

**The impact of the covid-19 pandemic on the resource system of mathematics teachers: a case study in Amazonas**

**El impacto provocado por la pandemia del covid-19 en el sistema de recursos del profesor de matemática: un estudio de caso en amazonas**

**L'impact de la pandémie de covid-19 sur le système de ressources des enseignants de mathématiques : une étude de cas en Amazonie**

**O impacto provocado pela pandemia da covid-19 no sistema de recursos do professor de matemática: um estudo de caso no Amazonas**

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**Abstract**

The present study constitutes a segment of a postdoctoral research project that seeks to examine the effects of the Covid-19 epidemic on the resource system used by mathematics teachers in elementary education. In this paper, we describe a qualitative case study conducted with a group of nine teachers working in the state of Amazonas. The study adopts a phenomenological approach to explore the experiences and perspectives of these teachers. The research is grounded in the theoretical and methodological frameworks of documental didactic approach and reflective inquiry. The data for this study were collected using semi-structured video-recorded interviews and subsequently subjected to content analysis. The study emphasized that the disparity between public and private schools had a significant impact on how teachers from these institutions were affected by the pandemic in regard to technical resources, infrastructure, and institutional support. It was observed that, upon resuming in-

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person lessons, a significant number of teachers had enhanced their RS by incorporating applications such as WhatsApp™ and platforms such as Canva. However, it is imperative for future research to investigate the extent to which teachers incorporated these additional resources into their teaching practice.

**Keywords:** Mathematics education, resources, Amazonas, pandemic.

### Resumen

Este trabajo es un fragmento de una investigación de posdoctorado que tiene como objetivo analizar el impacto del escenario pandémico del Covid-19 en el sistema de recursos de los profesores de matemáticas de la educación básica. Presentamos aquí un estudio de caso cualitativo fenomenológico realizado con 9 profesores de Amazonas. Los marcos teóricos y metodológicos de la investigación son el Enfoque Documental Didáctico y la investigación reflexiva. Los datos se obtuvieron a través de entrevistas semiestructuradas grabadas en video y se analizaron mediante el análisis de contenido. La investigación puso de manifiesto que la desigualdad entre las escuelas públicas y privadas influyó fuertemente en la forma en que los profesores de estas escuelas fueron afectados por la pandemia en cuanto a recursos tecnológicos, infraestructura y apoyo institucional. Observamos que, con la reanudación de las clases presenciales, el sistema de recursos de la mayoría de los profesores se enriqueció con la incorporación de aplicaciones como WhatsApp™ y plataformas como Canva. Sin embargo, futuras investigaciones deberían indagar si y cómo los docentes integraron estos recursos adicionales en sus actividades pedagógicas.

**Palabras clave:** Educación matemática, Recursos, Amazonas, Pandemia.

### Résumé

Ce travail est un extrait d'une recherche postdoctorale visant à analyser l'impact du scénario pandémique de la Covid-19 sur le système de ressources des enseignants de mathématiques de l'éducation de base. Nous présentons ici une étude de cas qualitative phénoménologique réalisée avec 9 enseignants de l'Amazonas. Les références théoriques et méthodologiques de la recherche sont l'Approche Documentaire Didactique et l'enquête réflexive. Les données ont été obtenues à partir d'entretiens semi-structurés enregistrés en vidéo et analysés à la lumière de l'analyse de contenu. La recherche a mis en évidence que l'inégalité entre les écoles publiques et privées a fortement influencé la manière dont les enseignants de ces écoles ont été impactés par la pandémie en ce qui concerne les ressources technologiques, l'infrastructure et le soutien institutionnel. Nous avons observé qu'avec la reprise des cours en présentiel, le système de

ressources de la plupart des enseignants s'est enrichi grâce à l'intégration d'applications telles que WhatsApp™ et de plateformes telles que Canva. Cependant, des recherches futures devraient enquêter sur la manière dont les enseignants ont intégré ces ressources supplémentaires dans leurs activités pédagogiques.

**Mots-clés** : Éducation mathématique, Ressources, Amazonas, Pandémie.

### **Resumo**

Este trabalho é um recorte de uma pesquisa de pós-doutorado que visa a analisar o impacto do cenário pandêmico da Covid-19 no sistema de recursos de professores de Matemática da Educação Básica. Trazemos aqui um estudo de caso qualitativo fenomenológico realizado com nove professores do Amazonas. Os referenciais teórico e metodológico da pesquisa são a Abordagem Documental do Didático e a investigação reflexiva. Os dados foram obtidos a partir de entrevista semiestruturada gravada em vídeo e lidos à luz da análise de conteúdo. A pesquisa evidenciou que a desigualdade que há entre as escolas públicas e as particulares influenciou fortemente na forma como seus professores foram impactados pela pandemia no que tange a recursos tecnológicos, infraestrutura e suporte institucional. Observamos que, com a retomada das aulas presenciais, o sistema de recursos da maioria dos professores foi enriquecido com a inserção de aplicativos como o *WhatsApp*™ e de plataformas como o *Canva*. Contudo, futuras pesquisas deveriam investigar se, e de que maneira, os docentes integraram esses recursos adicionais em suas atividades pedagógicas.

**Palavras-chave**: Educação matemática, Recursos, Amazonas, Pandemia.

## **The impact of the COVID-19 pandemic on the resource system of mathematics teachers: a case study in Amazonas**

Teaching activities comprise a variety of resources, such as textbooks, curriculum materials, and educational software (Gueudet & Trouche, 2015). The act of teaching incorporates its own distinct curriculum and generates new educational materials (Ball & Cohen, 1996). According to Adler (2000), teachers can consider the activities conducted by students, classroom interactions, and advice received from colleagues to be valuable resources.

Similarly to many other human activities, teaching is sensitive to significant changes, such as the spread of digital resources or major health crises, such as the new coronavirus SARS-CoV-2, which causes Covid-19. Those changes alter the essence of the means of communication, as well as their resources and the conditions of their practice, conception, and dissemination (Bachimont & Crozat, 2004).

