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Experiences of teachers teaching mathematics leading to the challenge of the exercise paradigm

Experiencias de profesores que enseñan matemáticas que conducen al desafío del paradigma del ejercicio

Expériences d'enseignants qui enseignent les mathématiques menant au défi du paradigme de l'exercice

Experiências de professores que ensinam matemática que levam ao desafio do paradigma do exercício

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Abstract

The objective of this study is to investigate how elementary education mathematics teachers correlate learning aimed at challenging the exercise paradigm to their experiences. In order accomplish that, we started by conceptualizing teacher learning as a transformation in their participation in school pedagogical practice. The data for this qualitative study were generated through semi-structured interviews conducted with six elementary education mathematics teachers. The analysis suggests that these teachers perceive their approach to challenging the exercise paradigm in the classroom context as a dynamic process of learning, encompassing multiple shared practices. Therefore, we highlight the significance of articulating the connection between the life experiences of teachers and their initial and continuing education programs and courses, in order to provide them with multiple avenues of professional action.

Keywords: Teacher learning, experiences, critical mathematical education, teacher education, social Practice.

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Resumen

Este estudio busca comprender cómo los profesores que enseñan Matemáticas en la Educación Básica relacionan sus experiencias con el aprendizaje orientado a desafiar el paradigma del ejercicio. Para hacerlo, partimos de una comprensión del aprendizaje del profesor como un cambio en su participación en la práctica pedagógica escolar. Los datos de este estudio cualitativo se obtuvieron a través de entrevistas semiestructuradas con seis profesores que enseñan Matemáticas en la Educación Básica. El análisis indica que estos profesores relacionan la forma en que desafían el paradigma del ejercicio en el contexto escolar con un proceso dinámico de aprendizaje en el que están involucradas diversas prácticas compartidas. Así, destacamos la relevancia de la articulación entre las experiencias de vida de los profesores y los cursos y programas de formación inicial y continua, para que se les ofrezcan diferentes modos de acción professional.

Palabras clave: Aprendizaje docente, Experiencias, Educación matemática crítica, Formación docente, Práctica social.

Résumé

Cette étude vise à comprendre comment les enseignants de mathématiques en enseignement primaire et secondaire lient leurs expériences à l'apprentissage visant à défier le paradigme de l'exercice. Pour ce faire, nous partons de la compréhension de l'apprentissage de l'enseignant comme un changement dans leur participation à la pratique pédagogique scolaire. Les données de cette étude qualitative ont été produites grâce à des entretiens semi-structurés avec six enseignants de mathématiques en enseignement primaire et secondaire. L'analyse indique que ces enseignants relient la manière dont ils défient le paradigme de l'exercice dans le contexte scolaire à un processus dynamique d'apprentissage, impliquant diverses pratiques partagées. Ainsi, nous mettons en avant l'importance de l'articulation entre les expériences de vie des enseignants et les cours ainsi que les programmes de formation initiale et continue, de manière à leur offrir différents modes d'action professionnelle.

Mots-clés : Apprentissage de l'enseignant, Expériences, Éducation mathématique critique, Formation des enseignants, Pratique sociale.

Resumo

Este estudo busca compreender como professores que ensinam Matemática da Educação Básica relacionam suas experiências com suas aprendizagens orientadas a desafiar o paradigma do exercício. Para tanto, partimos de uma compreensão da aprendizagem do professor enquanto

mudança na sua forma de participação na prática pedagógica escolar. Os dados do presente estudo qualitativo foram produzidos por meio da realização de entrevistas semiestruturadas com seis professores que ensinam Matemática da Educação Básica. A análise indica que esses docentes relacionam o modo pelo qual desafiam o paradigma do exercício no contexto escolar a um processo dinâmico de aprendizagem, em que estão envolvidas práticas variadas e compartilhadas. Assim, evidenciamos a relevância da articulação entre as experiências de vida dos docentes e os cursos e programas de formação inicial e continuada, de sorte que venham a ser-lhes oportunizados modos distintos de atuação profissional.

Palavras-chave: Aprendizagem docente, Experiências, Educação matemática crítica, Formação docente, Prática social.

