/investigations with the curricular components of Mathematics, Portuguese, Arts, Sciences, and Informatics. Mathematical investigations permeated the entire workbook intending to discuss data from the new Coronavirus pandemic and stimulate (providing subsidies) the production of digital mathematical cartoons. One of the tasks was the "Coronavirus panel" (Figure 2), whose objective was to provide real numerical data on cases of Coronavirus in Brazil so that students could understand the dimension that this pandemic has reached in terms of deaths and infected people. In Figure 2, we present the image of the answers elaborated by the student Maria.

Figure 2: "Coronavirus Panel" — Intertoons Project Workbook — Aluna Maria



Source: 2020 Survey Data

As we can see in Figure 2, the "Coronavirus Dashboard" contains, systematically, numerical data on recovered, confirmed, follow-up, deaths, and new cases. The students had some difficulty in analyzing and understanding these data, requesting the teacher's help. According to Souto (2013), doubts and difficulties like these can be clues to the beginning of a minicyclone of expansive learning. In this sense, below, we rescue excerpts from the discussions in carrying out this task:

> Maria: *Teacher, I didn't understand this table, why are the new cases among the confirmed cases already?* (Math class held by the Teams platform on 11/03/20).
>
> Thais: *I didn't understand either, but then I took and added the new cases and confirmed cases because I understood that they are not confirmed yet?* (Math class held by the Teams platform on 11/03/2020).
>
> Teacher: *That's right Thais, these new cases have not yet been confirmed, but they have already emerged as suspects, and then it is released in the daily bulletin with the confirmed cases. In the case of deaths, it's the same thing* (Math class held by the Teams platform on 03/11/2020).

Although Maria answered the task correctly (Figure 2), in the previous excerpt she has doubts about the numerical data on the panel, about the new cases, as they are presented

separately and are considered notified cases, but not yet confirmed. Her colleague Thaís tries to contribute, noting that at first, she did not understand, but then she describes her mathematical strategy: "I added new cases and confirmed cases". Then, the teacher confirms that the analysis performed by Thaís was correct.

These movements by Thaís and the teacher contributed to the non-development of a possible minicyclone that could be in progress. This is because their responses to Maria's questioning were precise and closed, with no room for conjectures, reflections, or broader criticisms to the moment they were experiencing — the pandemic. According to Souto and Borba (2016, 2018) closed questions and answers can stagnate S-H-C-M systems as they transmit beliefs and images of mathematics as an exact and isolated science. It is possible to indicate that the numerical data, at that moment, were treated as merely illustrative, because, despite being frightening, they did not cause any kind of reaction or questioning either from the students or the teacher. It could be other data or even dummy data that the exact and closed answer would be found.

From this perspective, as Souto (2013) describes, the minicyclones can be considered a collective journey in which there is a shift from the condition of repeating the usual procedure to a search for something new, that is, the break with the dominant pattern of mathematical production. from these students, criticism, doubts, being provoked by both the teacher and the students. However, as the answer was already in the panel, there was no search for the new one, only for a closed answer that was there in the panel itself.

