



AN EXAMINATION ABOUT THE DIDACTIC TRANSPOSITION IN THE POST-REMOTE TEACHING SCENARIO: OBSTACLES AND POSSIBILITIES

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Abstract:

The aim of this work is to present the vision of the mathematics teacher about Didactic Transposition in the discipline of mathematics, pointing out their perceptions and various ways of working in two moments, one in the remote modality and another in the return to classroom teaching. To this end, we used a qualitative-qualitative methodology, in which fifteen mathematics teachers from the city of Sobral, Ceará, Brazil participated in the research, sharing their experiences through two virtual forms, answering some questions in two different periods – August/2021 and July/2022. The data provided us with information to reflect on the subject, verifying the main obstacles faced during and after the period of social isolation, as well as the good practices experienced and prospects for a post-pandemic scenario. Based on the answers and experiences shared by the research subjects, we understand that there were advantages in carrying out the Didactic Transposition of contents in the remote scenario, such as the possibility of using more than one technological resource during a teaching session, the dynamism that the use of different games and applications can provide, among other possibilities. However, negative aspects were also pointed out, such as difficulties in obtaining positive feedback, student participation and motivation, difficulties in handling technology in some cases or even reconciling work routine and activities in the home environment, negatively

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impacting teaching work. In addition, there is a perspective that face-to-face feedback brings the imperative of change, both in the format of classes and teaching methodologies, and in the professional attitude of the mathematics teacher.

Keywords: mathematics teaching; didactics of mathematics; emergency remote teaching; post-pandemic

1. Introduction

The impacts generated in the educational scenario arising from the New Coronavirus pandemic demanded new work formats, which were opposed to the model of the traditional expository class. Thus, based on the experiences of teachers in their practice during remote teaching, we reflect on the need for changes in posture in front of the classroom both during and after the period of social isolation, the role of technology being undeniable for the evolution of the student learning and optimization of pedagogical time along this path.

In this sense, the Didactic Transposition (Chevallard, 1991) in relation to the subject of Mathematics has been the subject of discussions in research and a concern of teachers, who faced difficulties in teaching this subject in the remote modality, as well as experiencing severe consequences perceived in the face-to-face return, such as learning gaps, students' emotional problems, excessive use of digital technologies, among other peculiarities.

In view of the remote teaching scenario, other difficulties arose in the teaching of mathematics, but also opportunities to diversify teaching work. In the case of this work, we seek to carry it out in two stages: the first bringing the perspectives of the mathematics teacher during emergency remote teaching and, the second, dealing with the good practices that remained and the new difficulties encountered.

At the present time, the responsibility for the curricular replacement and student learning is directed to the school, which, as a social institution of education and promoter of knowledge, is expected to offer quality education and some form of pedagogical support to students and teachers (Campos et al., 2020) in the scenario of returning to face-to-face teaching.

Therefore, the objective of this work is to bring the mathematics teacher's vision regarding the Didactic Transposition of contents, pointing out their expectations, anxieties, and different ways of working in the remote modality, as well as the varied possibilities that can be explored in the period after social isolation. We list some difficulties, advantages, and reflections of the participating teachers, based on their speeches, seeking to see other ways of working and enriching classroom practices.

The methodology of this work is a qualitative-quantitative study, based on Knetchel (2014), carried out with a group of 15 (fifteen) mathematics teachers working in the classroom. At first, we conducted a qualitative step to understand our object of study,

followed by the tabulation of statistical data, in which we performed a subjective analysis, based on the interpretation of the subjects' perceptions, beliefs and attitudes.

Based on the above, in the following sections, we present the theoretical framework that structures this work, its methodology and data collection, as well as the results, their discussion and the authors' considerations.

2. Literature Review

The Didactic Transposition, introduced by the French scholar Yves Chevallard (1991), provides a transformation from scientific knowledge to the knowledge to be taught, enabling a mediation between this knowledge to facilitate student understanding. The different ways in which these transformations can occur provide the teacher with a range of methodological alternatives. The author presents the following definition for Didactic Transposition:

“A knowledge content that has been defined as knowing how to teach, undergoes, from then on, a set of adaptive transformations that will make it able to occupy a place among the teaching objects. The ‘work’ that makes an object of knowledge to be taught, an object of teaching, is called didactic transposition.” (Chevallard, 1991, p. 39).

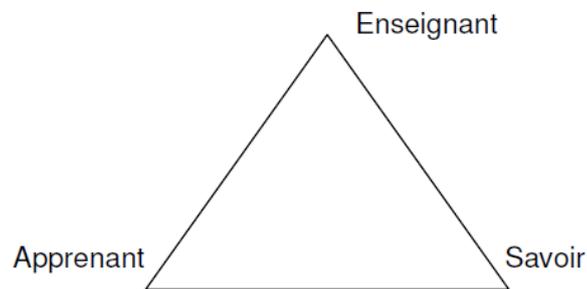
Thus, according to Chevallard (1991), there is a distinction between what is developed in purely scientific spaces and what is developed in educational environments. Thus, for the teaching of certain mathematical content to be possible, knowledge will undergo changes that allow it to be taught.

Colomb (1986) explains that there are restrictions that establish teachable (and taught) knowledge, these being the desyncretization of knowledge, depersonalization of knowledge, programmability of knowledge acquisition, publicity of knowledge and social control of learning. This list of constraints, which very clearly refers to a model of the type of transmissive knowledge, deserves a broad debate. In this case, the main idea is that, for the development of teaching practice, priorities are established in the dissemination or propagation of educational procedures.

Starting from this premise, we understand that the fundamental notion is the existence of an essential need to adapt knowledge to the various issues related to the school situation: the time and space available to the size of the group of students, their levels, to their projects, its relationship with knowledge, the didactic contract in force, the pedagogical relationship, as well as the assessment requirements (Chevallard, 1985).