Experiences of Teachers Teaching Mathematics Leading to the Challenge of the Exercise Paradigm

While it may be challenging to provide a precise definition of "tradition" in mathematics education, Alro and Skovsmose (2002) suggest that traditional teaching in mathematics is characterized by distinct classroom behaviors. These include solely focusing on solving problems with limited solutions and a single correct answer which may compromise student engagement. Such features are essential elements of what Skovsmose (2000) refers to as the "exercise paradigm" which represents a distinct aspect of traditional mathematics education. In this setting, the primary focus is on solving exercises, resulting in classroom activities being limited to a binary assessment of correctness (Skovsmose, 2014, p. 64).

However, Alro and Skovsmose (2002) argue that the exercise paradigm has been challenged in many ways. Studies conducted by Faustino (2018); Matos, Giraldo, and Quintaneiro (2021); Meneghetti, Netto, and Zuffi (2021); Milani (2020); and Soares (2022) provide examples of the exploration of alternative methods for teaching mathematics. Such methods involve thematic approaches, project work, dialogic approaches, and exploratory-investigative activities. Alro and Skovsmose (2002) refer to this collection of methodologies as "investigative approaches." In this context, scholars are exploring the concept of "scenarios for investigation", based on investigative methodologies suggested by Skovsmose (2000), as a potential approach to question the traditional exercise paradigm. The author describes research scenarios as situations in which students are encouraged to inquire, seek explanations, and participate in cooperative endeavors alongside teachers (Skovsmose, 2014).

Therefore, it is reasonable to explore the factors that may lead teachers to transition from traditional exercise-based methods into investigative approaches. Existing research which examined such changes in the teaching practices of mathematics teachers within the classroom includes studies by Desimone (2009); Guimarães (2019); Honorato and Fiorentini (2021); Miranda (2015); Pereira (2019); Pita (2020); and C. Silva and M. Silva (2020). According to their findings, the education process of mathematics teachers does not culminate with their initial education or within institutional settings. In order to gain a comprehensive understanding of the evolution of teachers' practices and their consequent professional growth, it is essential to analyze their experiences across different settings (Borko, 2004)[3].

[3] The above-mentioned concepts of “experience” and “teacher learning” will be defined in the following section.

The objective of this study is to investigate the interrelationships between different contexts and experiences which contribute to teacher learning. More specifically, we seek to gain a deeper understanding of how teachers interpret and utilize their experiences to advance their own learning. Our goal was to investigate how elementary education mathematics teachers perceive their learning experiences and how they apply them to challenge the exercise paradigm.

This research may provide a comprehensive understanding of the elements that influence teacher learning, in particular, with regard to the impact of the experiences of mathematics teachers on their classroom practices. Thus, this research has the potential to provide a valuable contribution to the theoretical field of mathematics education, as well as to the advancement of teacher education policies and programs.

The following section will explore the core concepts that underpin the connection between experiences and the teaching and learning processes, drawing from the Social Theory of Learning (Lave & Wenger, 1991; Wenger, 1998). After that, we will examine the concepts of the "exercise paradigm" and "scenarios for investigation" by drawing from previous discussions under the perspective of critical mathematics education. This will provide the essential theoretical foundation for the research objective. Subsequently, the methodological approach employed in the development of this study, as well as the data analyzed and findings will be discussed in detail.

Teacher Learning: experience and change in practice

The responsibilities of mathematics teachers extend beyond the confines of the classroom. The work of teachers is influenced by several factors arising from various social contexts (Borko, 2004). Such contexts contribute both to the training and professional development of teachers by providing experiences that shape and inform their practice. According to Desimone (2009, p. 182, translation), teachers engage in a wide range of activities and interactions “that have the potential to enhance their teaching practice and foster their personal, social, and emotional development”. In her doctoral thesis, Pita (2020) emphasizes the significance of considering various aspects of the lives of mathematics teachers that may influence their professional practice. Pita also highlights how those “dimensions can influence teachers and shape their teaching practices” (p. 153). Viera, Silva, and Dias (2023, p. 9) argue that education is fundamentally impacted by the experiences of teachers. Such experiences can serve as catalysts for transformative changes in their practice (Desimone, 2009; Guimarães, 2019).