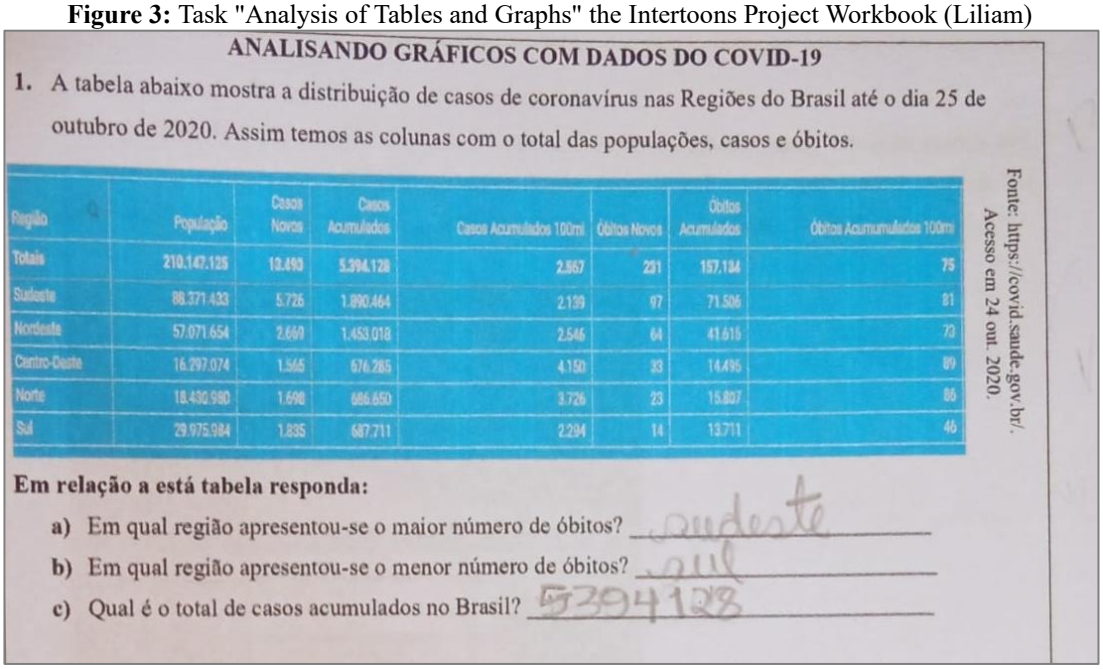
Still in this task (Figure 2), the letter "c" question: "Explain with your words what the data are informing?", being open, could be explored in order to favor the emergence and development of a minicyclone. This type of open question contributes to the search for information, questions and criticism that can answer the question. But that's not what happened. It is indicated that by ignoring or not stimulating the discussion of this issue, the teacher may have been influenced by external systems, by the way Mathematics teachers have been historically trained, both in initial and continuing education. Therefore, translational movements (influence of other systems) are observed, which also influenced the stagnation of the system. According to Borba *et al*., (2022, p. 99-100), in general, "the translations are marked by tensions historically accumulated by the way we have been learning and teaching, in particular, mathematics, as something fragmented and isolated (geometry, algebra, arithmetic) without relation among themselves and with the 'world' — environment, economy, social inequality, cultural beliefs and values, among other aspects".

At another time, in terms of the local historicity of the S S-H-C-M, another task addressed the analysis of tables and graphs with Covid-19 data. In it, several tables were presented with data on cases of coronavirus in Brazil. Then it was limited to data from the municipality of Campo Novo do Parecis — MT. The following excerpts concern the use of graphics. After the comments, the students would have to carry out the analysis activities and the construction of a graph with the data of the referred municipality.

> Graziely*: A graph is that thing that goes up and up, like the number of people infected with the Coronavirus, while the table shows the day, age, names and such* (Math class held on the Teams platform on 11/10/2020).
>
> Maria: *The graphs show data, years, months and even days, then they put it in a way that makes it possible for us to understand the type, the percentage mode, a circle for example the pie graph, then it leaves different colors separated, then it put the caption of what it represents. For example, you can use the price of food that has risen, export chart, table chart, chart of how much the Coronavirus has risen* (Math class held by the Teams platform on 10/11/2020).

Based on these excerpts, it is possible to observe that the students spoke what they understood in a superficial/colloquial way about the representations of graphs and tables. Then, they answered the questions about the table of Covid-19 cases in Brazil. Figure 3 shows student Liliam's answer. In the task, we have a table with the regions of Brazil, its population, the number of cases of Covid-19 and the deaths by region.

Figure 3: Task "Analysis of Tables and Graphs" the Intertoons Project Workbook (Liliam)



ANALISANDO GRÁFICOS COM DADOS DO COVID-19

1. A tabela abaixo mostra a distribuição de casos de coronavírus nas Regiões do Brasil até o dia 25 de outubro de 2020. Assim temos as colunas com o total das populações, casos e óbitos.