The onset of SARS-CoV-2 in Brazil occurred in February 2020, when the country declared a national health emergency. As a result, in-person education was immediately and drastically suspended. Therefore, teachers endeavored to identify the prerequisites for deploying a new teaching-learning proposition centered on Emergency Remote Teaching (ERT), which, according to Hodges et al. (2020), aims to provide temporary access to curricular content that would otherwise be addressed in the classroom.

The main strategies adopted and/or announced by education departments during the quarantine were teaching through online platforms and other digital resources, distribution of printed study materials and broadcasting of lessons via open TV and radio. For Behar (2020), ERT consists of "a mode of teaching that presupposes geographical distance between teachers and students", "temporarily adopted at different levels by educational institutions worldwide."

Based on that assertion, state education departments began to formulate strategies to combat the novel coronavirus. Some suspended lessons altogether during the quarantine, while others reorganized schoolwork and chose to resume the educational process complying with the school calendar and workload through non-face-to-face activities, with or without the use of digital information and communication technologies.

Consequently, teachers experienced many effects, including changes in their working environment, the dynamics of their teacher-student interactions, and their access to teaching resources (Marques et al., 2021). The emergence of this framework has had a profound impact on the discussions surrounding mathematics education. This impact stems from the increased availability of resources for teachers and the subsequent need for them to be equipped with the ability to adapt and innovate, even in the absence of prior foundational training. As a result,

teachers were compelled to reinvent themselves, which involved creating and selecting novel instructional materials or modifying existing ones.

Moreover, the pandemic, which can be viewed as a symbolic event of transition (Rocha, 2018), spawned new relationships between teachers and those resources. This led us to pose the following question: What are the effects of the changes brought about by the SARS-CoV-2 pandemic on the resource systems (RS) of elementary school mathematics teachers?

The resource systems (RS) of teachers are a window for analyzing what has changed and what has remained stable in their documentational work. (Gueudet & Trouche, 2015). The study of resources and the interactions/work of mathematics teachers with these resources has become a prominent field of study (Pepin et al., 2013). In light of this, the objective of the present study was to examine the impact of the SARS-CoV-2 pandemic on the resource systems (RS) of mathematics teachers in the state of Amazonas.

The present article is organized in four sections. The first contemplates theoretical references, specifically the documentational approach to didactics (DAD). The second section encompasses the choices regarding methodology and delineates the instruments employed for data collection and analysis. The third section focuses on data analysis, specifically examining the data gathered from a sample of nine mathematics teachers residing in the state of Amazonas. And, finally, the fourth section encompasses concluding remarks regarding the research conducted.

### **Theoretical framework: documentational approach to didactics**

The documentational approach to didactics (DAD) is a didactic theory of mathematics developed by Luc Trouche, Ghislaine Gueudet and Birgit Pepin. Its purpose is to examine teaching practice in relation to the resources available to teachers, as well as the development and modification of resources, thereby highlighting the intricate nature of teachers' usage of resources (Gueudet & Trouche, 2008). Therefore, the notion of resources contemplated by DAD is expansive, as it encompasses everything that can nourish, feed, or refeed teaching practice. The resources available to teachers encompass a variety of elements, including textbook, academic programs, teaching-specific software, student activities, classroom interactions, and advice from colleagues (Trouche et al., 2017).

The DAD differentiates between what is available for the activities of teachers, namely the resources, and what teachers create to support teaching, the documents (Bellemain & Trouche, 2016). Gueudet and Trouche (2008) define documents as aids to the pedagogical practice of teachers, establishing the following representation: document = resources + usage

scheme. The term *usage* refers to "all didactic actions of the teacher, from the selection of resources to their adaptation, structuring, implementation in the classroom, and subsequent revision, etc." (Bellemain & Trouche, 2016, p. x).

The notion of *scheme* is central to DAD. It is inspired by the contributions of Vergnaud (1989), according to whom *scheme* is the invariant organization of behavior for a class of situations aimed at the specific learning of a concept. For Vergnaud (1993), *situation* is a combination of tasks whose specific nature and difficulties are important to know.

Vergnaud (1993), refers to the elements that contribute to a clear understanding of a scheme as "ingredients." These ingredients include goals and anticipations, which are focused on a specific set of situations where individuals can identify the purpose of their actions and, at times, sub-goals. Additionally, rules of action are used to gather information and maintain control over activities, similarly to how individuals observe the sequences of actions. Operational invariants, which can be considered as theorems-in-action and concepts-in-action, guide individuals in recognizing relevant aspects of a given situation. Lastly, the possibility of inference-reasoning allows individuals to predict rules and make informed predictions based on the information and operational invariants available to them.

Gueudet & Trouche, (2009) coined the phrase “documentational genesis” to describe the process of creating a document, which encompasses the learning of teachers. It combines two movements: instrumentation, in which the characteristics of resources influence the practice of teachers, and instrumentalization, in which teachers’ habits and knowledge guide the choices and transformation of different resources, as shown in Figure 1 (Trouche et al. 2020).



Figure 1.

*Schematic representation of a documentational genesis (Bellemain & Trouche, 2016, p. 118)*

DAD emphasizes the dialectical nature of *teacher-resource* interactions, combining instrumentation and instrumentalization (Vérillon & Rabardel, 1995). These processes encompass design, re-design, and design-in-use, wherein teachers make real-time modifications to a document in order to align it with their educational needs. In this approach,

all the work performed by teachers to create or adapt a tool is referred to as documentational work, which is considered the core of teaching activity.