However, Didactic Transposition actually occurs in the relationship between different elements that make up the didactic relationship: the teacher, the student and knowledge, whose interests are questioned and which, therefore, must be in constant stability. This ternary relationship is called the didactic system and will compose the fundamental diagram of Chevallard's Didactic Transposition process (1991, p. 23):

Figure 1: The Didactic System, according to Chevallard



In this way, Figure 1 presents, in addition the elements that make up the didactic system – teacher (*enseignant*), student (*apprenant*) and knowledge (*savoir*) – and the interactions that exist between them. Thus, there is no hierarchy, position of power or distinction, but a relationship in which each element of the system has a unique function and relevance. Therefore, the set of didactic systems will constitute the teaching system, which presents an association of structural devices that allow didactic functioning.

The education system brings the binomial relationships between student-knowledge, teacher-knowledge and teacher-student according to Chevallard (1985; 1991), that comprise elements such as conceptions and obstacles, as well as the strategies of knowledge appropriation (student-knowledge relationship), the didactic transposition itself and the elaboration of content (teacher-knowledge relationship) and the didactic contract, that according to Brousseau (2008) consists of a pre-established system, with reciprocal obligations so that the functioning of a didactic situation occurs efficiently (teacher-student relationship).

However, from what Chevallard (1985; 1991) points out about Didactic Transposition, as well as what Brousseau (2008) brings about the didactic contract, we realize that both have suffered complications with regard to the teaching of Mathematics in the remote modality, with consequences that extend to the face-to-face return. Such difficulties are inherent to the teacher's epistemology (Arsac, 1991), with regard to the complexity in the process of building a learning environment or situation (Alves, 2021) considering remote teaching sessions.

As Cidrão, Azevedo and Alves (2021, p. 253) point out, “*the absence of the classroom implies a greater weight of the explicit rules of the contract, which are strongly manifested in the teaching materials, in the exposition of objectives, in the weights given to the assessments, assignments, etc.*”. That is, there are difficulties in the Didactic Transposition by the teacher, which can culminate in ruptures in the didactic contract established between the teacher and students, making the teaching, and learning process unfeasible, and generating gaps in the students' evolution.

On the one hand, the lack of teacher training to deal with so much information, and on the other hand, the urgency of absorbing such information and successfully

putting it into practice (Santos, 2019; Souza et al., 2021). About this training, Perrenoud (1998) brings the importance of knowledge, especially in the practical field:

Hence the importance of recognizing the existence and diversity of knowledge linked to a form of professional specialization or, more generally, to the practical domain. This specialized knowledge exists and is at work in most social practices, whether or not it has a foundation in academic knowledge, whether or not those foundations are known to practitioners. (Perrenoud, 1998, p. 497).

Training courses for remote work emerged as new resources appeared, that is, in general terms, the teacher had to learn during practice about new ways of teaching their classes. And, in particular, in the field of Mathematics, there is a tendency toward traditionalism and difficulties in the very transposition of knowledge with dynamic mechanisms. According to Borba and Penteadó (2003, p. 56), many teachers admit the fact that their praxis has not sufficiently favored student learning, expressing dissatisfaction and *“some teachers try to walk in a comfort zone, where almost everything is known, predictable and controllable”*.

Thus, we reinforce the discussion about one of the great challenges for teachers in remote teaching, which is the difficulty in obtaining feedback on student learning, that is, in being able to establish a situation of devolution, which according to Brousseau (1998) is:

“the student accepts the problem as his own and the moment he produces his answer, the teacher refuses to intervene as the one who proposes the knowledge he intends to bring out. The student knows perfectly well that the problem was chosen to lead him to acquire new knowledge, but he must also know that this knowledge is absolutely justified by the internal logic of the situation and that he can build it without resorting to didactic reasons.” (Brousseau, 1998, p. 59).

In this way, devolution, according to Brousseau (1998) is configured in a behavior on the part of the teacher to make the student aware of his/her role and responsibility towards him/her during his/her journey in the course of an didactic situation. In a general panorama, the mathematics teacher faced difficulties to obtain feedback from students in their discipline in the remote modality, as well as identifying their main difficulties in relation to learning.

Faced with the mishaps of this teaching model, specifically in relation to this discipline, Lima and Moura (2015) and Martínez (2021) emphasize that Mathematics is the discipline that took the longest to routinely insert technological resources into teaching practice, even adopting teaching mechanisms and the relationship between mechanical and decontextualized procedures, which has possibly reverberated in the current scenario. In this sense, Lima, and Moura (2015) emphasize that:

“In the continuing education of teachers in Brazilian schools, both public and private, little has been developed in relation to new skills, especially those necessary for the intentional use of digital technologies, which directly reflects on the continuity of outdated pedagogical practices, many of which, for in turn, reflect a graduation that is incompatible with the current scenario of classrooms.” (Lima & Moura, 2015, p. 128).

According to Sousa et al. (2021) teachers are used to interacting and establishing relationships with students in person. This model of interaction is part of the molds of its formation, which somehow shows that *“the description of an individual’s state of knowledge cannot be made without reference to an institution: it is through an institution that the subject comes into contact with the knowledge”* (Arsac, 1991, p. 42). However, as a way of minimizing the obstacles imposed by physical distancing and the damage to the development of students, teachers necessarily adopted several technological tools, with the intention of maintaining interactivity, welcoming, and promoting student autonomy when learning. Martinez (2021) and Vega et al. (2015) mention that technology, as a tool to explore and visualize content, needs to encourage the student to establish connections/relationships between the various mathematical objects, appropriating their general characteristics, particularities and manipulating them for the apprehension of knowledge. This reveals the importance of making the content approach clearer for a better understanding of the student.

Among the mishaps and opportunities for teaching Mathematics in remote reality, we have to consider the teacher in its entirety, with their experiences, challenges, anxieties, and a new learning and the sudden drastic change in routine, which brought this professional to a new context, with profound (and imperative) transformations in its practical field. Chevallard et al. (1997) point out the fact that educational institutions sometimes demand a disorderly role from teachers and an excess of responsibility for the functioning (or not) of the didactic process and the consequent student learning:

“The teacher was led to believe that he is the fundamental part of the educational system and that the functioning of the system and the success of any educational reform depend on his will and his training. It is responsible for making the student have a positive attitude and the necessary motivation to learn mathematics, while these (attitude and motivation) are considered the basic conditions of all learning. In summary, it is accepted that the student’s learning result essentially depends on the instruction given by the teacher.” (Chevallard et al., 1997, p. 80).

