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Remote teaching in High School in the East Zone of Manaus: analysis of the methodologies applied to Mathematics teaching in the 2020-2021 period

Abstract: In the face of the measures to combat and control the Covid-19 health emergency, education has been affected at all levels. This situation motivated the proposal of the research with the objective of analyzing the use of technologies in the teaching-study-learning of Mathematics, considering the context that occurred between 2020 and 2021. This is a documentary and bibliographical research, which analyzed the teaching plans of Mathematics teachers and the Political Pedagogical Projects of schools in the East Zone of Manaus. The results indicate that Mathematics teachers and students overcame the limitations of the educational system in implementing the emergency teaching plan, despite socioeconomic obstacles, contributing to the understanding of technological tools as a permanent part of Mathematics teaching.

Keywords: Schooling. Covid-19. Online Education. Active Methodologies.

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Article

Enseñanza remota en la Enseñanza Secundaria de la Zona Este de Manaos: análisis de las metodologías aplicadas a la enseñanza de las Matemáticas en el período 2020-2021

Resumen: Ante las medidas para combatir y controlar la emergencia sanitaria por Covid-19, la educación se vio afectada en los diferentes niveles educativos. Esta situación motivó la propuesta de investigación con el objetivo de analizar el uso de las tecnologías en la enseñanza-estudio-aprendizaje de las Matemáticas, considerando el contexto ocurrido entre 2020 y 2021. Se trata de una investigación documental y bibliográfica, que analizó los planes de enseñanza de los profesores de Matemáticas y los Proyectos Políticos Pedagógicos de las escuelas de la Zona Este de Manaus. Los resultados apuntan a la superación de las limitaciones del sistema educativo por parte de los docentes y estudiantes de Matemáticas en la implementación del plan de enseñanza de emergencia, incluso con obstáculos socioeconómicos, contribuyendo a la comprensión de las herramientas tecnológicas como parte permanente de la enseñanza de las Matemáticas.

Palabras clave: Escolarización. Covid-19. Educación en Línea. Metodologías Activas.

Ensino remoto no Ensino Médio na Zona Leste de Manaus: análise sobre as metodologias aplicadas ao ensino de Matemática no recorte 2020-2021

Resumo: Diante das medidas de combate e controle da emergência sanitária de Covid-19, a educação ficou prejudicada nos diferentes níveis de ensino. Tal situação motivou a proposição da pesquisa com o objetivo de analisar o uso das tecnologias no ensino-estudo-aprendizagem de Matemática, considerando-se o contexto ocorrido entre 2020 e 2021. Trata-se de uma pesquisa documental e bibliográfica, que analisou os planos de ensino dos professores de Matemática e os Projetos Políticos Pedagógicos das escolas da Zona Leste de Manaus. Os resultados apontam para superação das limitações do sistema educacional pelos professores de Matemática e estudantes na efetivação do plano emergencial de ensino, mesmo com empecilhos socioeconômicos, contribuindo para o entendimento das ferramentas tecnológicas como parte permanente no ensino de Matemática.

Palavras-chave: Escolarização. Covid-19. Educação Online. Metodologias Ativas.

1 Introduction

At the end of 2019, there was talk of an epidemic that began in China, through a virus that spread quickly and intensified as it caused respiratory system damage and could lead to death. Soon, what seemed to be a local occurrence was considered a health emergency by the World Health Organization (WHO) and, subsequently, many documents with guidelines on measures to combat the spread of the virus began to emerge, among which social isolation stood out.

In the search to ensure the collective good, measures such as this were part of the strategies adopted by many countries, following WHO guidelines and, as a consequence, the interruption of in-person classes was inevitable, with a special regime of non-in-person classes being implemented as a temporary solution to mitigate the effects of this shutdown.

Emergency Remote Education (ERE) ended up being outlined as a structured teaching model that divided opinions in general society, but which brought its contributions to formal education with the development and insertion of Information and Communication Technologies (ICT) in the school routine through numerous tools.

The problem of ERE appeared on several fronts, whether on the part of teachers in having experience with the tools that would be used, on the part of students in having the technological resources necessary for educational practice, or on the part of the educational system in making tools and training in the use of these tools available to the school body.

Within the Piagetian constructivist view and influenced by Costa's theory of didactic transposition (2024, p. 8), it is considered that

> according to this theory, the Mathematics taught by teachers is different from the Mathematics learned by students and is different from the Mathematics practiced by mathematicians and is composed of an experience, converted in a didactic way, meticulously worked on. This set of mechanisms capable of exchanging an object of knowledge for an object of teaching is called didactic transposition.

Thus, school documents were observed in order to present data resulting from the existing ERE due to the health emergency, aiming to contribute to clarifying its impacts on education and to make the appropriate criticisms.

But, was the school prepared for these changes? Was the school community able to keep up with contemporary technological developments? Or will we remain in the traditional expository class?

These questions do not reflect only a local reality, despite this investigation taking place in a specific region, but express the need experienced by the school on a planetary scale. Furthermore, this research was prepared with the objective of analyzing the use of Information and Communication Technologies (ICT) in the teaching-study-learning process of Mathematics content applied to high school classes, considering the context of the health emergency, which occurred between 2020 and 2021, with the eastern zone of Manaus as the locus.

To this end, it is essential to use the specific objectives: to qualitatively and quantitatively evaluate the use of ICT as part of the evolutionary process of the didactic procedures for teaching Mathematics adopted by teachers in state public schools belonging to the *Coordenadoria Distrital Leste* [East District Coordination], regarding the ERE model,

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taking the time frame between 2020 and 2021 as an indicator of adherence; identify the methodological tools available in such schools; evaluate the impact on learning resulting from students' adherence to the remote teaching model, taking into account the data recorded on the *Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira* [Anísio Teixeira National Institute for Educational Research and Studies — INEP] portal in parallel with the results of external evaluations; and characterize the difficulties and barriers that the socioeconomic situation of families imposed against the adoption of the remote teaching modality.