The viewpoint of Adler (2000) is supported by DAD. Adler suggests that the concept of "re-source" in English might be understood as a resource that seeks nourishment from the source again or in a different manner (Adler, p. 207). In addition to the fundamental resources such as school infrastructure, utilities, and personnel, it is imperative to acknowledge the broader range of resources required for effective mathematics instruction. These include material instruments such as technological devices, mathematics-specific teaching materials, mathematical objects, as well as everyday tools. Additionally, cultural and social factors, including language and temporal considerations, must also be considered. In this context, the concept of DAD encompasses a wide range of educational materials. These resources encompass various elements that are meaningful to teachers, including those highlighted by Remillard (2005) in her investigation of curricular resources that facilitate teachers' professional practice. (Trouche et al., 2020, p. 3)

Contrary to Adler (2000), Pepin and Gueudet (2018) do not regard humans as being resources; rather, resource is the content of the interaction with a human (e.g., a discussion, or an email message). Thus, DAD considers anything that can replenish teachers' documentational activity as a resource, such as physical or digital textbooks, exchanges of email messages with colleagues, students' worksheets, consultation of a website or platform for teaching mathematics, suggestions from colleagues on activities to introduce specific content, or participating in training events. (Trouche et al., 2017). Thus, various types of resources can be considered within the scope of DAD. These resources include:

Curriculum resources encompass a variety of materials, such as digital and traditional textbooks, as well as digital interactive resources. These resources are created and used by educators and learners to facilitate their engagement with mathematics, both within and beyond the confines of the classroom. The digital curricular materials, as distinguished by Pepin and Gueudet (2018), are integrated with them, but separated from the Information and Communication Technologies in Education (ICTE). Additionally, Trouche et al. (2020, p. 3) identify three distinct categories of resources in the educational context: material curricular resources, social resources, and cognitive resources. Material curricular resources encompass textbooks, digital resources, manipulation instruments and calculators. Social resources include web conversations and forums. Lastly, cognitive resources refer to theoretical frameworks and tools that are used in collaboration with teachers.

Two other concepts proposed within the scope of DAD are: meta-resource and mother-resource. The term "meta-resource" refers to a collection of principles that govern the design

of various resources (Prieur, 2016), which are themselves considered resources that facilitate access to other resources (Bellemin & Trouche, 2016). The instruments employed and implemented in the lesson planning process are referred to as mother-resources, which after being adapted and refined, produce daughter-resources (Hammoud, 2012).

When selecting resources to teach mathematical content in the classroom, teachers create, select, and modify a range of resources, collectively referred to as the resource system (RS) by Gueudet and Trouche (2008). Rocha (2018, p. 43) points out that "this system is not a mere list of resources, as the resources are interconnected and linked". Additionally, Rocha points out that access to the system is limited, given its dynamic nature, and constant evolution.

The complex nature of the RS and its diverse characteristics render the analysis of this phenomenon more intricate. In the context of a teacher's repertoire of strategies, Rocha (2018) suggests that many resources can be employed to address similar situations. Furthermore, it is possible for a single resource to be utilized across multiple categories of situations. Moreover, the analysis of temporal changes in this specific RS enables the observation of shifts in the teachers' documentational trajectory, described by Rocha (2021) as "a trajectory that encompasses the professional experiences (both individual and collective) encountered by the teacher and the changes in their documentational practices over time" (p. 43).

The purpose of examining the documentational trajectory is to find noteworthy occurrences that illustrate the transformations taking place within this specific activity (Rocha, 2021). The examination of teachers' documentational trajectory involves the identification of symbolic events, which are defined as events that expose disruptions in the documentational work of teachers and lead to the emergence of new resource creation processes (Rocha, 2021, p. 48). When teachers identify such events, they are characterized as reflective. Conversely, when researchers identify the events during analysis, they categorize them as inferred (Rocha, 2021). Events that reveal ruptures (creative fidelity) in the work of teachers, which result in new ways of creating resources, are called transition symbolic. According to Rocha (2021), "the identification of such resources is linked to the modeling of the trajectory of teachers by periods, for which we can infer an orientation in the teachers' work for a family of activities; such orientation is called documentational dominance (conservative fidelity)." (p. 48).

The stability of a symbolic resource in the RS of a teacher is determined by its continued presence during a symbolic event, regardless of whether the event involves a transition or not. Individuals possess the ability to ascribe events to a consistent sequence, highlighting the prevalence of continuity rather than interruptions (Pastré, 2005). In this specific case, it can be argued that there is conservative adherence. On the other hand, it is evident that there is a



correlation between events that are perceived as disruptions. Such correlation enables individuals to assign their own meanings to disruptions, as stated by Pastré (2005, p. 256). As a result, this process leads to the development of creative fidelity.

In light of the aforementioned circumstances, this study uses the previously mentioned concepts to investigate the impact of the SARS-CoV-2 pandemic, as a symbolic event, on the RS of mathematics teachers within the particular setting of the state of Amazonas, Brazil. In order to do so, a series of methodological instruments have been developed and applied, which will be described in the next section.

### **Methodology**

This article offers part of a study conducted as a result of the doctoral research of the first author, supervised by the second author, in conjunction with the third author, between 2022 and 2023. The study uses a qualitative approach, which, as defined by Creswell and Creswell (2021), "is a means to investigate and understand the meaning that individuals or groups assign to a social or human problem" (p. 26). Regarding its nature, the study can be classified as phenomenological research, which "seeks to recover the meanings ascribed by the participants to the object under investigation." (Gil, 2019, p. 15).

The rationale for selecting a phenomenological approach for the study is justified by the need to describe the shared meanings attributed by participants to their experiences throughout the Covid-19 pandemic. The relevance of choosing this research method lies in the fact that it "focuses on describing what all participants have in common when they experience a phenomenon" (Creswell & Creswell, 2021, p. 72). In this study, the participants are mathematics teachers who had a collective experience of the impact of the Covid-19 pandemic on their RS.

The study focuses on the phenomenon of the Covid-19 pandemic, and the resulting symbolic event of transitioning to Emergency Remote Teaching (ERT). The objective of the study is to examine the effects of this shift on the RS of mathematics teachers. The research was prompted by the question: What are the effects of the changes resulting from the SARS-CoV-2 pandemic on the RS of elementary education mathematics teachers?

The results derive from a case study, which is an "empirical investigation that analyzes a contemporary phenomenon (the case), in depth and in its real-world context, particularly when the boundaries between phenomenon and context are not readily apparent." (Yin, 2014, p. 32).

In order to select the participants of the study, the following inclusion criteria were used: individuals were required be elementary education mathematics teachers, who had prior experience teaching mathematics in the final years of elementary school or high school, both before and during the implementation of ERT, furthermore, participants should be teaching mathematics to classes within those grade levels after the ERT, that is, when in-person lessons resumed. Thus, the exclusion criteria contemplated individuals who did not have prior experience teaching mathematics to students within the specified grade levels during the ERT period.