This still occurs today, even if subtly, in the most diverse Brazilian cultural contexts. This was a posture that was largely reinforced in the period of remote teaching, which brought emotional overload to the teacher and the fact that he questioned himself about his own professional competence. It should be noted that there is an expedient employed by researchers such as Pastré et al. (2009), which shows that the manifestation of professional competence is revealed through the expression of skills, not always

explained by certain scientific knowledge of reference. However, as Alves (2022) adds, teaching skills are associated with various situational and/or pragmatic knowledge that can be caused by non-trivial and unforeseen situations or problems. In the meantime, we understand as one of these non-trivial problems the case of remote teaching, as well as the entire learning path and adaptation of this teacher to a new format of execution of his *métier* and a new change in the locus of work to carry out the transposition didactic. To this end, we seek to bring the view of Mathematics teachers about their experience in the remote period, as well as their process of adaptation to the face-to-face return, in order to reflect on the teaching practice of this discipline.

3. Material and Methods

The methodology that structures this study is part of a qualitative-quantitative research, because according to Knechtel (2014, p. 106) this type of research *“interprets quantitative information through numerical symbols and qualitative data through observation, participatory interaction and the interpretation of the subjects’ discourse (semantics)”*, which, in this case, were the reflections of mathematics teachers, with regard to the Didactic Transposition of the contents taught and their anxieties regarding the use of digital technologies during this period of remote classes, as well as their perceptions about the changes in the return to face-to-face teaching.

The target audience of this research was a group of 15 (fifteen) Mathematics teachers from the city of Sobral, Ceará, Brazil, working in the classroom in the public school system. Data collection took place through two virtual forms, in which the same group participated in two moments: the first was proposed in August/2021, during the emergency remote teaching period, and the second in July/2022, after returning to school for face-to-face teaching. The participation of the subjects was voluntary and carried out based on an invitation letter, in which the criterion for selecting these subjects was the fact that they were teaching during the remote teaching period.

Based on the data, we sought a way to recognize the nature of these professionals' adaptations during this interstice. The first stage of data collection brings the online form indicated in Table 1, with questions aimed at knowing the profile of participating mathematics teachers, as well as identifying their difficulties and advances during remote teaching. Thus, we provided a link to access the form via WhatsApp, to search for teachers who could voluntarily collaborate with the research.

Table 1: First online form

<p>01) How long have you been a Mathematics teacher?</p> <ul style="list-style-type: none"><input type="checkbox"/> Less than 5 years.<input type="checkbox"/> Between 5 and 10 years.<input type="checkbox"/> More than 10 years. <p>02) Do you teach Mathematics at which of these levels?</p> <ul style="list-style-type: none"><input type="checkbox"/> Elementary School I<input type="checkbox"/> Elementary School II<input type="checkbox"/> High School<input type="checkbox"/> Higher Education <p>03) How do you rate your skills in using digital tools?</p> <ul style="list-style-type: none"><input type="checkbox"/> Very good<input type="checkbox"/> Good<input type="checkbox"/> Indifferent<input type="checkbox"/> Bad<input type="checkbox"/> Very bad<input type="checkbox"/> I have no skills <p>04) How do you feel about emergency remote teaching?</p> <ul style="list-style-type: none"><input type="checkbox"/> Very satisfied<input type="checkbox"/> Satisfied<input type="checkbox"/> Indifferent<input type="checkbox"/> Dissatisfied <p>05) Which of these difficulties did you face or face in preparing materials to teach your mathematics classes:</p> <ul style="list-style-type: none"><input type="checkbox"/> Lack of personal motivation or emotional issues.<input type="checkbox"/> Lack of feedback or student participation<input type="checkbox"/> Lack of technological equipment to meet the demand for activities.<input type="checkbox"/> Internet access difficulties.<input type="checkbox"/> Difficulties in creating / producing materials for remote teaching.<input type="checkbox"/> Difficulties in reconciling personal and professional activities. <p>06) Which of the resources and/or platforms below do you, a teacher, use or have already used as a methodological tool in your remote mathematics classes?</p> <ul style="list-style-type: none"><input type="checkbox"/> GeoGebra<input type="checkbox"/> Kahoot!<input type="checkbox"/> Quizizz<input type="checkbox"/> Wordwall<input type="checkbox"/> Padlet<input type="checkbox"/> GrafEq<input type="checkbox"/> Cábri-Geometry<input type="checkbox"/> Graphmatica<input type="checkbox"/> None <p>07) Knowing that each professional experience is unique, this space is open for you, the teacher, to share your successful experiences, desires, and difficulties in carrying out the Didactic Transposition of Mathematics contents in the face of remote teaching.</p>

We obtained expressions of interest in participating in the research voluntarily from fifteen teachers of Basic Education, from the city of Sobral, Ceará, Brazil. All were teachers in public schools, both municipal and state, who provided us with data to carry out the first analysis of this work. After this stage and the release of face-to-face teaching by the Brazilian government in some cities at the end of 2021 and the beginning of 2022, we seek to continue this research. Thus, the second form was created (Chart 2), in which the same teachers were contacted and asked about their agreement to collaborate for the continuation of this study, assuring their participation.