Região	População	Casos Novos	Casos Acumulados	Casos Acumulados 100mi	Óbitos Novos	Óbitos Acumulados	Óbitos Acumulados 100mi
Totais	210.147.125	13.493	5.394.128	2.567	231	157.134	75
Sudeste	88.371.433	5.726	1.890.464	2.139	97	71.506	81
Nordeste	57.071.654	2.669	1.453.018	2.546	64	41.615	73
Centro-Oeste	16.297.074	1.566	676.285	4.150	33	14.496	89
Norte	18.430.980	1.698	686.650	3.726	23	15.807	86
Sul	29.975.984	1.835	687.711	2.294	14	13.711	46

Fonte: https://covid.saude.gov.br/. Acesso em 24 out. 2020.

Em relação a está tabela responda:

a) Em qual região apresentou-se o maior número de óbitos? Sudeste

b) Em qual região apresentou-se o menor número de óbitos? Sul

c) Qual é o total de casos acumulados no Brasil? 5394128

Source: 2020 Survey Data

As in what happened previously, as the questions were specific and closed, the minicyclone of expansive learning could not be observed at that time. In this way, the answers were formulated with the accuracy that the question demanded and the discussions of other aspects about mathematics, public health and social inequality did not advance. We can consider that the students reproduced a stable pattern of Mathematics. That is, according to Souto (2013), we can interpret that learning, at that moment, is in a process of internalization — the reproduction of culture.

The proposal advances and the students are motivated by the teacher's questions. With that, they began to discuss some aspects, as shown in the following excerpts. This type of discussion can act as a springboard for the emergence and development of minicyclones of expansive learning.

> Teacher: *What can you say about the distribution of Covid-19 cases in Brazil?* (Math class held by the Teams platform on 11/10/2020).
>
> Maria: *Teacher, we can see that in some states the contamination is higher, but the number of inhabitants is also higher* (Math class held by the Teams platform on 11/10/2020).
>
> Thaís: *In the case of the southeast region, I researched the states on the internet and, for example, São Paulo is a very large state with many people, so I think it has the highest number of infected people* (Mathematics class held on the Teams platform in 10 /11/2020).
>
> Graziely: *The southern region is the one with the lowest number of infected people, but the population is also smaller* (Math class held on the Teams platform on 11/10/2020).

When discussing the distribution of Covid -19 cases in Brazil, students highlight that

they looked for other sources of information on the internet. According to Souto and Borba (2016), when this type of movement occurs, in general, the internet (information that it transmits to the system) is no longer just an artifact and can also become a community. This is because the consultation on the problem under discussion suggests that there is a sharing of the same object. In the case under analysis, an approximation of the object could be: cases of Covid-19 in the regions of the country.

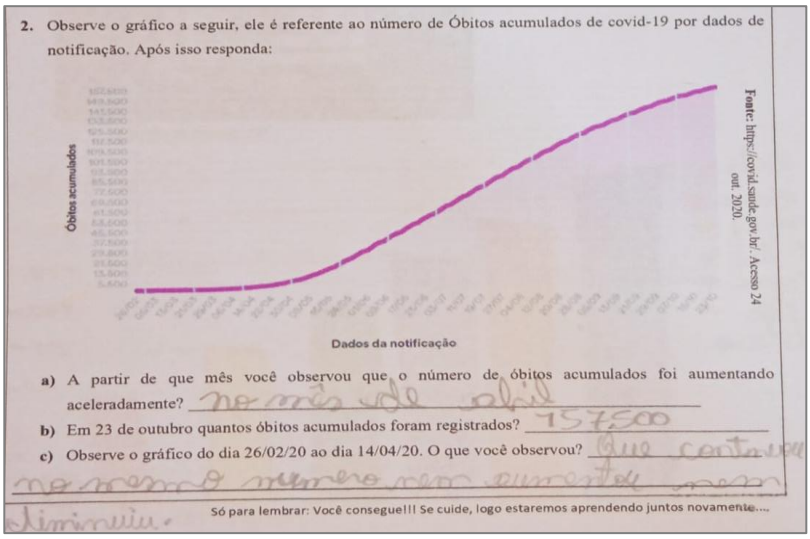
Although mathematics is not explicit in the object of the activity, in the excerpts by Maria, Thaís and Graziely it is possible to observe the establishment of relationships with the concept of proportionality: *in some states the contamination is greater, but the number of inhabitants is also greater; Southeast region, I researched the states on the internet and, for example, São Paulo is a very large state with many people, so I think it has the highest number of infected people; The southern region is the one with the lowest number of infected people, but the population is also smaller.* The students' reasoning is that the number of cases per region is directly proportional to the number of inhabitants. However, this mathematical concept is not explored in greater detail and the discussion moves to another path.