To ensure a comprehensive representation of various educational settings, the sample consisted of a teacher from a prestigious private school, three teachers from urban regions in three different towns located in the countryside, and four teachers from rural areas of two countryside towns, in the state of Amazonas. The selection of a single high standard private school stems from the fact that such institutions possess comparable physical and administrative infrastructures.

We sought to identify elements of the teachers' documentational trajectory (Rocha & Trouche, 2016) in order to analyze which resources were generated and used prior to, during and after ERT. The production and examination of such trajectories entailed the use of data obtained from a semi-structured interview that was recorded in both audio and video. This particular type of interview entails the use of a pre-established script, while also allowing additional inquiries to be posed during the exchange between interviewer and respondent (Glesne, 2015). This approach enables the researcher to further characterize previously analyzed aspects; the focus of the research. Figure 2 shows an excerpt of the script of the semi-structured interview conducted in the course of the investigation.

12. As perguntas a seguir dizem respeito aos **recursos do seu ensino** (TIC, livros didáticos, sites...) O que são ou têm sido, os recursos mais utilizados? Que critérios para sua escolha? Que uso faz desses recursos?

Ano anterior à pandemia		
Recursos	Critérios de escolha	Forma de uso (como eram usados)

  

Durante as aulas remotas		
Recursos	Critérios de escolha	Forma de uso (como eram usados)

  

Após o retorno às aulas presenciais		
Recursos	Critérios de escolha	Forma de uso (como eram usados)

Figure 2.

*Study data (2022)*

Thus, we engaged the respondents in conversation by posing comprehensive questions pertaining to their documentation practices, with emphasis on the object of investigation,

namely the changes induced by ERT in their RSs. We attentively listened to the interviewees while simultaneously questioning them in order to obtain a comprehensive understanding of their responses and respective perspectives.

To clarify and comprehend the RS explored and constructed by teachers before, during, and immediately after ERT, we adopted schematic representation of the resource system (SRRS), one of the reflective investigation techniques proposed by Gueueut and Trouche (2012). In the context of this research, the representation was conveyed verbally during the interview.

For the analysis of the findings, we employed content analysis (Bardin, 2015), which is widely used for examining written materials (Bauer & Gaskell, 2017). Textual data used in this study were extracted from the transcripts of the interviews. The study used content analysis as a methodological approach to analyze linguistic materiality, considering the empirical conditions of the texts. Categories were established for the interpretation of the texts based on the concept of resource (Trouche et al., 2017), meta-resource (Bellemain & Trouche, 2016; Prieur, 2016), as well as mother and daughter resources (Hammoud, 2012).

Regarding the ethical aspects of the research, the participants were provided with a clear explanation of the objectives of the study and were given the opportunity to consent in a voluntary and informed manner through the use of the free, prior, and informed consent form (FPIC). Each individual accepted and signed the form, which is securely kept in the researchers' confidential records. According to Resolution CNS 466/12, item V, all research involving human subjects entails various types and degrees of risk. We also highlight item II.22 of the same resolution, which defines "research risk as the potential for physical, psychological, moral, intellectual, social, cultural or spiritual harm to human beings, both during or as a consequence research." In order to mitigate potential negative effects on psychological and/or moral aspects, accessibility to all audiovisual and documental records was strictly limited to the research team, and disclosure to the general public prohibited. The anonymity of the subjects was safeguarded in the publication of the findings.

## **Results**

An ethical position was adopted by obtaining informed consent from the teachers, which involved providing a detailed explanation of all research phases and obtaining their consent through the signing of a consent form. Moreover, to prevent potential harm or embarrassment, the identities of all persons involved have been protected through the use pseudonyms throughout the text, namely, Marcos, Antônia, Moisés, Eduarda, Wallace, Elton,

Hamilton, Carla and Marcela. To improve readability, this section was divided into three subsections according on the educational settings in which teachers worked: schools located in rural areas of countryside towns, schools located in urban areas of countryside towns, and a school located in the capital city, Manaus.

### **Setting 1: Schools in rural regions of countryside municipalities**

Two teachers, Marcos and Antônia, work in the same school located in a rural community in the town of Presidente Figueiredo, 153 kilometers away from Manaus. Marcos obtained his degree in Biological Sciences in 2019, while Antônia graduated in mathematics in 2010, both from a publicly-funded university in the state of Amazonas. They have been working at the school since 2020 and 2011, respectively.

According to the teachers, the education department provides limited courses and specialized training for teaching mathematics, and there was no training to adequately guide and prepare them for the challenges of ERT. They claimed that the school does not have a dedicated computer laboratory and instead uses small whiteboards that are placed on tables. In relation to collaborative efforts, they expressed a lack of interest in engaging in joint activity planning. Furthermore, the statements made by the teachers did not describe any discernible symbolic events.

In the period preceding, during, and subsequent to the pandemic (when in-person lessons resumed), Marcos taught the sixth grade of elementary school, and Antônia taught seventh to ninth grade and adult education. Before the pandemic, the only resource used by both teachers to plan their lessons was the textbook, a mother-resource.

During ERT, in addition to the textbook, Marcos used the meta-resources *Internet* and *search engines*. From Marcos' remarks it was possible to infer the *educational websites* resource. When in-person lessons resumed, he maintained educational websites as resources to prepare his lessons, in addition to textbooks. This demonstrates that both the resource *educational websites*, and the meta-resources *Internet* and *search engines* remained stable in the teacher's RS after the return to in-person lessons. On the other hand, Antônia used textbooks as the main mother-resource during and after ERT, demonstrating that the tool is stable in her RS, thus showing conservative fidelity.