Table 2: Second online form

<p>01) How do you feel about returning to face-to-face classes?</p> <ul style="list-style-type: none"><input type="radio"/> Very satisfied<input type="radio"/> Satisfied<input type="radio"/> Indifferent<input type="radio"/> Dissatisfied <p>02) Regarding the obstacles that you consider to be part of the current reality in your pedagogical practice, when teaching your Mathematics classes, choose one of the options:</p> <ul style="list-style-type: none">• Learning delay on the part of students<ul style="list-style-type: none"><input type="radio"/> Totally agree<input type="radio"/> Partially agree<input type="radio"/> Neither agree nor disagree<input type="radio"/> I partially disagree<input type="radio"/> I totally disagree • Lack of student interest or participation<ul style="list-style-type: none"><input type="radio"/> Totally agree<input type="radio"/> Partially agree<input type="radio"/> Neither agree nor disagree<input type="radio"/> I partially disagree<input type="radio"/> I totally disagree • Lack of technological resources to meet the demand for activities<ul style="list-style-type: none"><input type="radio"/> Totally agree<input type="radio"/> Partially agree<input type="radio"/> Neither agree nor disagree<input type="radio"/> I partially disagree<input type="radio"/> I totally disagree • Lack of support material for the preparation of classes<ul style="list-style-type: none"><input type="radio"/> Totally agree<input type="radio"/> Partially agree<input type="radio"/> Neither agree nor disagree<input type="radio"/> I partially disagree<input type="radio"/> I totally disagree • Difficulties in creating / producing diversified materials for post-isolation teaching<ul style="list-style-type: none"><input type="radio"/> Totally agree<input type="radio"/> Partially agree
--

- Neither agree nor disagree
- I partially disagree
- I totally disagree

03) Which of the resources and/or platforms below do you, a teacher, use or have already used as a methodological tool in your remote Mathematics classes?

- GeoGebra
- Kahoot!
- Quizizz
- Wordwall
- Padlet
- GrafEq
- Cábri-Geometry
- Graphmatica
- Nenhum

04) Regarding the previous question, how often do you currently use these tools when returning to face-to-face activities?

- Always
- Often
- Sometimes
- Rarely
- Never

05) What new strategies for teaching Mathematics did you use in the period of remote teaching that remained in use when returning to face-to-face teaching? Open space for reflection and sharing of experiences.

From the survey and analysis of the data collected in the two different periods, we present in the following section a description of the results, their analysis and discussion. It is worth mentioning that the data presented in graphs in the subsequent sections are written in Portuguese, which was the official language in which the data collection took place, but that all the questions asked are presented in this section and the descriptions in the body of the text are self-explanatory.

We seek support in the testimonies and experiences of mathematics teachers who participated in the research, bringing both their practical experiences and adaptation to remote teaching during the pandemic period, as well as the changes that have occurred and their perception regarding the return to face-to-face activities.

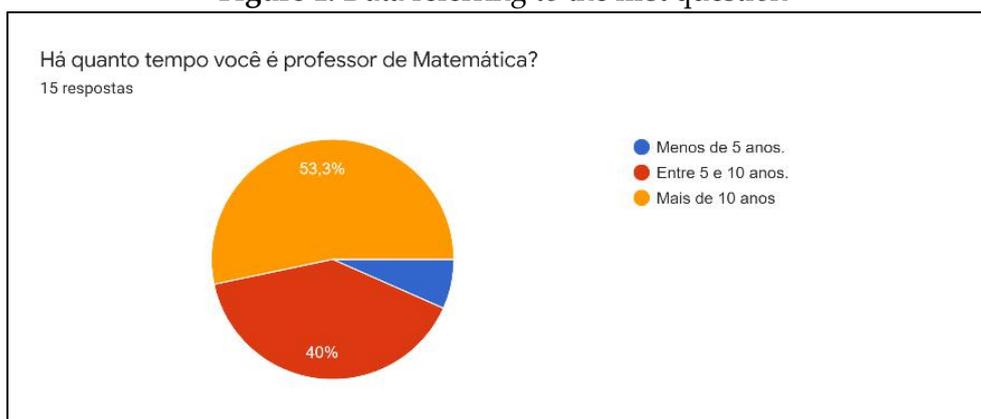
4. Results and Discussion

Each of the forms was made available for a period of seven days. After this period, an analysis of the collected responses was initiated. In this section we present a description of the main surveys and results identified, divided into two subsections, referring to each of the forms.

4.1 Form 1: didactic strategies and perspectives during remote teaching

This form was proposed in August 2021, after more than a year of carrying out activities in the remote modality. We seek, at first, to outline the professional profile of the participating teachers with information about the length of service, level of education at which they work, their perception of remote teaching and their skills with technologies. In Figure 1 we have the data referring to the first question of the form, which seeks to identify the time these teachers have been working in the classroom:

Figure 1: Data referring to the first question



We can see in the graph shown in Figure 1 that among the participants, more than half, that is, eight of the teachers (53.3%) have been in the classroom for more than 10 years. The others were divided into six teachers (40%) who have been working for between 5 and 10 years and only one teacher (6.7%) with less than five years in the classroom. In this way, we conclude that we are dealing with professionals with minimum experience requirements.

In the second question, we investigated the level of education at which these teachers worked at that time. Among the participants, we have those twelve (12) teachers work in High School and three (3) in Elementary School II and of these, 3 work at both levels of education. We did not obtain the participation of teachers from the other levels mentioned above. We also observed that most of these teachers work in the state education network and given the reality of the city of Sobral, Ceará, Brazil, we know that during the period from March/2020 to September/2021, mathematics classes and continuing education remained remotely.