> Teacher: *But why did the cases become more intense in these regions?* (Math class held by the Teams platform on 11/10/2020).
>
> Maria: *So, I saw in the newspaper that some protective measures were not taken, in an article there were crowded buses, and it was from São Paulo. As for the South region, I don't know why there were fewer cases, but I believe that because the population is smaller* (Math class held by the Teams platform on 11/10/2020).
>
> Thaís: *So, I also think that when the city receives a lot of people from outside it also helped, so since there was Carnival, many tourists came and ended up spreading. And the cities that received the most people from outside had more cases* (Math class held by the Teams platform on 11/10/2020).
>
> Patrícia: But how are people going to stay at home? You have to work to buy food, so there's no way to take care of yourself if you have to be crowded, and also some people can't stay at home alone, there are a lot of people going hungry *(Math class held by the Teams platform on 11/10/20).*
>
> Caio: *Teacher, but I think people are not taking care of themselves, they need to understand that this can get worse* (Math class held by the Teams platform on 11/10/2020).

The teacher's questions continued to foment the debate about the pandemic, the situation in each state. When students highlight "*I looked it up on the internet*", "*I saw it in the newspaper*", they are informing that the sources of information went beyond the handout. In light of the Humans-With-Media System, this student movement may indicate an expansion of the community which, in turn, implies movements in minicyclones (Souto & Borba, 2018). However, at this initial moment, it is premature to indicate whether this expansion has occurred and whether minicyclones are forming or not.

The teacher's statements, according to Souto (2013), Borba, *et al*., (2022), can establish a favorable field for the beginning and development of a minicyclone of expansive learning, since there is an incentive for the culture of questions, criticism, search for the new, for the establishment of relationships between mathematics and social, economic, cultural issues, however it was not observed in the excerpts. Next, the task (Figure 4) continued with the graph analysis.

Figure 4: Task "Analysis of Graphs 2" from the Intertoons Project Workbook (Liliam)



Source: 2020 Survey Data

After answering the task in Figure 4, the students commented on the pandemic data and began to establish relationships and build critical thinking on this topic, as illustrated in the following excerpt:

> Maria: *Wow, there are many cases and many deaths. It has a lot to do with the political issue that they haven't bought a vaccine yet, nor do they encourage the creation of a vaccine, there's also the attitude of the president that made some people not care* (Mathematics class held by the Teams platform on 10/11 /2020).

Apparently, this excerpt from Maria criticized relating Mathematics to social, political and economic issues that occurred during the Covid-19 pandemic. When external issues influence the Humans-With-Media System, it is possible that translational movements are taking place, Borba et. al. (2022).

Continuing the analysis, but starting with another focus of analysis, Figure 5 shows the continuation of the investigation, focusing on the municipality of Campo Novo do Parecis — MT. For this, a survey of Covid-19 data was carried out in the bulletins of the City Hall.

At first, the students analyzed the chart and, according to their understanding, answered each question the way they thought. In a second moment, the teacher explained the data mathematically, relating them to aspects of the pandemic. During this period, the students and the teacher discussed this subject.

> Teacher*: How is the contamination process in Brazil, in Mato Grosso? Campo Novo do Parecis?* (Math class held by the Teams platform on 11/17/2020).
>
> Maria*: I think it's higher in São Paulo. Here there haven't been as many cases as in São Paulo, I believe it's because of the distance between the cities or even because Mato Grosso receives few people from other countries, or nobody wants to come here, is it?* (Math class held by the Teams platform on 11/17/2020).
>
> Thais*: Oh! I saw that Brazil took a while to take care of itself, people don't take care of themselves, it seems that they don't care. Teacher, the internet is going down all the time, so if I don't come back, it's because it's gone...* (Math class held by the Teams platform on 11/17/2020).
>
> Teacher*: Okay. No problem. Anything send a message on WhatsApp* (Math class held by the Teams platform on 11/17/2020).