Moisés holds a degree in mathematics from a privately-owned university in Amazonas and has been working at the school since 2021. The school is located in another community in the rural area of Presidente Figueiredo. Typically, he plans his lessons both at the place where he resides in the community and at the school. As mother-resources he uses *textbooks* and an

exercise booklet, obtained through the *Internet* meta-resource. Moisés is the only mathematics teacher in the school, and taught students ranging from sixth to ninth grade, prior to, during and after the pandemic. Before the pandemic, his mother-resources were textbooks and video lessons from YouTube™. His material resources were *rulers, compasses and protractors*. His meta-resources were the *Internet* and *search engines*. Amidst the pandemic, he developed daughter-resources such as activities accompanied by tutorials and video lesson links for students who had Internet access. During the creation of the material, he used the textbook as a mother-resource and conducted some research on websites (meta-resource). Throughout this period, Moises mostly relied on WhatsApp™ as a commonly used resource for the students who had Internet access. Students submitted questions for him to answer, via message or photographs. Upon resuming in-person lessons, Moises reverted to the same resources he used prior to the onset of the pandemic.

Carla has a degree in Philosophy. She is pursuing a mathematics degree at a publicly-funded university in the state of Amazonas through the *Parfor*<sup>4</sup> program. Since 2015, she has held a teaching position in a public school located in the rural region of Urucurituba, Amazonas (AM). Carla is the only mathematics teacher in the school, thus precluding any collaborative work with fellow teachers in the same area.

Carla's planning is carried out biweekly; in general, in one of the four classrooms at the school, as there is no designated teachers' lounge. Moreover, the school has no computer laboratory and only a small library. At home, Carla has a dedicated place where she conducts her planning on the weekend. Resources at her disposal include a computer, a printer, books and Wi-Fi connection. Those resources have been acquired through her own financial means.

Carla's documentational trajectory encompasses a diverse array of symbolic events in various courses, such as *Introduction to Computer Science, Geometry and New Technologies in Teaching Mathematics*, associated with the following resources Python/CodeBench, Geogebra and Google Spreadsheets, respectively. Carla stated that she regularly participates in training courses and mentioned the following: pedagogical training, guide for the development of lesson plans, course program proposals and the *Trilhas do Saber* project<sup>5</sup>.

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<sup>4</sup> *Programa Nacional de Formação de Professores da Educação Básica* (National Program for Training of Elementary Education Teachers) is a program that seeks to contribute to the adequacy of the initial education of teachers working in the public basic education network by providing degree courses relevant to their field.

<sup>5</sup> The *Trilhas do Saber* project encompasses a diverse range of themes that have been specifically designed to cater to teachers working in both the early and final years of elementary school. The themes encompass curricular and pedagogical principles, novel strategies for the teaching-learning process, and the incorporation of the Amazon Curricular Reference (RCA).

In the year preceding the onset of the pandemic, Carla taught students ranging from sixth to ninth grades in elementary school, as well as in the initial phase of adult education. The teacher used many resources, such as the whiteboard, textbooks, online booklets, the National Common Core Curriculum (*Base Nacional Comum Curricular - BNCC*) and the Amazonas Curricular Reference (*Referência Curricular do Amazonas - RCA*). During ERT, her work focused solely on teaching sixth through ninth grade of elementary school. She used a variety of resources, including textbooks; Internet booklets, which were distributed to students' residences on a weekly basis and afterwards collected for assessment; the National Common Core Curriculum (BNCC); the Amazonas Curricular Reference (RCA); a mobile phone; tablet; and printer. Based on her statement, it can be inferred that the implementation of remote teaching was regarded as a symbolic transition event associated with the documental dominant *production of non-digital resources*, specifically *booklets*. Carla also highlighted the creation of booklets for her educational sessions in that particular period.

After in-person lessons resumed, Carla continued teaching grades six through ninth while maintaining the resources she had used during the pandemic. Additionally, she resumed using the whiteboard. Thus, we found that textbooks, booklets, the *BNCC* and *RCA* are stable resources in the teacher's RS, whereas cell phones, tablets and the printer, which were introduced during the pandemic, became stable in her RS.

Marcelo has a full degree in mathematics from a private university in Amazonas and has been a teacher since 2019. In 2021, he began teaching at the only school in a rural community located in Presidente Figueiredo, a town 158 km away from Manaus.

The school has both a projector and computer laboratory, although a number of computers are inoperable. In addition, there is a teachers' lounge and lodging for teachers who do not reside in the community. Such spaces are used by teachers to convene and plan lessons, as well as to store their materials, including textbooks, booklets, and computers. Such locations have Internet connectivity provided by the school.

Marcelo is the only mathematics teacher at his school. According to his account, the only time he engages in direct communication with fellow mathematics teachers is during meetings organized by the Board of Education. However, he claims that he exchanges ideas with other teachers via WhatsApp™ in order to discuss challenges and share experiences pertaining to their respective teaching practice. When asked about the potential for collaboration with other mathematics teachers in training programs, Marcelo replied :

In Manaus I had other training sessions in mathematics with colleagues (...). We worked a lot on Golden Materials, creating games, concrete materials, in that area (...). We managed to successfully implement those, but I must admit that it is a little complicated, difficult, because we meet in groups, students too, it is a mess, but we are able to create something (Marcelo).

As a result, we have the reflective symbolic event *continuing education courses*, and the associated documental dominant, *use and/or creation of concrete materials*.

Before the pandemic, Marcelo taught sixth through ninth grade and high school students aged 15 to 17. As teaching resources he used textbooks, workbooks, research of content on the Internet, Google Scholar™ and YouTube™ video lessons as well as the concrete materials available (ruler, compass, protractor), when practicable. As meta-resources, he used the Internet, YouTube and Google Scholar, whereas he used textbooks and video lessons as mother-resources, and concrete materials as material resources.

During and after ERT, Marcelo worked with elementary school classes ranging from sixth to ninth grade. During the pandemic, remote teaching was not carried out due to limited access to cellphones among a significant portion of students. Furthermore, a significant portion of those who owned such devices faced challenges in obtaining reliable internet access. In order to address this particular scenario, the teacher devised a strategy wherein he used the mother-resources curriculum planning and textbook and created daughter-resources, which consisted of *tutorials* that offered instructions on how to solve the exercises, as well as supplementary *handouts*. These materials were subsequently printed at the school premises using a material resource, namely a printer. To ensure that students received the resources, the Department of Education arranged transportation to deliver them directly to the students' residences. The conditions of the unpaved roads had a significant impact, resulting in the teacher personally transporting said material via motorcycle. In essence, the assistance provided by the Department of Education can be summarized as providing ink and paper for printing documents, however in inadequate quantities. Additionally, the Department of Education offered transportation to students' residences, although this responsibility frequently fell upon the teacher.