The third question refers to the skills of these teachers, regarding the use of digital tools and, implicitly, during their pedagogical work in mathematics classes. In Figure 2, we find a quantitative on how these teachers consider their skills during the period of remote classes:

Figure 2: Data referring to the third question

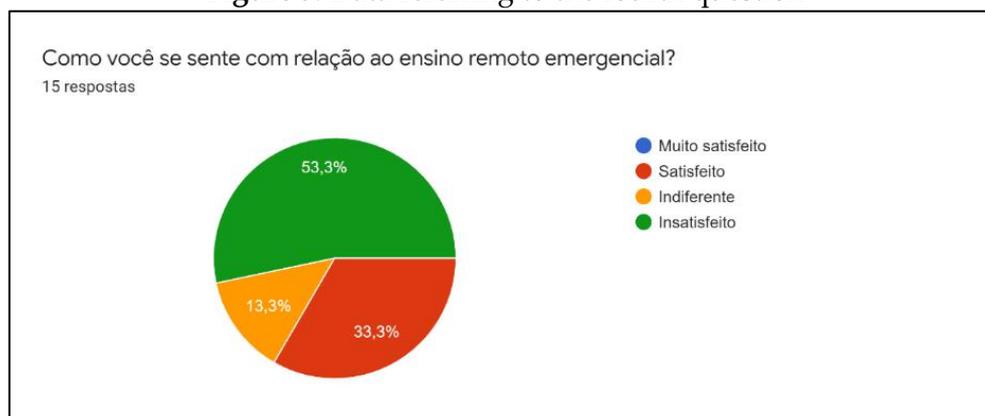


We can see in Figure 2 that most teachers consider their skills as “very good” (20%) and “good” (66.7%) in the use of digital tools for teaching mathematics. However, we still identified that 6.7% (1 teacher) marked the option “indifferent” and 6.7% (1 teacher) marked that they consider their skills to be bad.

Research such as Santos (2019) and Souza et al. (2021), among other works, state that one of the biggest mishaps of teachers in remote teaching was the lack of training for this type of teaching. The fact of having access to digital tools, but without the ability to use them effectively in their communication or interaction when managing learning situations, led to the exclusion of some professionals, anxieties, and demotivation.

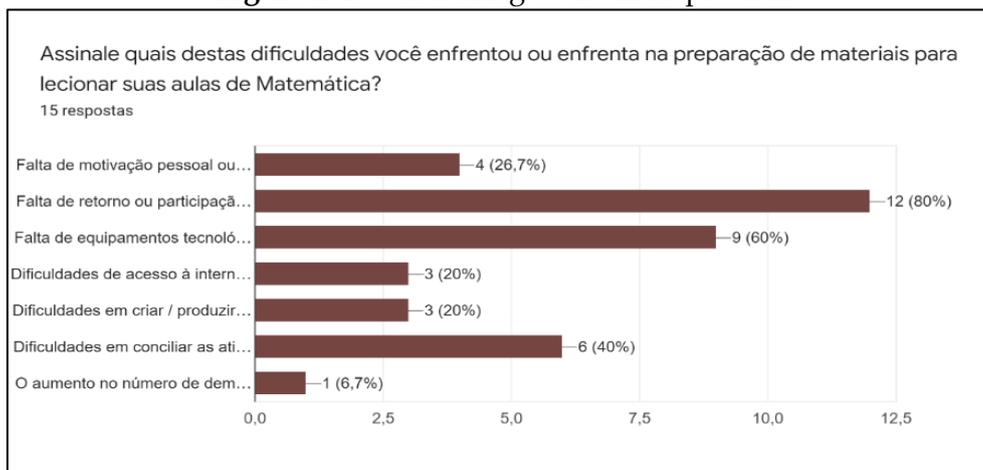
In Figure 3, referring to the fourth question, we bring an overview of these teachers regarding their satisfaction with remote teaching:

Figure 3: Data referring to the fourth question



From Figure 3, we can see that just over half of the participating teachers (53.3% or 8 teachers) reject remote teaching. However, there is a considerable portion (33.3% or 5 teachers) who say they are satisfied with this modality, while a minority (13.3% or 2 teachers) say they feel indifferent. A better understanding of the dissatisfaction presented in relation to remote teaching can be seen in Figure 4, which points out the difficulties of teachers in the act of their professional practice:

Figure 4: Data referring to the fifth question

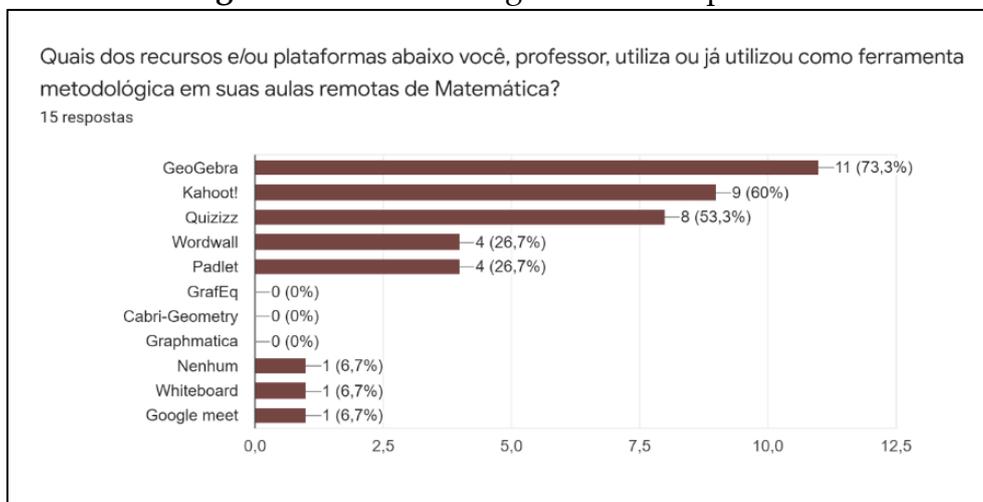


Among the options highlighted in relation to the difficulties faced during the period of remote teaching, most teachers pointed out the lack of return or participation of students (80%), followed by the lack of technological equipment to meet the demand for activities (60%) and difficulties in reconciling personal and professional activities (40%).

In accordance with these data, Abrantes and Filho (2020) and Souza et al. (2021) point out, in a general panorama, explicit difficulties in the execution of remote teaching: the lack of access to the internet or electronic equipment by the students, the difficulties in the assimilation of the content in a virtual way, the absence of face-to-face contact with the teacher to clear immediate doubts in the classes, and, in some situations, the obstacles in the adaptation of both some teachers and students to the execution of their role within the didactic system, harming the process of Didactic Transposition.