Caio*: There are also those people who can't stay at home, then they don't know they are infected and pass it on to others. I entered a website and you keep seeing the numbers from all over the world* (Math class held by the Teams platform on 11/17/2020).

Maria*: Send us the link...* (Math class held by the Teams platform on 11/17/2020).

Caio*: https://www.worldometers.info/coronavirus/#countries this is the one I had in my brother's workbook [link sent via WhatsApp]* (Math class held on the Teams platform on 11/17/2020).

Teacher*: Why don't people stay at home what do you think about it?* (Math class held by the Teams platform on 11/17/2020).

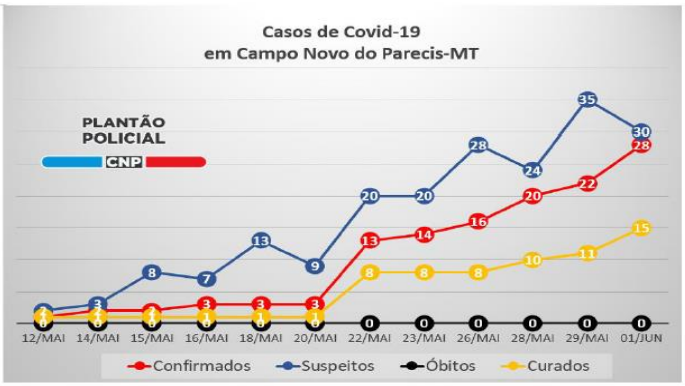
Caio*: I don't know, some don't want to, others have to work, like those who work on farms can't stay at home* (Math class held by the Teams platform on 11/17/2020).

Maria*: I think the issue is people's lifestyle, some may not, and that's difficult, but I think they could have used measures before increasing* (Mathematics class held on the Teams platform on 11/17/2020).

Figure 5: Investigation "Coronavirus in Campo Novo do Parecis — MT" from the Intertoons Project Workbook

CORONAVÍRUS EM CAMPO NOVO DO PARECIS

No município de Campo Novo do Parecis-MT, tivemos o primeiro caso de coronavírus em abril, depois disso os casos foram crescendo rapidamente. Observe o gráfico de Linhas abaixo:



Fonte: DELGADO, 2020.

Essa imagem apresenta o "*Gráfico de Linha*", que também chamado de "Gráfico de Segmento", ele é usado para apresentar valores (sequência numérica) em determinado espaço de tempo. Ou seja, mostra as evoluções ou diminuições de algum fenômeno.

Responda:

a) A partir de qual período a curva de crescimento de casos confirmados foi aumentando?

b) Descreva a curva de suspeitos durante o período de 12 de maio a 01 de junho.

c) Qual o percentual de aumento dos casos confirmados entre o período de 22/05 a 01/06? Esse crescimento foi durante quantos dias?

Source: 2020 Survey Data

From the previous excerpts, we verified that the students related social and economic issues, but not to the point of provoking tensions or identifying historically accumulated tensions in the system. However, students are dialoguing about everyday aspects with a more critical eye, which may have been influenced by the expansion of the community with the participation of the Internet actress – external information that she transmitted to the system.

This movement is more evident when Caio says "*I entered a website and you see the numbers from all over the world*" and Maria asks "*Send us the link*". The website (https://www.worldometers.info/coronavirus/#countries) written in English transmitted to the system not only numerical and graphical information, but also the beliefs, moral, ethical and cultural values of those who built it. In view of the above, Souto and Borba (2018) state that when this type of behavior occurs, the internet can play two roles at the same time: artifact and community.