Therefore, the scope of this article has three sections. The first deals with the methodological design divided into the subsections of study area, bibliographic research, and documentary research. The second presents the data and the analysis of these data, also divided into subsections that deal with the relevance of the topic of remote teaching in published articles, the use of ICT as part of teaching procedures by Mathematics teachers, the use of ICT as a teaching tool available in schools, the impact on learning resulting from the migration from regular in-person teaching to remote teaching, and the characterization of socioeconomic barriers. Finally, the third part presents the final considerations, inviting reflection on the use of technology in daily school life after the pandemic.

2 Methodology

The research carried out is descriptive in nature, as characterized by Gil (2002): descriptive research is related to the survey of opinions and observation of the existence of an association between variables, aiming to determine, if there is one, the nature of this association.

As for the methodological approach of this research, it can be said that it is of a qualitative and quantitative nature, since, as stated by Costa and Costa (2017, p. 50), “first, we seek to understand a certain reality in order to later seek an explanation”, using descriptive statistics with qualitative and quantitative variables within a representative sample of the sample universe. Therefore, at first, it will be done through a documentary analysis followed by field research.

That said, for this study, it was decided to start with a bibliographical research, making an analysis of the accessible publications that deal with the same topic and, subsequently, a documentary research, targeting the school documents that present evidence of the methodologies used by Mathematics teachers.

2.1 Study area

The territorial scope of the field research is restricted to High Schools under the jurisdiction of the District Coordination 5 (CDE 5) of the Amazonas State Secretariat for Education (SEDUC/AM), which is located in the East Zone of Manaus, a region that emerged from migrations around the Manaus free trade zone and became the most populous in the capital, with precarious basic sanitation conditions. This problem was reflected in education in schools with little structure.

A Math teacher was selected from each of the participating schools to teach high school classes. The criteria for choosing the classes was based on those that had had the ERE since 2020.

The selection of schools and participants was random in the form of stratified sampling by clusters, which was divided around the neighborhoods covered by the coordination office.

The sample universe is the total number of existing High Schools and the sample size was defined based on the number of teachers working in the area of Mathematics. In other words, for the total number of schools linked to the coordination, those belonging to the same

neighborhoods were grouped together. For neighborhoods with more than one school, a draw was carried out on the website https://sorteio.com/sorteio-de-nomes. In order to maintain equality in the selection, in neighborhoods with only one school, the selection was automatically direct, maintaining the representativeness of the neighborhood.

2.2 Bibliographic research

This first part consists of a literature review, an exploratory research, according to Gil (2002), which has the function of making the problem more explicit and giving notoriety to the subject involved. As for the methodology of this research, the same author classifies it in the same way, as it uses searches in bibliographic databases that can be divided into three categories: books, periodicals and various printed materials.

Thus, the search included books of current reading that deal with the teaching of Mathematics and periodical publications of scientific journals, which were placed in relevance because they were publications that went through an editorial board and because they had issues published periodically within the period investigated, even though it was a period of health emergency.

The point of observation within the teaching of Mathematics was the theory of didactic situations by Guy Brousseau (2008), which, in turn, is based on the psychogenesis of Jean Piaget. For this topic, the most recommended type of source was the current reading books of scientific dissemination works.

To explore the scientific productions related to ERE, preference was given to scientific articles, because they are shorter scientific communications with discussions on the topic of ongoing research, or with results of completed research. Therefore, the research was carried out through the database of the journal portal of the *Coordenação de Aperfeiçoamento de Pessoal de Nível Superior* [Brazilian Federal Agency for Support and Evaluation of Graduate Education — CAPES], considering its validation before the scientific community.

During the research, the descriptors used were *Mathematics and Emergency Remote Education*. From the advanced search, each descriptor is used as it is written and in the following specific period: January 1, 2020 to March 29, 2023.

2.3 Documentary research

Documentary research differs from bibliographic research precisely because of the origin of the sources consulted. While bibliographic research is dedicated to analyzing popular works and research results, documentary research is concerned with investigating documents that have not yet been analyzed, such as files in public agencies (Gil, 2002).

In this stage, the official documents found in the schools' archives were analyzed, in addition to indicators such as approval, failure and school dropout rates, as well as results from national and regional assessments.

Thus, the materials consulted were: records in teachers' teaching plans (physical or electronic), found in virtual classrooms; physical files and cloud drives; schools' Political Pedagogical Projects, even those that were still under construction; and school data on the INEP website.

The means for accessing school materials was a request filed with the coordinator, with a letter sent to school principals, requesting a partnership in sharing the data.

The points of interest were the use of technological tools and the frequency of this use by Mathematics teachers, observed through records of the methodological procedures carried out by the teachers, as well as the tools used in the teaching plans, whether digital or printed,

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and the information contained in the schools' policy, its methodology, vision and socioeconomic characterization.

3 Presentation, analysis and interpretation of results

The analysis of the results was based on the exploratory research described by Gil (2002). Using descriptive statistics, records were collected based on the availability of search sources and participants in the field researched with quantitative and qualitative data, in order to describe the situation experienced by the community in the time frame of interest of this research.

3.1 Relevance of the topic in published articles

As a result of the bibliographic search, 35 articles were obtained, of which only 26 appeared as peer-reviewed; however, of the 26, five were duplicates, leaving 21 peer-reviewed articles. The articles were separated into two categories, one by level of education and the other by their approaches.

Thus, taking into account the selection criterion for the level of education to which each of the articles referred, the following subcategories were created, as shown in Table 1.