However, in the sixth question we have a survey about the main software and/or digital platforms used by these teachers to carry out their praxis, as shown in Figure 5:

Figure 5: Data referring to the sixth question



In question 6, referring to the computational methodological resources most used by teachers, we found that most teachers indicated that they used GeoGebra (73.3%), followed by Kahoot! (60%) and Quizizz (53.3%). It is worth mentioning that teachers could choose more than one resource option as an alternative answer.

In the seventh question, we seek to know a little about the professional experience of these teachers specifically in this period, encouraging the sharing of successful experiences, their desires, and difficulties with regard to the Didactic Transposition of Mathematics contents in the face of remote teaching.

Many of the teachers' statements stated that it was difficult to reach students, involve them and instil in them a change in habits and routine, as well as encourage them to participate in classes, in addition to the uncertainty of knowing if these students are really learning and developing.

Regarding the obstacles pointed out, we have a lack of access for students and a lack of material resources for teachers to prepare a class with quality. Another difficulty highlighted was the feeling of loneliness, resulting from mandatory social distancing. In Table 3 we bring some testimonies from teachers that we would like to highlight, given its relevance to our analysis, in which they pointed out the advantages and disadvantages of remote teaching, with regard to their way of working, considering their reality at that time (August/2021). To preserve the identity of the subjects, we call them Participant A, Participant B, and so on:

Table 3: Testimonials from teachers

"I think digital resources are fantastic. I can use GeoGebra in the same class, show a video, show an animated slide, and accompany students manipulating GeoGebra and performing the activity in real time, through Classroom. All this quickly and practically. In person, just to set up the data show, there goes 15 minutes". (Participant A).

"In this period of a pandemic, I learned that there is more than one way to teach classes. I also learned how difficult it is to work remotely, away from co-workers and students. But, like everything new, it's a learning experience. I studied and improved more." (Participant B).

"Although our student body is of an alpha or z generation, many of them do not know how to send an email or attach a file and the lack of feedback from them, because for the current model there is a preparation of a different planning from the models that already exist. we were used to, on the other hand there were students who stood out, as they, although remotely, got closer to the teachers". (Participant C).

"I have a lot of difficulty reconciling work time with home demands, filling in data, classes to produce. Using Quizizz as an auxiliary tool, it helped a lot in student participation and interest. In my opinion, what is disturbing the most is the time for the teacher to develop an activity using digital technologies". (Participant D).

"In this modality, we often feel alone in front of the computer screen, especially when we are presenting the screen and we lose visual contact with the room. The long-awaited silence of the physical classroom, in the virtual environment, is extremely disturbing. However, when you feel that a student gives a positive return, it strengthens you because, given the great difficulty of perceiving expressions in the real environment, the fact of having a positive return in the virtual is elevated to a great degree of satisfaction with the task accomplished". (Participant E).

“In the midst of the moment, we live in, seeking motivation to prepare and present a good class is increasingly difficult. In addition, many students are unable to participate in the class due to lack of access to a good internet and few of those who are present are not so participative. It is frustrating to teach classes under these conditions”
(Participant F).

We can observe in the speeches of these professors that there are advantages such as using more than one type of technological resource in the methodology of the class, offering more possibilities for carrying out an effective Didactic Transposition, with optimization of pedagogical time.

According to Chevallard (1991), when carrying out the Didactic Transposition, the impositions of normalization and institutionalization are directly related to the establishment of pedagogical time and the configuration of the contents worked in the school. However, the disadvantages, such as the lack of appropriate equipment (such as a graphics tablet, for example), eye contact, access and active student participation were considered something of concern.

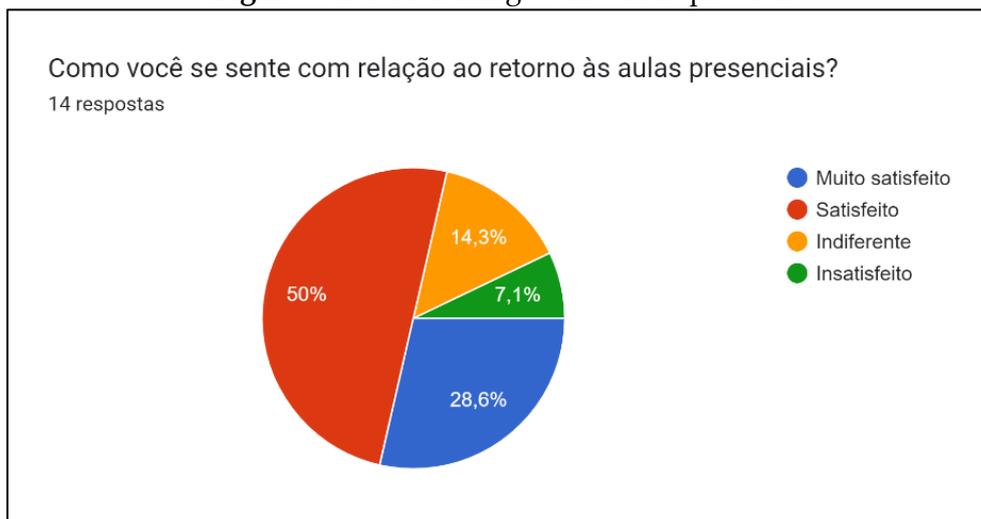
Souza et al. (2021, p. 16) state that *“Reality reveals the need for a transformative and revolutionary education that is capable of accompanying the evolutions and transformations of society and the role of the teacher”*. And we can see, based on the above, that teachers proved to be resilient and willing to learn and reinvent themselves in such a difficult scenario, but that the reality of education in general needs to be rethought and restructured, as technologies make increasingly part of our routine.

4.2 Form 2: changes and perspectives of teachers in the post-pandemic scenario

The second form was proposed to teachers as a continuation of this research in July 2022, using the same system. The same teachers were invited to participate, as a way of perceiving how they feel about the return to face-to-face activities, their view on mathematics teaching and the strategies currently used for the transposition of the contents, as well as what remained as a habit in the remote teaching and that was internalized and brought to the post-pandemic context in the face-to-face modality.