In the aftermath of the pandemic, the teacher reverted to using pre-pandemic resources, including textbooks, video lessons, and tangible materials. This choice reflects the teacher's perception of the stability and reliability of such resources within his RS. Furthermore, it is apparent that the pandemic had a significant impact on his RS, since it rendered the use of tangible resources impossible, a practice that was prevalent in his educational practice prior to the pandemic.

## **Setting 2: Schools located in urban regions of cities located in the interior of the state of Amazonas.**

Wallace obtained a degree in Pedagogy from a publicly-funded university in the state of Amazonas, in 2016. Since 2002, has been teaching in the municipality of Urucurituba, located 218.26 kilometers away from the state capital, Manaus. As symbolic events, it may be noted that he engaged in a self-funded professional development course as well as the *Trilhas do Saber* project. The former dealt with the creation of concrete materials for the purpose of facilitating educational activities with children, which led to the incorporation of recycled materials, such as cardboard and bottle caps, into his teaching resources. The latter, provided by the state government, focused on topics pertaining to education, incorporating instructional and interactive lectures, discussions, and sharing of personal experiences.

At the beginning of his career, Wallace worked in multi-level classrooms ranging from first to fifth grade; children aged 6 to 10 years. Nevertheless, from the year preceding the onset of the pandemic to the present, he has been engaged in technology-mediated education, a pedagogical approach that facilitates the dissemination of educational content from a centralized hub to several classrooms spread throughout the country. This method is predicated on the principles of real-time instruction and the physical presence of educators, both within the classroom and the broadcasting studio. The teacher reported that the responsibility for organizing video lessons lies with the educators affiliated with the media center located in the state capital. In addition, he stated that there were no other teachers with a degree in mathematics at the school where he works, thus making collective work unfeasible.

In the period preceding the pandemic, Wallace used several teaching resources, including *notebooks, Data show equipment, whiteboards, and printed materials*. Additionally, the teacher incorporated the *RCA* as a curricular resource, used *website* and *internet* meta-resources, and relied on the mother-resources *textbook* and *handouts*. Throughout the ERT period, the teacher effectively used various material resources such as *cell phones, WhatsApp™* (for video communication with students), *Google Meet™*, *Canva* (a graphic design platform enabling the creation of social media graphics, presentations, infographics, posters, and other visual content), as well as printed materials. Additionally, the teacher maintained the use of traditional educational tools including textbooks, the *RCA*, *websites*, and *notebooks*. Upon resuming in-person lessons, the teacher used the same educational materials that were initially utilized during the period of remote teaching. It was observed that the mother-resource textbook and the *RCA* remained stable in the teacher's RS, as well as the resources introduced



during the pandemic, namely WhatsApp™, Canva and Google Meet™, which revealed improvements in his RS.

Elton holds a degree in Pedagogy from a public university in the state of Amazonas, which he obtained in 2015. Currently, he is pursuing a full degree in mathematics from another publicly-funded university in Amazonas, with the support of the *Parfor* program. Since 2008, he has been a teacher in the municipality of Itacoatiara, located 260 kilometers away from the capital city, Manaus, in addition to operating a motorbike taxi service in his spare time. As a symbolic event, the teacher highlights his participation in the specialization course *Inclusão na Educação* (Inclusion in Education), in 2010, when he had his first contact with *Google Classroom*™ and *Google Meet*™ resources.

In the year preceding the pandemic, Elton taught elementary school students ranging from fifth to ninth grades, aged 11 to 14 years. He utilized the mother-resource *textbook*, as well as material resources such as a whiteboard and disposables (such as plastic containers) as resources. The teacher emphasized the frequent use of handouts in the classroom because, according to his testimony, "*handouts effectively support the explanations and enable students to engage in class activities, thereby enhancing their comprehension of content.*" This, demonstrates a belief-in-action.

During ERT, Elton worked in the third year of elementary school. The resources he used most were the cellphone and computer, which were used for conducting research and preparation of teaching materials. Based on his testimony, it can be inferred that *remote lessons* are configured as a symbolic transition event associated to the documental dominant *adaptation and / or creation of digital resources*. The teacher also highlights the production of handouts for his classes at that time.

Currently, Elton is the only mathematics teacher at a school with multi-level classes in the early years of elementary school, which makes collaborative work with colleagues unfeasible. Although he acknowledges that his activities are enhanced by his use of the mobile phone and computer, he has reverted to using textbooks, handouts, and posters as his primary resources. In this teacher's RS, handouts are identified as a stable resource.

Hamilton is enrolled in a publicly-funded university in Amazonas, through the *Parfor* program, to pursue a degree in mathematics. Since 2014, he has been teaching in the municipality of Silves, located 267 kilometers from the capital, Manaus.

As a documental dominant, he uses *methods to integrate special-needs students*, evidenced by the symbolic event brought about by the *participation in the Trilhas do Saber*

program. Regarding the professional gains or benefits a teacher receives from participating in a specialization course, he states, "*in my opinion, it contributes to the individual acquiring new methods and a fresh perspective on a particular area of interest.*"

Regarding cooperative work, the teachers' lounge is the only place in the school where teachers and their colleagues can plan classes collectively. During the academic year, pedagogical meetings provide opportunities for teachers of the same discipline to collaborate. As the teacher stated: "*it is a moment to share our diverse perspectives in an effort to find the best solution for all students, taking into account the difficulties encountered in daily life.*"

Prior to the onset of the pandemic, Hamilton worked with sixth and seventh grades of elementary school and used the textbook, the National Common Core Curriculum (BNCC), and the Amazonas Curricular Reference (RCA) as resources to plan his classes. During the ERT, he worked in sixth, seventh and eighth grades of elementary school using the textbook, printed handouts, cellphone, the Internet, as well as the National Common Core Curriculum (BNCC) and Amazonas Curricular Reference (RCA). Upon resumption of in-person lessons, the teacher started teaching solely sixth grade classes in elementary school, employing textbooks, handouts, the National Common Core Curriculum (BNCC), the Amazonas Curricular Reference (RCA) as resources, as well as online resources available on the Internet. It is worth noting that the textbook, the National Common Core Curriculum (BNCC), and the Amazonas Curricular Reference (RCA) are considered stable resources for the teacher due to their consistent presence in his RS. Furthermore, the implementation of remote lessons brought about a transformation in that system by integrating cellphones, the Internet and printed resources; which, following the return to in-person lessons, remained stable in his RS.