Table 1: selection criteria by level of education

Article title	Authors	Year	Journal name
Focus on Elementary, Middle and High School			
Ensino remoto emergencial: as experiências de uma escola pública e de uma escola particular em Campina Grande/PB *[Emergency remote teaching: the experiences of a public school and a private school in Campina Grande/PB]*	Almeida, Mendes and Araújo	2021	Revista Prâksis
Personalização de um sistema operacional Linux para projeto de doação de notebooks para alunos em situação de ensino remoto emergencial *[Customizing a Linux operating system for a notebook donation project for students in an emergency remote education situation]*	Costa and Teixeira	2022	Revista Brasileira de Ensino de Ciências e Matemática
They focus only on Elementary and Middle School			
Educação em tempos de pandemia: dificuldades e oportunidades para os professores de Ciências e Matemática da Educação Básica na rede pública do Rio Grande do Sul *[Education in times of pandemic: difficulties and opportunities for Science and Mathematics teachers in Basic Education in the public school system of Rio Grande do Sul]*	Flores and Lima	2021	Revista Insignare Scientia
Reflexões sobre os desafios para a aprendizagem matemática na Educação Básica durante a quarentena *[Reflections on the challenges of learning mathematics in Basic Education during quarantine]*	Santos and Sant'Anna	2020	Revista Baiana de Educação Matemática
O papel da família na aprendizagem	Santos, Silva,	2022	Diversitas Journal

matemática durante o ensino remoto: um relato de experiência na Residência Pedagógica *[The role of the family in learning mathematics during remote teaching: an experience report in the Pedagogical Residency]*	Barros, Fonseca and Silva		
O Ensino Remoto Emergencial e o ensino da Matemática: percepção dos estudantes e professores de Matemática durante a pandemia do novo coronavírus na cidade de Desterro-PB *[Emergency Remote Education and Mathematics teaching: perceptions of Mathematics students and teachers during the new coronavirus pandemic in the city of Desterro-PB]*	Gonçalves and Cunha	2021	EaD em Foco
Percepção de professores que ensinam Matemática sobre o ensino remoto emergencial e o processo de ensino-aprendizagem *[Perceptions of Mathematics teachers about emergency remote education and the teaching-learning process]*	Teixeira, Fraz, Ferreira and Moreira	2021	Debates em Educação
Uma investigação sobre percepções de professores que ensinam Matemática em relação às práticas avaliativas durante o ensino remoto emergencial *[An investigation into the perceptions of Mathematics teachers regarding assessment practices during emergency remote education]*	Caldato, Silva, Baccar and Moura	2022	Revista de Educação Matemática
They focus only on High School			
Sala de aula invertida e aprendizagem de temas financeiros-econômico *[Flipped classroom and learning of financial-economic topics]*	Oliveira and Kistermann	2021	Boletim Cearense de Educação e História da Matemática
Avaliação no ensino remoto de Matemática: analisando categorias de respostas *[Evaluation in remote education of Mathematics: analyzing categories of responses]*	Lima and Nasser	2020	Revista Baiana de Educação Matemática
O planejamento de aulas assentes no ensino exploratório de Matemática desenvolvidas no ensino remoto de emergência *[Planning lessons based on exploratory teaching of Mathematics developed in emergency remote education]*	Oliveira and Basniak	2021	Educação Matemática Debate
Ensino remoto e conhecimentos matemáticos: desafios e perspectivas na visão docente *[Remote teaching and mathematical knowledge: challenges and perspectives from the teaching perspective]*	Eguez, Silva and Veloso	2021	Boletim Cearense de Educação e História da Matemática
Incorporação das TDIC nas práticas pedagógicas de professores de Ciências e Matemática da Educação Profissional Técnica de Nível Médio *[Incorporation of ICT in the*	Machado, Ramos and Ortega	2022	Revista Insignare Scientia

pedagogical practices of Science and Mathematics teachers of Technical Professional Education in High School]			
They focus only on Higher Education			
Construto seres-humanos-com-mídias (SHCM) por pós-graduandos em Educação Matemática e Científica *[Human-beings-with-media (SHCM) construct by postgraduate students in Mathematics and Science Education]*	Santos, Maia and Solto	2022	Ciência & Educação
A disciplina de Tópicos de Educação Matemática I: afetos e desafetos *[The subject of Topics in Mathematics Education I: affections and disaffections]*	Baier, Godoy and Campos	2021	Revista BOEM
Concepções de professores multidisciplinares em formação inicial sobre a Matemática e seu ensino: algumas compreensões *[Conceptions of multidisciplinary teachers in initial training about Mathematics and its teaching: some understandings]*	Mitsuuchi, Agranionih, Costa and Zimer	2021	Educação Unisinos
Análise de perfil de futuros docentes de Matemática em face das implicações da pandemia *[Profile analysis of future Mathematics teachers in view of the implications of the pandemic]*	Lavor and Oliveira	2022	Educação Matemática Debate
Ensino remoto emergencial em Matemática e o milieu didático-virtual: uma reflexão teórico-propositiva em contexto institucional e adverso *[Emergency remote education in Mathematics and the virtual-didactic milieu: a theoretical-propositive reflection in an institutional and adverse contexto]*	Silva	2021	Amazônia
Ensino remoto emergencial: uma experiência no ensino de cálculo *[Emergency remote education: an experience in teaching calculus]*	Simonetti, Braga e Santos-Wagner	2022	Tangram
Ensino remoto emergencial: desafios e estratégias *[Emergency remote education: challenges and strategies]*	Barbosa, Paula e Santos	2022	Docência do Ensino Superior

Source: Prepared by the author based on data collected from the CAPES Periodicals Portal

Considering the criteria for selecting approaches in the texts, the following subcategories were separated, as shown in Table 2.

Table 2: Criteria for selecting approaches in the texts

Article title	Authors	Year	Journal name
Focus on teachers' views			
Educação em tempos de pandemia: dificuldades e oportunidades para os professores de Ciências e Matemática da Educação Básica na rede pública do Rio Grande do Sul *[Education in times of*	Flores and Lima	2021	Revista Insignare Scientia