In this second stage of the fifteen (15) teachers who initially participated, only fourteen (14) expressed interest in participating and contributing to the research. In the first question, we seek to know how these teachers feel about returning to face-to-face activities, where we can observe the division of opinions in Figure 6:

Figure 6: Data referring to the sixth question



There are teachers who expressed dissatisfaction with the face-to-face feedback (7.1% or 1 teacher), indifference (14.3% or 2 teachers) and the vast majority feel satisfied (50% or 7 teachers) or very satisfied (28.6% or 4 teachers). This demonstrates how much the absence of the face-to-face classroom and the teacher-student contact made a difference for these professionals. Research that took place during the remote teaching period, such as Godoi et al. (2021, p. 11) point out that many teachers bring difficulties such as “access to digital technologies and the Internet, the lack of support from parents or guardians, the bureaucracy of institutional demands, the absence of bodily interaction between students in the virtual environment”, which was minimized with the return to the physical classroom.

In the second question, we sought to raise the obstacles that teachers have currently faced, after face-to-face feedback, where we listed five items for them to mark one of five options, according to their reality. We organize this data in Table 4:

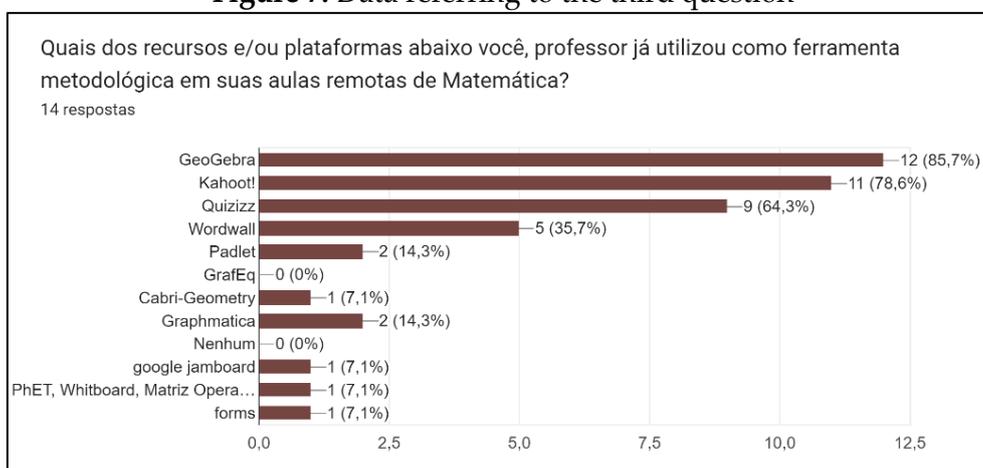
Table 4: Data referring to the second question

Alternatives Obstacles	I totally agree	I partially agree	I neither agree nor disagree	I partially disagree	I totally disagree
1. Learning delay on the part of students	12	2	0	0	0
2. Lack of student interest or participation	6	8	0	0	0
3. Lack of technological resources to meet the demand for activities.	5	6	2	1	0
4. Lack of support material for the preparation of classes	2	4	3	5	0
5. Difficulties in creating/producing diversified materials for post-pandemic teaching	2	2	2	3	5

Regarding the first item, which refers to the delay in student learning, there is unanimous agreement among the participating teachers that this is an obstacle, if not the most visible, seen in face-to-face return. That said, as the research by Godoi et al. (2021), remote learning cannot reach all students with equity. Many children and adolescents depend on their parents' or guardians' phones to carry out their activities, which was often not possible, given the varied socioeconomic contexts experienced in Sobral and, above all, in the country.

Regarding the third question, this was purposely duplicated in the two forms, as a way of observing whether, in this interval, the teachers appropriated other digital tools for the elaboration of their classes and Didactic Transposition of the contents. The results can be seen in Figure 7:

Figure 7: Data referring to the third question

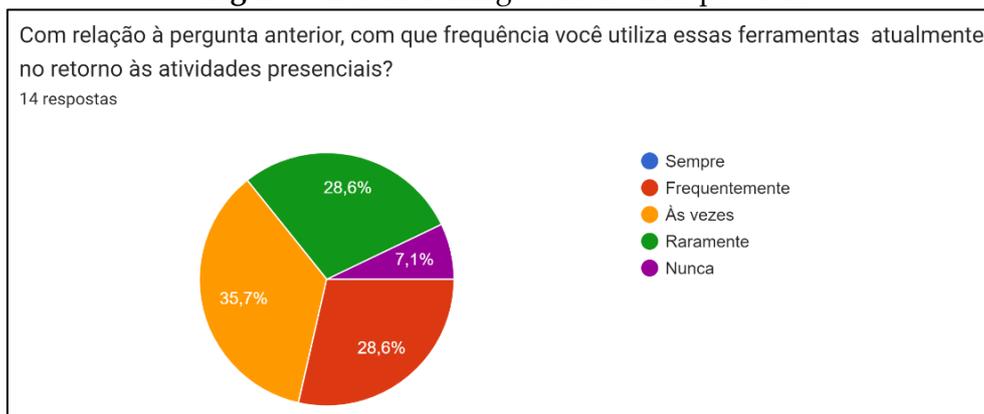


Comparing the use of digital tools, we can see that their use has grown. Among the most used are GeoGebra, Kahoot!, Quizizz and Wordwall. We also noticed that tools that had not been used before were explored in the meantime, such as Cabri-Geometry and Graphmatica. In addition, in the “others” field, different resources such as Google Jamboard, PhET Colorado, Whiteboard, Matrix Operation and Google Forms were pointed out.

We also noticed that none of these teachers did not use digital resources and/or platforms in the preparation of their classes. According to Lavor and Martins (2020, p. 79), technologies “are resources that contribute to the way of informing and communicating, including software, applications and simulators, among others”. In this way, the training environments offered during the period of social isolation promoted different possibilities of learning and approach for teachers.