However, it is also necessary to analyze the movement of the teacher. She seems to be following a script of questions previously constructed, disregarding what was happening in the discussions. Caio's suggestion and Maria's interest could have been a great opportunity to explore the site and carry out new discussions, but it was not considered by the teacher. In cases like this, we can say, according to TA, that the teacher was in one activity system and the students in another, and the hierarchical way in which the teaching and learning of Mathematics has been historically developed, perhaps students and teacher have considered the situation (the teacher's interest prevails) as "natural".

Regarding internet access, we highlight Thais' comment "it seems that they don't care. Teacher, the internet is down all the time, so if I don't come back, it's because it's down". This type of difficulty accessing the internet was recurrent and also influenced learning by generating tensions. We point out that the research was developed in the context of a rural school, where very few managed to maintain full-time access.

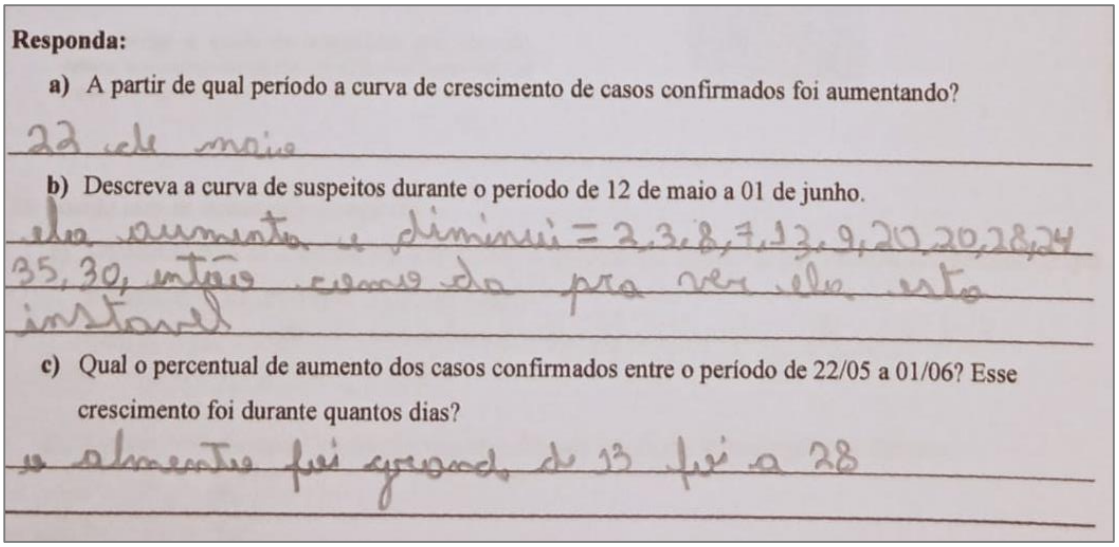
> Caio: *Prof, I can't access my internet, it's too slow* (Math class held on the Teams platform on 11/04/2020).
>
> Patricia: *I'm logging in, but the internet is down all the time, prof if I don't come back, it's because the internet is over* (Math class held by the Teams platform on 11/10/2020).
>
> Thaís: *Teacher, the internet is crashing all the time, so if I don't come back, it's because it crashed...* (Math class held on the Teams platform on 11/17/2020).

In the previous excerpts, we can see that the lack of internet was something that generated tensions for the development of the project. This can be linked to several factors such as the context of the field, internet speed and climate factors. The internet, in this case, was necessary for online interactions. Thus, we can say that at that moment she was playing the role considered natural, according to TA, that is, as an artifact.

Despite these problems with internet access, the work continued and the discussions held began to focus on the pandemic in the municipality of Campo Novo do Parecis - MT. The students answered the tasks with structured and closed questions. In Figure 6, we have student Maria's response to the questions regarding the graph of cases of the new Coronavirus in the municipality.

In Figure 6, we have the answer of the student "Maria" referring to the proposed task. In it, we can verify that the student does not present (in her answers) Mathematics in a rigid way, but interprets it in a colloquial and direct way, meeting what the questions requested. From an TA point of view, structured questions like these lead to the process of internalization, reproduction of culture (Souto, 2013). That's exactly what happened at that moment.