Consistent with the views of Lave and Wenger (1991), the learning process specifically pertains to the transformation of one's actions and behaviors. According to the aforementioned authors, learning is characterized by the pattern of engagement in social activities, in which individuals are actively involved. Such involvement is dynamic and subject to change. Human exploration of social settings, in many aspects and contexts, is an essential component of the learning process. This phenomena is characterized by a reciprocal relationship between individuals, their experiences and actions, the communities they belong to, and the social practices they engage in (Wenger, 1998).

According to Wenger (1998), throughout their lives, individuals engage in various social communities, such as family, work, friend groups, church, and social movements. Within these communities, they communicate, share experiences and skills, and learn from one another (Vilas Boas & Barbosa, 2016, p. 38). Those communities are characterized by a variety of "social practices" that are carried out within a specific historical and social context, imparting structure and meaning to their actions. Practice is connected to the way a social group collectively understands and interprets the significance of its actions, thereby imparting it with a social aspect (Vilas Boas & Barbosa, 2016). Learning can be defined as the process of "altering one's participation in culturally established situations of everyday life, leading to a shift in understanding within practice (Lave, 2013, p. 237).

From this perspective, "experience" cannot be regarded from a merely subjective standpoint. On the contrary, as per the Social Theory of Learning, the social and shared character of a person results from interactions between the individual and their social setting. The perception of things is influenced by a wide range of social activities and the corresponding communities associated with them. Therefore, experience pertains to the ways individuals engage in social behaviors through social practices .

However, upon examination, it becomes evident that the professional, personal, and academic experiences of teachers, among others, serve as the foundation of their pedagogical actions. Teachers engage in a particular social community and social practice: the school community and pedagogical practice, which impacts their professional actions (Vilas Boas & Barbosa, 2016). For those authors, the participation of teachers in the social community of the school extends beyond the confines of the discipline they teach and include aspects such as the organization of the school and classrooms. Within this community, teachers engage in a distinctive social practice that is specifically connected to the "process of teaching and learning within the formal education setting" (Vilas Boas & Barbosa, 2016, p. 1101). When engaging in this educational practice at school, teachers define actions and decisions that characterize their

teaching performance based on experiences which are significant in this particular environment (Vilas Boas & Barbosa, 2016).

At this point, however, we must emphasize that the relationship between learning and participation does not presuppose an automatic connection. Learning can be defined as the comprehensive engagement of an individual in a social practice, during which members consistently exchange information they deem significant, and which evokes new meanings that require validation (Lave & Wenger, 1991; Vilas Boas & Barbosa, 2016). Therefore, this phenomena is associated with changes in the "characteristics" of the individuals' involvement in a social activity, as well as a shift in the frequency or organization of the individuals' participation (Borko, 2004; Vilas Boas & Barbosa, 2016).

It is also important to acknowledge that teaching and learning may occur in various contexts, including informal conversations such as a "quick hallway chat" (Borko, 2004, p. 6). Teachers-learners are members of many social systems and engage in different experiences, which subsequently influence their participation in pedagogical practice. Learning can take place both *while* teaching and *for* teaching (Vilas Boas & Barbosa, 2016).

Learning while teaching involves the transformation of the level of engagement of teachers in school pedagogical practices, based on their personal experiences within this particular social context. Learning for teaching, on the other hand, encompasses the transformation of the involvement of teachers in various social activities, which can lead to purposeful or unintentional changes in their approach to teaching within the classroom (Vilas Boas & Barbosa, 2016). For instance, Honorato and Fiorentini (2021), by examining the first author's journey when incorporating mathematical modeling activities into their classes, concluded that the "process of learning about and with modeling" (p. 20) is made possible by the pedagogical approach itself; furthermore, they observed that a variety of life experiences beyond the classroom "can augment the flexible and diverse implementation of such modeling practices" (p. 22).

Thus, the various social settings in which teachers operate, as well the different ways they experience such contexts, enable them to alter their professional conduct, in order to develop different teaching activities. In the following section, we will explore that transition process of teacher learning, and how it takes place while teachers navigate between the exercise paradigm, associated with traditional methods of teaching mathematics, and investigative approaches.