pandemic: difficulties and opportunities for Science and Mathematics teachers in Basic Education in the public school system of Rio Grande do Sul]			
Percepção de professores que ensinam Matemática sobre o ensino remoto emergencial e o processo de ensino-aprendizagem *[Perceptions of Mathematics teachers about emergency remote education and the teaching-learning process]*	Teixeira, Fraz, Ferreira and Moreira	2021	Debates em Educação
Uma investigação sobre percepções de professores que ensinam Matemática em relação às práticas avaliativas durante o ensino remoto emergencial *[An investigation into the perceptions of Mathematics teachers regarding assessment practices during emergency remote education]*	Caldato, Silva, Baccar and Moura	2022	Revista de Educação Matemática
A disciplina de Tópicos de Educação Matemática I: afetos e desafetos *[The subject of Topics in Mathematics Education I: affections and disaffections]*	Baier, Godoy and Campos	2021	Revista BOEM
Concepções de professores multidisciplinares em formação inicial sobre a Matemática e seu ensino: algumas compreensões *[Conceptions of multidisciplinary teachers in initial training about Mathematics and its teaching: some understandings]*	Mitsuuchi, Agranionih, Costa and Zimer	2021	Educação Unisinos
Ensino remoto emergencial: desafios e estratégias *[Emergency remote education: challenges and strategies]*	Barbosa, Paula e Santos	2022	Docência do Ensino Superior
Ensino remoto e conhecimentos matemáticos: desafios e perspectivas na visão docente *[Remote teaching and mathematical knowledge: challenges and perspectives from the teaching perspective]*	Eguez, Silva and Veloso	2021	Boletim Cearense de Educação e História da Matemática
Focus on the views of teachers and students			
Reflexões sobre os desafios para a aprendizagem matemática na Educação Básica durante a quarentena *[Reflections on the challenges of learning mathematics in Basic Education during quarantine]*	Santos and Sant'Anna	2020	Revista Baiana de Educação Matemática
O Ensino Remoto Emergencial e o ensino da Matemática: percepção dos estudantes e professores de Matemática durante a pandemia do novo coronavírus na cidade de Desterro-PB *[Emergency Remote Education and Mathematics teaching: perceptions of Mathematics students and teachers during the new coronavirus pandemic in the city of Desterro-PB]*	Gonçalves and Cunha	2021	EaD em Foco

They focus on the profiles and visions of future teachers			
O papel da família na aprendizagem matemática durante o ensino remoto: um relato de experiência na Residência Pedagógica *[The role of the family in learning mathematics during remote teaching: an experience report in the Pedagogical Residency]*	Santos, Silva, Barros, Fonseca and Silva	2022	Diversitas Journal
Análise de perfil de futuros docentes de Matemática em face das implicações da pandemia *[Profile analysis of future Mathematics teachers in view of the implications of the pandemic]*	Lavor and Oliveira	2022	Educação Matemática Debate
Comment on pedagogical practices in teaching Mathematics			
Ensino remoto emergencial: as experiências de uma escola pública e de uma escola particular em Campina Grande/PB *[Emergency remote teaching: the experiences of a public school and a private school in Campina Grande/PB]*	Almeida, Mendes and Araújo	2021	Revista Prâksis
Personalização de um sistema operacional Linux para projeto de doação de notebooks para alunos em situação de ensino remoto emergencial *[Customizing a Linux operating system for a notebook donation project for students in an emergency remote education situation]*	Costa and Teixeira	2022	Revista Brasileira de Ensino de Ciências e Matemática
Construto seres-humanos-com-mídias (SHCM) por pós-graduandos em Educação Matemática e Científica *[Human-beings-with-media (SHCM) construct by postgraduate students in Mathematics and Science Education]*	Santos, Maia and Solto	2022	Ciência & Educação
Ensino remoto emergencial em Matemática e o milieu didático-virtual: uma reflexão teórico-propositiva em contexto institucional e adverso *[Emergency remote education in Mathematics and the virtual-didactic milieu: a theoretical-propositive reflection in an institutional and adverse contexto]*	Silva	2021	Amazônia
Ensino remoto emergencial: uma experiência no ensino de cálculo *[Emergency remote education: an experience in teaching calculus]*	Simonetti, Braga e Santos-Wagner	2022	Tangram
Sala de aula invertida e aprendizagem de temas financeiros-econômico *[Flipped classroom and learning of financial-economic topics]*	Oliveira and Kistermann	2021	Boletim Cearense de Educação e História da Matemática
Avaliação no ensino remoto de Matemática: analisando categorias de respostas *[Evaluation in remote education of Mathematics: analyzing categories of responses]*	Lima and Nasser	2020	Revista Baiana de Educação Matemática
O planejamento de aulas assentes no ensino	Oliveira and	2021	Educação

exploratório de Matemática desenvolvidas no ensino remoto de emergência *[Planning lessons based on exploratory teaching of Mathematics developed in emergency remote education]*	Basniak		Matemática Debate
Incorporação das TDIC nas práticas pedagógicas de professores de Ciências e Matemática da Educação Profissional Técnica de Nível Médio *[Incorporation of ICT in the pedagogical practices of Science and Mathematics teachers of Technical Professional Education in High School]*	Machado, Ramos and Ortega	2022	Revista Insignare Scientia

Source: Prepared by the author based on data collected from the CAPES Journal Portal

Table 3: Percentage of articles by category

Total articles	31	Percentage
Peer reviewed	21	67,74%
Level of Education		
Elementary and Middle School	3	9,68%
High School	9	29,03%
Higher Education	11	35,48%
Elementary, Middle and High School	8	25,81%
Approach		
Teachers' perspective	10	32,26%
Students' perspective	2	6,45%
Future teachers' perspective	4	12,90%
Pedagogical practice	15	48,39%

Source: Prepared by the author based on data collected from the CAPES Periodicals Portal

Thus, the number of articles retrieved shows that the secondary level had a reasonable relevance among the published topics. Observing Table 1, it can be seen that the percentages of published articles, regarding the levels of education, are around 30%, with the exception of articles related exclusively to Elementary and Middle School.

It is important to highlight the fact that it was possible to retrieve only five (5) articles that deal with remote teaching of Mathematics under health emergency conditions. This is due to the fact that the topic, although relevant, is current and deserves greater attention from the scientific community.

3.2 The use of ICT as part of teaching procedures by Mathematics teachers

Studies on the use of Information and Communication Technologies (ICT) in the context of education have been growing (Pires, 2020). This growth proved necessary to maintain regular teaching during the period of social isolation, when everyone was encouraged to seek more practical knowledge about these tools.