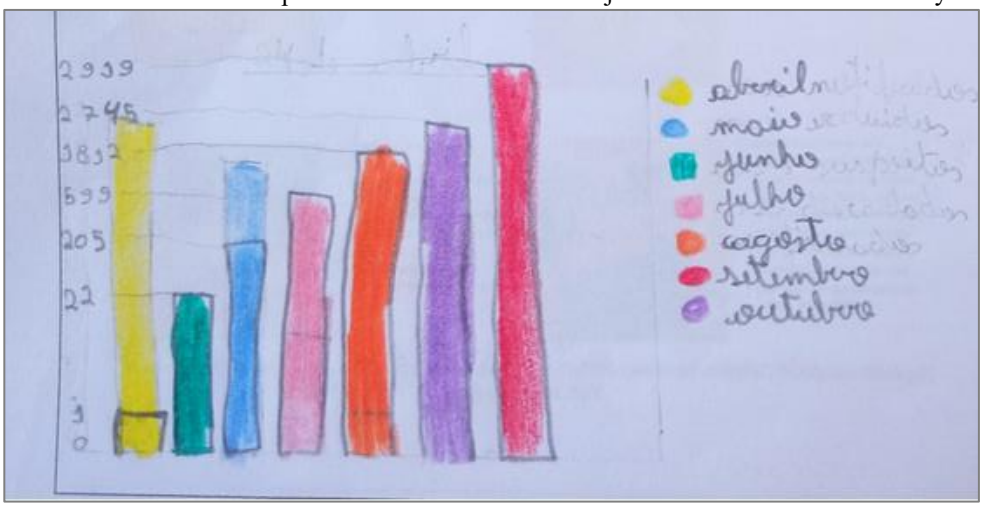
Figure 6: Task "Coronavirus in Campo Novo do Parecis — MT" from the Intertoons Project Workbook — Workbook by student Maria



Source: 2020 Survey Data

After that, in the next task, students should build a graph with data from the Coronavirus bulletins in Campo Novo do Parecis, MT. In it, a representation with the evolution of confirmed cases and confirmed deaths was requested. For this task (Figure 7) the use of a ruler, pencil and paper were requested, in addition to the inclusion of the source, caption.

Figure 7: Task "Construction of Graphics" from the Intertoons Project Workbook — Workbook by student Thaís



Source: 2020 Survey Data

In Figure 7, we can see the response of student Thaís. The chart was constructed "freehand", without the use of a ruler and the basic information required, such as information on the number of infected people. The students made the following comments about this investigation:

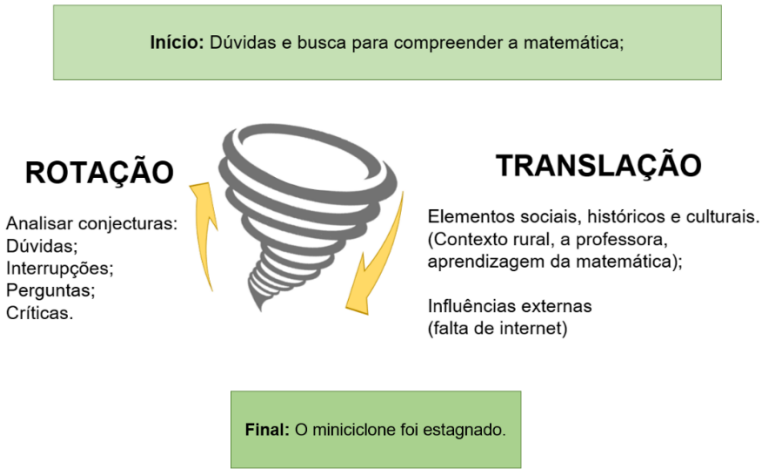
> Thaís: *To make this graph, I had difficulty seeing which numbers corresponded, I could not see which number belonged, [The student refers to the data presented at the end of the Intertoons project booklet] but, later I understood when the teacher explained* (Math class held by the Teams platform on 11/24/2020).
>
> Maria: *I added up the confirmed cases from the bulletins for each month, and then I added up the deaths, then I put it on the graph, I didn't know how to do it, I asked the teacher for help, so she explained to me*

how to make a graph (Math class held by the Teams platform on 11/24/2020).