### **Setting 3: School in the urban area of Manaus**

Eduardo holds a degree in mathematics from a private university in Amazonas, as well as a professional master's degree from a publicly-funded university. Eduardo has accumulated a total of nine years of teaching experience at his present educational institution. The institution in question is a private school which is widely recognized for its high level of excellence. As per his assessment, the school diligently provides ample support to its faculty members in terms of resource acquisition, while also making substantial investments in professional development. The school is equipped with various facilities, including a library in the teachers' lounge, a meeting room, as well as computer and science laboratories. At home, the resources available to Eduardo include *a chalkboard, a graphics table, a notebook, a 4K webcam, a microphone, internet connection, a voice recorder, and textbooks.* In 2019, the school

implemented the *Geekie One*<sup>TM</sup> educational platform and provided training sessions to teachers, which demonstrates the instrumentalization of teachers, and emphasizes the significance of the training event in relation to the adoption of the educational platform. In addition, it should be pointed out that every student used a Chromebook<sup>TM</sup> that housed all the didactic resources, hence eliminating the need for traditional printed textbooks. The transition to remote teaching was seamless, as the teacher stated that "*following the suspension of in-person classes on Friday, our school promptly resumed normal operations through the use of the Meet platform on Monday.*" Prior to the onset of the pandemic, Eduardo was engaged in educational activities with students ranging from the sixth grade of elementary school to the third year of high school. After transitioning from virtual to in-person lessons, he resumed teaching exclusively second and third year of high school.

Prior to the onset of the pandemic, Eduardo used various meta-resources from the *Geekie One*<sup>TM</sup> platform and websites, as well as a range of material resources including *notebooks, digitizing tables, projectors, blackboards, brushes, and televisions*. Additionally, mother-resources, such as *textbooks* and the *Xournal App* were used, as well as daughter-resources comprised of slides containing questions and .pdf versions of class slides, which included solutions to exercises. During the pandemic, he used *YouTube videos and textbooks* as mother-resources for planning, and the *Geekie One*<sup>TM</sup> educational platform meta-resource. During the classes also used *Geekie One*<sup>TM</sup> and *Google Meet*<sup>TM</sup> platforms, as well as the *digital tablet, camera, paper and pencil and Google Classroom*<sup>TM</sup> as material resources to post content and notifications. Upon resuming in-person lessons, the teacher maintained the resources used throughout the period of remote teaching. Additionally, the school gave students the option to participate in classes via *Google Meet*<sup>TM</sup>, thereby enabling remote attendance when deemed necessary.

While, during the pandemic, the teacher's strategies were more diversified, he reverted to the conventional teaching paradigm when in-person classes resumed. According to the teacher this is due to the fact that, although the school focuses on technological innovation, from a pedagogical standpoint the management of the institution prioritizes the traditional class model and strict compliance with the curriculum. Furthermore, in the words of Eduardo, there are scarce opportunities for collaborative work with peers within the same field.

## **Discussion**

In order to enable the identification of resources in the teacher's RS and their transformations, this study examined the conceptual frameworks for understanding resources

proposed by Trouche et al. (2017), as well as the concepts of meta-resources (Bellemain & Trouche, 2016; Prieur, 2016), mother-resources and daughter-resources (Hammound, 2012). The first aspect we emphasized is the fact that, as a result of the pandemic, all teachers involved in the research were required to transfer content and modify their in-person teaching, with insufficient training, or meager skills for using digital technologies. This was done to address the urgent demands of an emergency situation, which aligns with findings from studies such as Rondini et al. (2020).

The *textbook* as a mother-resource was stable in the RS of all participants. This phenomenon can be attributed to the longstanding usage of textbooks as a fundamental tool in the pedagogical practice of teachers. In numerous educational institutions across Brazil, textbooks often constitute the sole teaching resource available to teachers (Verceze & Silvino, 2008). Furthermore, throughout history, educators have consistently relied on this particular instrument, which, although is ideally intended to serve as a supplementary aid, ultimately assumes the role of a fundamental foundation for teachers in their practice (Soares, 2002, p. 2).

The *Internet* meta-resource was found to be available in the RS of just four of the eight teachers working in rural schools. Even in those cases, the internet connection was inadequate, hence impeding the complete implementation of the remote teaching model, as well as limiting accessibility to only a small subset of students who had internet connectivity. This finding supports the conclusions of Cardoso, Ferreira, and Barbosa (2020), who indicate that unequal socioeconomic conditions within the country result in a notable proportion of students facing obstacles in accessing the Internet and the necessary technologies for remote learning; particularly those in the public school system.

The curricular resource known as *RCA* was present in the RS of merely three of the participants. This finding suggests that the *RCA* is a consistent and enduring resource within the RS of such teachers, as it remained present across all pre-pandemic, pandemic, and post-pandemic stages. Nonetheless, it is not present in the RS of the majority of teachers. This is in line with studies as the one conducted by Boff (2022), who found disparities in understanding and implementation of the principles outlined in the National Common Core Curriculum (BNCC). According to Boff (2022), while some teachers possess a thorough understanding of the proposed guidelines and actively strive to incorporate them into their teaching practices, others exhibit a lack of familiarity with the normative principles, rendering the process of didactic transposition impractical.

The presence of the *concrete material* resource was observed in the RS of only two of the nine teachers, which is remarkable considering the recognized pedagogical advantages

associated with this type of resource. Concrete materials enable increased student engagement, facilitate the process of rediscovery, enhance the understanding of properties, and promote effective learning (Lorenzato, 2012). Moreover, it is worth noting that while these resources were omitted from teachers' RSs during the period of ERT, they were subsequently reintegrated into the RS, by the same teachers upon the resumption of in-person instruction.