With the decree of social isolation by the government of the state of Amazonas, regular teaching used remote classes through the virtual learning environment (AVA) of SEDUC itself, or through open TV channels, as stated in ordinance 311 of March 20, 2020, which “establishes,

within the scope of the Amazonas state public education network, the special regime of non-face-to-face classes for Basic Education, as a preventive measure against the spread of Covid 19" (Amazonas, 2020).

This transformation in the approach of the educational system caused great difficulty for the school community in maintaining teaching and learning in the virtual environment. However, these difficulties, at some point, became possibilities for teachers to rethink and reinvent their practices, considering the new virtual-didactic milieu and the new didactic contract that was established within the scope of the ERE.

When analyzing the teaching plans of Mathematics teachers for the period 2020-2021, it is clear that there is difficulty in describing the methodological teaching procedures, and even the tool to be used to execute said procedure is missing. This is because of the total of 23 (twenty-three) teaching plans analyzed, it is noted that 49% of the activities declared in the plans do not identify the tools used, as can be seen in Table 4.

Table 4: Activities regarding the declaration of ICT use

Teachers	Without identification of ICT use	With identification of ICT use
A	4	1
B	14	1
C	6	24
D	0	18
E	3	0
F	15	10
G	21	19
H	13	10
I	4	1
Activities in absolute values	80	84
Percentage values	49%	51%

Source: Prepared by the author based on data collected from teaching plans

It is clear that the use of ICT is not identified in almost half of the activities declared in the teaching plans, even though it is understood that these activities took place in a remote virtual environment, either synchronous or asynchronous. This is perhaps due to a failure in initial training or a lack of guidance from the teaching staff in the construction of a clear and concise teaching plan.

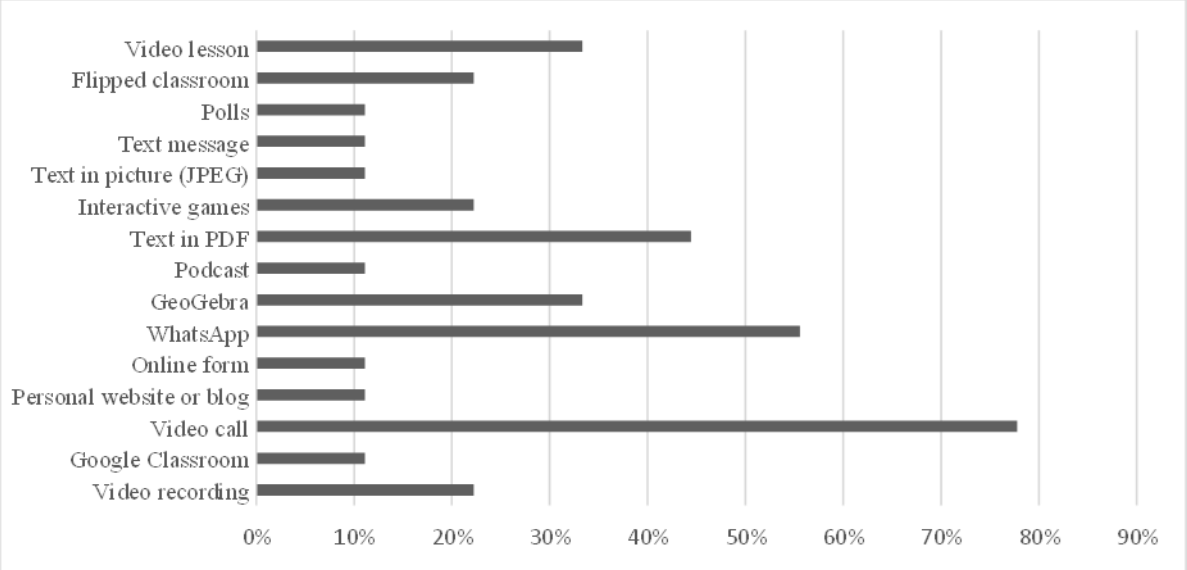
There are cases in which the teacher indicated one or no activity carried out through ICT, on the other hand, there are those who identified all the activities as using ICT.

It is also important to emphasize that the model used by schools to prepare teaching plans does not include the discrimination of the tool. This information is implicit in the field for describing the methodological procedure, and it is up to the teaching staff to guide the teachers on the accurate completion of the school documents, that is, whether or not to include the information that covers their practices, and it is up to the coordinator/secretary to regulate the standardization of these documents.

Regarding the tools used, we highlight in Graph 1 the variety of devices considered by

teachers in their teaching plans. This shows the concern of these professionals in achieving didactic transposition through diverse means.

Graph 1: Tools used by Mathematics teachers in the 2020-2021 time frame



Source: Prepared by the author based on data collected in teaching plans

From the graph, it is clear that the most used tools during this period of emergency education were videoconferencing and WhatsApp social networks, since they were the most accessible resources at the time, both for teachers and students.

Videoconferencing was the tool used for synchronous meetings almost unanimously, but it is believed that it is only not described as unanimous due to the lack of clarity in the information contained in the teaching plan.

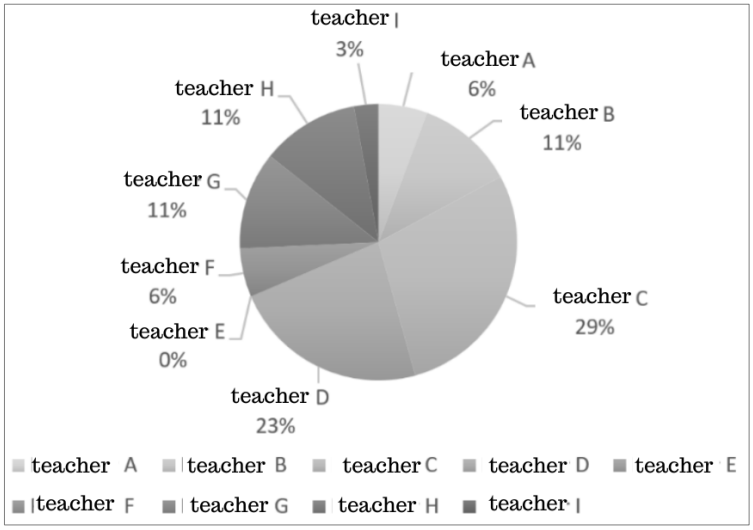
WhatsApp, which divided opinions regarding the exposure of teachers' privacy in relation to students, is the instant messaging tool that made asynchronous meetings possible. Like videoconferencing, the application was used almost unanimously, however, the importance of this record in planning was not observed and, for this reason, it appears as if it had been used by only 56% of the participants.