In the fourth question, we sought to find out from these professionals if the digital tools used in remote teaching for the Didactic Transposition of contents were still adopted in the return to face-to-face teaching. The results are shown in Figure 8:

Figure 8: Data referring to the fourth question



The results pointed out in this question called our attention, because among the participants there is a division regarding the use of these tools. None of the teachers claimed to always use this type of tool, while four stated to use it “often” (28.6%), which is an advance in the insertion of technologies in the teaching of mathematics. However, a majority stated that they used such resources “sometimes” (35.7% or 5 teachers), “rarely” (28.6% or 4 teachers) and “never” (7.1% or 1 teacher).

This is a worrying fact, because, despite the learning of new knowledge and exchange of experiences between peers in this period, as well as continuing education with the exchange of information for the development of research and teaching strategies (Silva & Novello, 2019; Godoi *et al.*, 2021), there are still teachers who have restrictions on the use of technology in mathematics teaching.

The technology was implemented on a large scale in the period of social isolation because educational practice must always be under the influence of the social and cultural context of the moment (Silva & Novello, 2019). However, there are still difficulties in continuing to exploit these resources properly, which go far beyond the skills and disposition of teachers, especially in the reality of public schools. Many of these barriers are of a structural level, such as the lack of quality internet connection in schools, maintenance of laboratories and computers, as well as the precarious conditions of physical spaces for this purpose in the infrastructure of schools.

Finally, in the fifth and last question, we provided an open space for teachers to share their reflections and experiences about the use of these tools, pointing out which strategies were used in their pedagogical practice during remote teaching that remained in use when they returned to the face-to-face classroom.

In some speeches, we felt that the use of technological tools for the Didactic Transposition of the contents was more restricted. We seek to present a summary in Table 5, highlighting in italics some excerpts that most caught our attention:

Table 5: Data referring to the fifth question (reflections of the teachers)

<p><i>"I don't use any tools I used during remote teaching". (Participant A)</i></p>
<p><i>"Using GeoGebra, Wordwall and Quizizz for some content reviews and introductions. Use of google meet and google forms for specific situations, such as extracurricular activities". (Participant B)</i></p>
<p><i>"GeoGebra, Kahoot, Matriz Operation, PhET. The school's resources are few". (Participant F)</i></p>
<p><i>"The use of active methodologies, the form of class planning and a new approach to class and assessment methodologies". (Participant G)</i></p>
<p><i>"Sometimes I use some resource or game, but the face-to-face routine takes more time, the laboratories don't have computers for all students, not everyone has a cell phone either. So sometimes we want to do something different, but it's not possible. In the remote, it was possible to use technology because we only had that option, but it seems that after going back to the face-to-face, it stayed as it was before". (Participant H)</i></p>
<p><i>"I used GeoGebra to show some concepts and I still use it, because it helps the student to see mathematics in a clearer and more concrete way. I know they didn't put it there, but I also used and still use social media to share content, especially Instagram, but less because of time". (Participant I)</i></p>
<p><i>"My didactic schemes. This makes it easier for students to learn. I use smart exits a lot, the famous tips". (Participant K)</i></p>
<p><i>"The use of materials in pdf and google forms". (Participant L)</i></p>
<p><i>"Chats and videos." (Participant M)</i></p>

Among the speeches of the participants, there are teachers who said they did not use any of the tools that were used in remote teaching. For others, the tools continued to be used, but with less frequency. Note in the speech of participants B, H and I that the time factor is mentioned, in the sense of a specific period for planning and elaborating these activities or even adapting these technologies to the school routine. The lack of resources and infrastructure of the school for this use are also pointed out in speeches such as that of participants F and H. On the other hand, we have the speech of participant K, who uses "tips" and didactic schemes prepared previously, configuring a traditional class model, in which apparently the physical classroom was transferred to the virtual model in the remote period and, upon returning, a reverse transfer has taken place.

It is a fact that many courses offered (free or paid) during remote teaching favored the learning of other methodologies and technological alternatives for the elaboration of classes and strategies for the transposition of the contents.

However, we understand that there are issues, as pointed out by Souza et al. (2021), which make it impossible to use many of the teaching strategies mentioned, such as the lack of infrastructure and appropriate environments, the difficulty of teachers, who have a cradle of traditional academic training, the lack of investment, both in initial training and in of these professionals, the time for planning activities, among other particular situations of the reality of each involved.

Changes in the educational scenario occurred abruptly and continued to change rapidly, as the context demanded such changes. And, parallel to this, many teachers did not have enough time to prepare for such social transformations. And a new reality was built, along with a perspective of expanding horizons in methodological terms, where the teaching professional is immersed in a universe of possibilities.

5. Conclusion

One of the priorities of the transformation in the treatment given to knowledge in a process of Didactic Transposition is, without a doubt, the selection of contents that will constitute a school program and that, in its entirety, will form school knowledge, having scientific knowledge as an originating source. For this scientific knowledge to be transformed into school knowledge, it will undergo a process of several modifications influenced by different parts of the educational system.

In the current scenario, we live with several social and, above all, educational transformations, especially the transition between remote and face-to-face teaching models. In the midst of so many difficulties in teaching Mathematics, the adaptation of teachers to the use of digital technologies has become essential for the progress of the teaching and learning process, being essential for the Didactic Transposition, given that they provide opportunities for the realization of activities synchronously and/or asynchronously and contact with the classes in both teaching models, with the necessary adaptations.

However, we realize that there are several barriers to the continuity of the use of these technologies of a structural nature, such as the lack of resources and infrastructure of many schools, and cultural, such as the cradle of teacher training, some resistance and difficulties in adapting to remote teaching, which culminates in a perpetuation of traditional teaching, even in a scenario where there have been so many transformations in the pedagogical work of the mathematics teacher.

Thus, we hope that this work brings reflections on the difficulties faced in this interstice, with a view to creative solutions and the possibilities of paradigmatic transformations regarding the teaching of mathematics in a connected society, such as the one we currently live.

Conflict of Interest Statement

The authors declare no conflicts of interest.

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