During the ERT, the resources most prevalent in the teachers' RSs were cell phones and the messaging application WhatsApp™. One potential explanation for this phenomenon lies in multimodal and multisemiotic nature of the application, which encompasses various languages and resources (Souza & Nascimento, 2020). These characteristics have facilitated the creation of meaning within the school setting, even prior to the implementation of remote teaching. Furthermore, this phenomenon has extended beyond its microsocial network function to encompass a broader range of possibilities, thus being recognized as a pedagogical approach that improves the teaching-learning process (Silva, 2022). However, upon returning to in-person lessons, those two resources remained stable in the RS of only two teachers, even though they can be perceived as “a means of enhancing didactic experiences by fostering collaboration in both teaching and learning processes” (Souza & Nascimento, 2020, p. 90). The ongoing debate about the use of calculators in mathematics classrooms prompts a reflection regarding the potential integration of cellphones and their functions into the RS of teachers. This integration holds promise for using cellphones as pedagogical resources within the context of elementary education.

Our investigation revealed that the private school displayed a higher level of preparedness for the transition from conventional face-to-face to remote teaching. This advantage can be attributed to the presence of a pre-established digital infrastructure and a wealth of educational resources readily available. The study highlights the disparity in the impact of the pandemic on public and private schools, as well as in the RS of teachers. This finding is consistent with previous research conducted by Palú (2020), Fioreze et al. (2021), and Andrade et al. (2021).

The educational model adopted in rural schools cannot even be classified as remote teaching, as the majority of students did not have internet connectivity. This situation illustrates the unequal access to the Internet in peripheral urban and rural areas, which, as Couto et al. (2020) contend, further exacerbates existing social vulnerabilities. In rural settings, teachers relied mostly on textbooks and, where available, websites, to help in their lesson planning. The teachers themselves undertook the preparation and delivery of the activities to students' homes, despite facing highly challenging circumstances. The teachers did not incorporate any new

resources into their RSs, nor were they provided with instruments to address the challenges posed by the pandemic.

In contrast, during the transition to remote teaching, the private school teacher incorporated novel educational resources and preserved them upon resumption of in-person lessons. However, despite the commitment of the school to providing comprehensive resources to teachers, they still feel compelled by the institution to adhere to the conventional educational model in the planning and delivery of classes, whose sole objective is the completion of the syllabus in preparation for college admission exams.

Overall, our study revealed that in five instances the resource system of teachers was enriched, as the resources which were incorporated during the pandemic remained stable upon resumption of in-person teaching. This issue speaks to the need for additional research to examine the extent to which such materials were effectively integrated into the teaching strategies of such teachers.

We will conclude this section by highlighting a recurring topic that was emphasized by all teachers involved in the study: the lack of collaborative work among colleagues. The isolation experienced by teachers can be attributed to various causes, including building layout and geographical location of educational institutions, the schedule, a heavy workload, and the individuals' limited inclination and aptitude for collaborative activities.

According to the teachers, there are instances of coordination, such as meetings in the teachers' lounge, teacher conferences or collective pedagogical work time. However, such situations mostly serve the purpose of conducting administrative tasks. Within the framework of the documentational approach to didactics, engaging in talks and exchanging ideas with colleagues is a useful resource for teachers that should not be squandered. The potential for collaboration among teachers to enhance their cognitive processes, behaviors, and problem-solving abilities suggests that this resource could have provided significant opportunities for teachers to address the challenges posed by the pandemic.

### **Conclusion**

The Covid-19 pandemic prompted the implementation of emergency remote teaching (ERT) which subsequently resulted in novel relations between teachers and their teaching resources. This phenomenon prompted the following research question: what are the effects of the changes brought about by the pandemic on the RS of elementary school mathematics teachers? Therefore, the objective of the present study was to examine the effects of the Covid-19 pandemic on the RS of mathematics teachers in the Amazonian context. To address this

query, a case study was conducted with nine mathematics teachers who are currently or were previously employed in various schools located in both the outskirts and the capital of state of Amazonas, Brazil.

One notable aspect to emphasize is the continued significance of textbooks as the main teaching resource for mathematics teachers. This resource remained stable in the RS of all participants; particularly for teachers in rural regions, where it was oftentimes the only resource.

During the period of ERT, the primary resources in the RS of teachers, in addition to traditional textbooks, were mobile phones and the WhatsApp™ application. However, upon returning to in-person lessons, these two resources remained stable in the RS of only two teachers. Therefore, it is crucial to consider the manner through which these resources might be integrated into the RS of mathematics teachers in order to foster student learning.

Our research indicates that the private school demonstrated a higher level of preparedness in transitioning from conventional in-person to virtual teaching. Moreover, the educational approach adopted in rural schools can hardly be described as a remote teaching model due to the limited access to the Internet of the majority of students. Consequently, teachers had to devise alternative strategies, such as developing educational materials that could be delivered directly to students' residences. Nevertheless, circumstances were extremely unfavorable. In remote areas, teachers mainly used textbooks as their primary teaching resource, occasionally supplementing their lesson plans with *Internet* resources. Education Departments did not implement any measures to help teachers effectively address the issues presented by the pandemic.

While transitioning to online instruction, the teacher at the private school integrated novel educational resources, and subsequently maintained their use at the reinstatement of in-person lessons. However, despite having access to all the resources available at the school, the teacher must adhere to the conventional teaching approach, mainly in order to conform to the syllabus and adequately prepare students for their college admission exams.

The current study revealed that private school teachers experienced the impact of the pandemic, albeit to a lesser extent compared to their counterparts in public schools, particularly those located in remote areas. Moreover, in both scenarios, teachers faced the outbreak of the pandemic by working individually and in isolation, thus wasting the potential for collaborative effort.

Our findings indicate that after the resumption of in-person lessons, the RS of the majority of teachers improved, as the resources adopted during ERT were maintained.

Therefore, future research must examine whether such resources contributed to the improvement of the teaching and learning processes by adding value to their work.

Lastly, the present study highlighted the significant need for educational policies that provide internet access and digital resources to all schools, particularly those in rural and riverside areas. Those actions must be accompanied by teacher training so that such resources can be integrated into classroom practice. This paves the way for future research into the effects of such actions on the teaching-learning process.

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