In third place were PDF texts, used by almost 50% of Mathematics teachers. These texts mostly represent lists of exercises and problem situations, as well as supplementary texts, support texts, tests and assessments.

GeoGebra — a platform composed of "various applications that seek to assist in solving function optimization problems" (Lickefett, Siple and Figueiredo, 2020, p. 1) — was used by a third of teachers to streamline graphic representations in remote classes and its use was widespread, both in expository and experimental practice classes. The use of diverse tools for students to achieve learning represents the numerous and diverse attempts by teachers to carry out a didactic transposition that meets school demands, especially with the advent of the health emergency. However, other demands also needed to be met. Graph 2 shows how some teachers used a variety of tools, while others not so much.

The diagram shows that, of the total number of technological devices available in the teaching plans, teacher C declared 29%, while teacher E did not use any ICT or did not describe it in his methodological procedure. The fact is that two of the teachers, teacher C and teacher D, are responsible for using more than 50% of the tools presented.

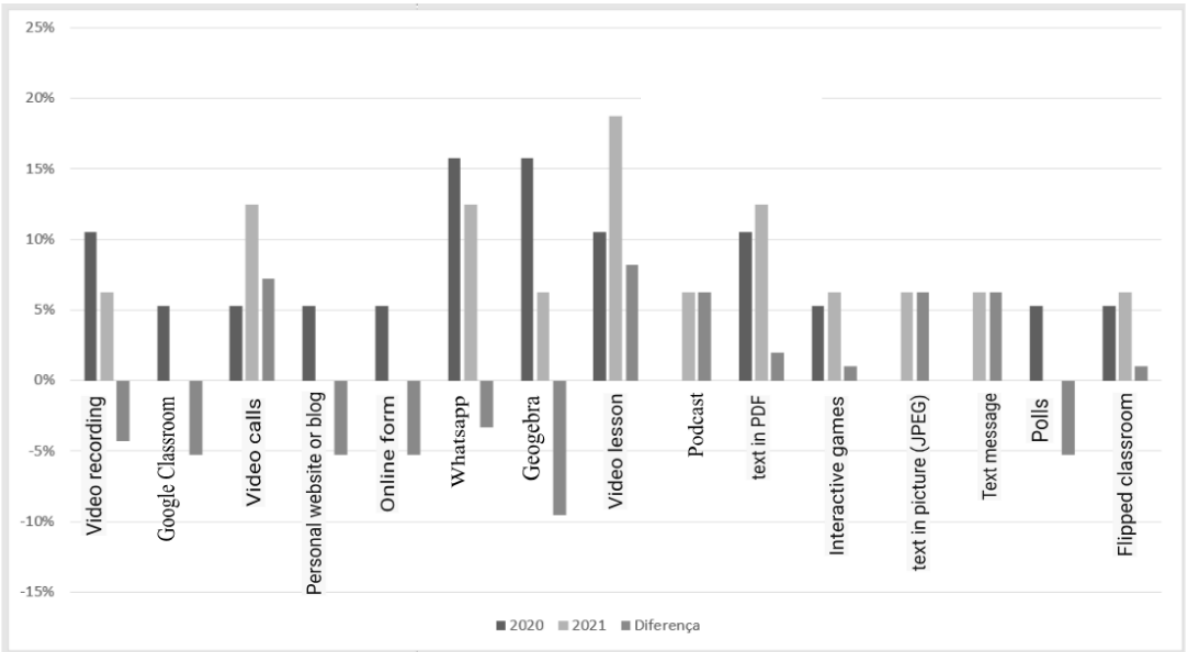
Graph 2: Variation of tools per teacher



Source: Prepared by the author based on data collected in teaching plans

This indicates that some of the teachers did not feel prepared, did not know or did not have mastery over the tools available for the elucidation of mathematical knowledge objects in the context of ERE. However, there is nothing to prevent these difficulties from having been diluted over time and with experience in this teaching model. Graph 3 shows the percentage of use of the tools in 2020 and 2021.

Gráfico 3: Evolução no uso das TIC



Source: Prepared by the author based on data collected in teaching plans

The evaluation of the evolution of the use of ICT as teaching resources was made based on the difference in use between the two years considered in the study.

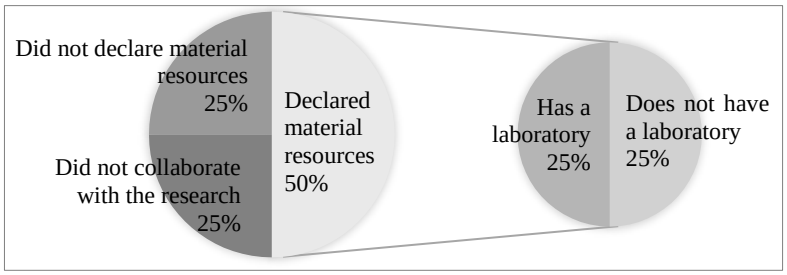
When comparing the years 2020 and 2021, one can see a behavior of adaptation of practices. It is observed that tools such as Google Classroom, personal website or blog, online forms and surveys were abandoned, while podcasts, text in pictures (JPEG) and text messages formed the new strategies applied from 2021 onwards. On the other hand, the methodological strategies of video calls, video classes, text in PDF, interactive games and flipped classrooms saw their use increase. This behavior is explained by the engagement of students in activities

that make use of these ICTs. This behavior provides evidence that methodologies such as these came to add to regular education, even with the return to in-person teaching. After all, the health emergency brought many difficulties to education, but the school community transformed these difficulties into possibilities.