Based on these excerpts, it was possible to verify that the students had doubts, and turned to the teacher to solve them, this can be an indication of expansive movements. Given the above, it is possible to indicate that the students felt the need to seek a kind of "legitimation" of their ideas by the teacher. However, when the teacher answers, she breaks with any possibility of creating minicyclones. This type of teaching behavior, as already mentioned, from an TA point of view can be considered an internal contradiction historically structured by the way we have learned and taught Mathematics (Borba *et al*., 2022). In this case, in particular, the internal contradiction is linked to the formative processes that were received by the teacher, which, according to Souto (2013), can be characterized as S S-H-C-M external to the analyzed system. In other words, there is a rotational movement that has paralyzed the expansive learning process. In our participant observation, we verified that the corrections of this task were performed only individually.

In Figure 8, we represent, in a summarized way, the movements that occurred in the minicyclone. According to the analyzed data, we verified that we cannot say that the minicyclone of expansive learning developed, which is due to the influence of several factors: time, teacher's answers, structured questions with closed answers, the difficulty in accessing the internet. However, we can see that there were initial movements of rotation and translation.

Figure 8: Summary of the initial movements that could constitute a minicyclone of learning



Source: Authors based on Borba, Souto & Canedo Junior (2022)

Considering the data and analyzing Figure 8, we highlight that some doubts and questions could characterize the beginning of a minicyclone. On the left, rotational movements are caused by internal influences, but they did not advance, mainly due to the structure of the teaching proposal, which had structured questions with unique and closed answers. On the right, the translational movements occur due to external influences, which were more intense and could be identified, mainly, when there was internet consultation, access to free-to-air TV, and social, economic, and cultural criticism.

According to Borba, *et al*., (2022, p. 100), the completion of the minicyclone can be verified when expansive learning occurs, that is, when there is "construction of justification for a solution produced with multimodal and intermediate connections that had not been hitherto thought by the subjects of the activity and that, with that, result in new forms of expression of mathematical thinking". The analyzed data indicated that the minicyclone was stagnant between the initial rotation and translation movements.

5 Considerations

This article sought to analyze how the minicyclones of expansive learning occurred during the development of mathematical tasks with 6th and 7th grade students of an elementary school in the interior of Brazil during the Covid-19 pandemic. The analyzed data suggest that the development of the minicyclone did not materialize. Several factors directed students towards the process of internalization, that is, reproduction of a dominant pattern of teaching and learning mathematics.

However, we verified that the process was not totally rigid or stagnant. The expansions were observed when the students established relationships between mathematics and society's health issues. On the other hand, the retractions — more intense movements and in greater quantity — occurred in two situations: when the tasks were structured with single and closed answers and when the teachers provided the answers without giving the students the opportunity to seek, elaborate, conjecture, produce something new.

Retractions are closely linked to the internalization process, which was also marked by the immediate actions of the teacher providing the answers. This behavior of the teacher in the face of students' doubts can be considered as influences from external systems, due to the way Mathematics teachers have historically been taught and trained.

On the other hand, at times, the teacher's questions were provocative, giving evidence of movements towards the formation of minicyclones of expansive learning. This occurred mainly when students related mathematics (numerical data) with social, political and economic issues.

It seems that the teaching proposal developed, to a certain extent, autonomy, research, queries of doubts, and related mathematical aspects with social, cultural and economic issues. This gives us evidence of expansive movements towards disruption of the usual patterns of teaching and learning processes in Mathematics.

The results of this research suggest that deeper changes, in the field of mathematics education, may occur gradually, not just in isolated works, but in something that is collectively planned, including short, medium and long-term public policies.

Beyond the purpose of this article, we conclude that thinking about approaches to break with the stable pattern of teaching and learning mathematics is not something simple or trivial, even more so in a pandemic moment in which everything that was usual in the classroom was transformed, including the classroom itself.

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