3.3 The use of ICT as a teaching tool available in schools

The source of research that supported this analysis was the information provided in the Political Pedagogical Project (PPP) of the schools participating in the research. However, it should be noted that 25% of the schools requested did not make the PPP available for analysis, claiming that it was in the process of approval; the others made it available even though it was outdated or in the process of being updated and approved. Furthermore, of the remaining 75% of PPPs, 25% did not mention the material resources linked to ICTs, and of the 50% that did provide this information, 25% stated that they had a computer lab. These values are shown in Chart 4.

Chart 4: Percentage of tools available in schools



Source: Prepared by the authors based on data collected in teaching plans

Table 5 presents the ICT assets included in the PPPs of the schools that made them available for this study.

Table 5: ICT assets in schools[1]

Schools	A	B	C	D	E	F	G	H	Averages	Sample standard deviation
Computer	8	9	13	0	15	0	0	0	5,63	6,39
Printers	1	2	2	0	2	0	0	0	0,88	0,99
Television	0	1	2	0		0	0	0	0,43	0,79
Digital projector	0	8	3	0		0	0	0	1,57	3,05
DVD player	0	1		0		0	0	0	0,17	0,41
Amplified speaker	0	3	1	0	5	0	0	0	1,13	1,89
Notebook	0	0	1	0		0	0	0	0,14	0,38
Digital whiteboard	0	0	0	0	1	0	0	0	0,13	0,35

Source: Prepared by the author based on data collected in teaching plans

Based on the data in Table 5, it is possible to estimate an average of 5.63 computers per school and, at most, two printers. Another piece of technological equipment that appears more frequently is the multimedia projector.

A curious fact is that only one school stated that it had a digital whiteboard. However,

[1] The value 0 was assigned to unidentified data in the school's PPP for calculation purposes.

this is a technology that should be used more in schools, as it opens up many possibilities in Mathematics classes by facilitating interaction with the object of knowledge and, thus, arousing curiosity in students. Therefore, the digital whiteboard can be very well explored in the use of GeoGebra — a tool that was used as part of the methodological procedures in the teaching plans studied.

Schools E and F stated in the PPP that they have computer labs, however, School F did not inform the number of computers it has. Furthermore, it is important to emphasize that the possibilities of interaction with ICT are increased in the context of Basic Education, with the existence of computer labs.

It is known, therefore, that a computer system is not made up of hardware alone, but also of software, which are programs, that is, the logical part of the computer that is not covered by the PPP, as well as peopleware, which is represented by qualified operators. Another important piece of information that is not covered by the PPP is that some teachers have used GeoGebra software in their practices, but it is not known what mastery these teachers have with this and other digital tools.

3.4 The impact on learning resulting from the migration from regular in-person to remote teaching

Every change requires a period of adaptation, and the ERE was no different. Teachers had to adapt to new forms of learning, students had to develop new ways of acquiring knowledge, school teaching staff had to meet new demands, and educational systems had to adapt their ways of managing the education network. Thus, the health emergency caused a change in the entire educational ecosystem.

With all this movement to ensure public education offered by the state, those most in need ended up suffering the greatest impacts, as they lack technological resources. Thus, to minimize dropout rates, schools worked with action plans. Data on this impacted aspect were compiled in Tables 6 and 7. They include the approval, failure, and school dropout rates.

Table 6: School performance index for the year 2020

Schools	Approval	Failure	Evasion
School A	99,9%	0%	0,1%
School B	99,7%	0,3%	0%
School C	99,1%	0%	0,9%
School D	98,9%	0,1%	1,0%
School E	100,0%	0,0%	0,0%
School F	100,0%	0,0%	0,0%
School G	99,9%	0,1%	0,0%
School H	99,8%	0,1%	0,1%
School I	99,9%	0,0%	0,1%
School J	100,0%	0,0%	0,0%
School K	100,0%	0,0%	0,0%
School L	100,0%	0,0%	0,0%
School M	96,8%	3,2%	0,0%
School N	100,0%	0,0%	0,0%

School O	97,2%	0,0%	2,8%
School P	99,8%	0,0%	0,2%
School Q	—	—	—
School R	100,0%	0,0%	0,0%
School S	100,0%	0,0%	0,0%
School T	100,0%	0,0%	0,0%
School U	100,0%	0,0%	0,0%
Averages	99,6%	0,2%	0,3%

Source: Prepared by the author based on data collected on the INEP portal[2]

Such high approval rates do not mean that all the knowledge objects inherent to a series/class were appropriated by 99.6% of students. On the contrary, they represent an effort on the part of teachers and teaching staff to minimize the harm caused by the health emergency and/or social isolation.

Table 7: Academic performance index for the year 2021

Schools	Approval	Failure	Evasion
School A	94%	6%	0%
School B	99,7%	0,3%	0%
School C	80,6%	0,2%	19,2%
School D	96,3%	0,2%	3,5%
School E	89,7%	1,6%	8,7%
School F	88,9%	1,0%	11,0%
School G	99,9%	0,1%	0,0%
School H	81,7%	13,0%	5,3%
School I	99,8%	0,0%	0,2%
School J	80,6%	7,9%	11,5%
School K	78,3%	2,9%	18,8%
School L	99,7%	0,2%	0,1%
School M	82,6%	0,2%	17,2%
School N	99,9%	0,0%	0,1%
School O	74,6%	0,8%	24,6%
School P	92,1%	0,0%	7,9%
School Q	94,0%	0,0%	6,0%
School R	80,1%	19,9%	0,0%
School S	100,0%	0,0%	0,0%
School T	100,0%	0,0%	0,0%

[2] https://www.gov.br/inep/pt-br/acesso-a-informacao/dados-abertos/indicadores-educacionais

School U	100,0%	0,0%	0,0%
Averages	91,1%	2,6%	6,4%

Source: Prepared by the author based on data collected on the INEP portal[3]

Comparing Table 6 with Table 7, we can see a gradual increase in failure rates and an even greater increase in school dropout rates. This increase concerns students who were not found through active searches. It is worth noting that those who drop out of remote classes are precisely low-income students, who do not have internet access at home, smartphones or computers, and who do not have a good family structure that would provide them with a study routine at home or, at least, an incentive.

These impacts are observable in the short term, but in the long term, teachers will continue to fill the gaps in unlearned knowledge. As seen in the DFO theory, mathematical knowledge is sometimes tools, sometimes objects; a student who has not yet understood a given mathematical knowledge as an object will not conceive of it as a tool.

Therefore, this process of recovering knowledge not acquired by students will occur slowly and will require the attention of everyone in the school community and, mainly, the creation of public policies for the restoration of marginalized populations.

3.5 Characterization of socioeconomic barriers

For the context of the ERE, it is worth noting that the use of some technological devices was necessary; however, it is essential to consider the socioeconomic situation of the students' families, their income brackets, and housing conditions. This is because many of their guardians are self-employed professionals who were unable to work to support their families due to social isolation, a condition taken as a measure to contain the virus, which led to the condition of remote education.

It is important to mention that the scope of this research was in schools in the East zone of Manaus whose PPPs of E.E. Profa. Cecília Ferreira da Silva (2022), E.E. Gilberto Mestrinho (2022), E.E. Maria Madalena Santana de Lima (2022), E.E. Padre Luis Ruas (2023), and E.E. Prof. Rofran Belchior da Silva (2022) describes a peripheral region of the city, with many families in precarious situations, living off informal work, in some cases in risk areas and/or dominated by organized crime, as reported by the PPP of E.E. Gilberto Mestrinho (2022, p. 12):

> However, there are still some negative influences such as drug and alcohol sales points, prostitution, violence and others. There are cases of students identified as drug addicts, users of marijuana, cocaine and other types of drugs, these in most cases do not have parental supervision.

The PPP of E.E Prof. Rofran Belchior da Silva (2022, p.11) also contains this same information:

> Regarding the community, it is made up of small-scale traders and, despite the school being located in a risk area due to the presence of crime, the students still feel protected [...] Regarding housing, a diversity of situations can be seen, as in society in general, from modest but comfortable constructions, to wooden houses, with a predominance, however, of regular standard housing, the majority live in their own homes, others in rental and shared housing

[3] https://www.gov.br/inep/pt-br/acesso-a-informacao/dados-abertos/indicadores-educacionais

systems.

In addition to these problems, there are many other barriers that hinder students' learning, such as the relationship between family and school, the monitoring of parents or guardians and the guarantee of meeting basic needs, as reported by the PPP of E.E Padre Luis Ruas (2023, p.16):

> There are a significant number of mothers who need to work outside the home to help with the family budget; unemployed night school students and, on the other hand, a considerable number of dysfunctional families, separated and absent parents, thus affecting the family-school relationship, resulting in problems of aggression, absences, indiscipline and lack of supervision by guardians in school activities..

It is known that the family in any of its configurations is fundamental for the healthy development of the student, especially during periods of social isolation, since, according to the PPP of the E. E. Cecília Ferreira da Silva (2022, p.13), there are "clear cases that one of the supplements to the income of this community is the considerable number of families that are served by social programs reported in the enrollment forms".

A considerable variation in this analysis is regarding the education level of parents and guardians, since according to information extracted from the PPP of the E. E. Maria Madalena Santana de Lima (2022, p. 27), the "level of education of parents varies between incomplete elementary school and incomplete high school, but students report that they are held accountable by their parents regarding their formal education".

All of these social conditions directly influence the acquisition of the most basic abilities and abilities of school-age human beings, since they leave for school and, even immersed in another cultural environment, remain trapped by family difficulties. But considering an education system like ERE, all these conditions are even more aggravated.

4 Final considerations

Regarding school education, Cruz (2015) states that there is no single model or form of education and that it does not take place only at school, or perhaps it is not even the best place for it, because "school education is not its only practice, and the teacher is not its only practitioner. Education takes place in many other non-school spaces, in life and at work" (Cruz, 2015, p. 11).

Such statements lead us to believe that distance learning is also a way of teaching, and that ICT-mediated learning is a way to protect students, teachers and other education professionals from the risk of infection. As a result, it was necessary to reorganize the content scheduled for 2020, also due to the suspension of school activities (Amazonas, 2020).

Considering the context imposed by the health emergency, it was up to the teacher to learn how to use new tools and explore the means to achieve an effective teaching and learning process, combining theory and practice in the classroom or in virtual environments, always taking into account the aim of promoting meaningful learning and bringing students closer together through technology.

On the other hand, we can consider that, in this context, the difficulties in accessing the internet, the level of education of students' parents and guardians, and the lack of technological resources in low-income families made the learning process more difficult, in agreement with Pimenta et al. (2020) who place these variables as an influential part of the knowledge acquisition process.

Furthermore, with all the difficulties that have arisen during the health emergency, both with the ERE and the rotation system, and with the return to in-person teaching, there is a tendency for educational systems to increasingly make use of ICTs. This tendency is already a reality in the post-pandemic period, which invites us to delve deeper into future studies on the use of these tools and the development of others to meet the demands of the student community.

As for the teaching of Mathematics, this trend prevails, and the use of simulation software has become an ally for teachers in developing their classes. Games, whether analog or digital, are also on this list of tools, as they generate interactions and engagement in the class, including those students who do not have much aptitude for mathematical knowledge.

In this way, we can expand this reflection to planetary issues, since the teaching methods of Mathematics teachers have been renewed, the methods and techniques have evolved, and the approaches have diversified in search of meaningful learning of mathematical knowledge, guaranteeing the social role of the school, and scientific and technological evolution.

Therefore, the result of this research is an invitation for Mathematics teachers to rethink their practices and open up to a redefinition through ICT as a cultural, didactic, and virtual tool in a post-pandemic future, but with this new didactic-virtual legacy pointing out the challenges, difficulties, and barriers encountered by these teachers from their training to the reality shock in the practice of the new school routine. On the other hand, it is dedicated to listing the potential and success stories arising from innovative practices and the dedication of teachers, students, and teaching staff to overcome the geographical, political, cultural, and social barriers that have worsened with the advent of the health emergency in this region of social vulnerability. It is also a criticism of the current school system that insists on traditional teaching techniques and an awakening for us education scientists to further studies on virtual teaching even in face-to-face classrooms.

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