Teacher Learning and the Exercise Paradigm

The Critical Mathematics Education movement is primarily concerned with challenging traditional methods for teaching mathematics. Alro and Skovsmose (2002) argue that traditional mathematics education is characterized by what they refer to as the "exercise paradigm." This paradigm encompasses class management, communication patterns among teachers and students, and the role of mathematics within civilization. This didactic model as described by Tenório et al. (2016) emphasizes the importance of memorization and mechanization in solving exercises. In the exercise paradigm, the teacher often introduces mathematical concepts and methods taken from a textbook. The students then do exercises to reinforce the information taught by the teacher, with the expectation of finding a single correct solution. As a result, the focus is placed on solving exercises created by an external authority, without involvement of either teachers or students (Alro; Skovsmose, 2002).

Several studies emphasize that there is no standardized approach to effectively challenge traditional methods of teaching mathematics. This can be done in various ways, as discussed by Skovsmose (2020, 2000) and Lima et al. (2022). However, in general, the challenge to the exercise paradigm involves considering a distinct learning environment, which provides "resources for carrying out investigations" (Skovsmose, 2000, p. 2). In summary, the investigative approaches discussed in this context encompass broader concepts such as "autonomy, freedom, equity and social justice, as well as issues regarding interactions, teaching and learning within mathematics classrooms" (Moura, 2020, p. 55). Skovsmose (2000, p. 3) suggests conceptualizing investigative approaches in terms of "scenarios for investigation", which are situations conducive to investigative activity. As students engage in the process of investigation and explanation, a new learning environment emerges wherein they assume responsibility for the process.

Essentially, research scenarios and exercise-based approaches create distinct learning environments as they promote different classroom activities. These categories can be distinguished by specific criteria, namely: pure mathematics, semireality (imaginary scenarios), and reality (actual life events). The distinction among these three categories, along with the differentiation between the two paradigms of classroom practice, generates a matrix comprising six unique types of learning environments (Skovsmose, 2000). According to the aforementioned scholar, learning environments centered around investigative scenarios and related to the three types of reference enable students to further participate by posing questions, presenting arguments, conducting analyzes and reflections.

For instance, Lima et al. (2022, p. 6), conducted research that demonstrated that mathematical modeling can be a teaching approach that fosters "a continuous process of

analyzing and critically evaluating real-world situations that students encounter". A study conducted by Meneghetti et al. (2021) examined the significance of ethnomathematics and problem-solving in the development of an essential understanding of mathematics. Research by Alves and Tatsch (2017), and Soares (2022), underscores the importance of fostering teaching situations in which students recognize the significance and applicability of mathematical knowledge, in an interdisciplinary process of valuing historical issues and practices which helps students develop critical thinking skills and reflective abilities. The work of Milani (2020) and Faustino (2018) centers on the need to (re)think communication and dialogue in mathematics teaching.

According to Polizeli (2019), teacher education is a crucial factor to be considered while examining the dynamic shift in traditional mathematics teaching methods. According to the study, when mathematics teachers begin using alternative approaches, they transition into a state of instability and dynamism, which leads to a reorganization of their teaching practice as well as a continuous revaluation of their practice. Therefore, the education process is inherently present in the daily lives of teachers, encompassing both practice and reflection (Miranda, 2015; Pita, 2020).

This study examines the idea that when teachers consistently modify aspects of their professional practice, opposing hegemonic approaches for "practicing and understanding mathematics learning" (Soares, 2022, p. 161), they effectively engage in a teaching learning process geared towards challenging the exercise paradigm. Therefore, given the discussions presented in the previous section, we believe that the distinct experiences of teachers may impact their practice, resulting in a learning process that deviates from traditional approaches for teaching mathematics.

Methodological Approach

Considering the purpose of the present study, we opted for a qualitative methodological approach. This approach places the observer in the real world and enables the examination of the phenomenon in its natural setting. In the context of this investigation, it enabled the interpretation of the phenomenon by considering the significance ascribed to it (Denzin & Lincoln, 2006). Therefore, we emphasize the importance of everyday activities as the "locus of creation of people's lives" (Lave, 2015, p. 42). Our goal was to provide flexible descriptions and explanations that enable the understanding of the social practices and participation of individuals in teaching and learning processes (Hammersley, 2013).

The data were generated through semi-structured interviews conducted with a group of elementary education mathematics teachers, whose participation in school pedagogical practice underwent changes aimed at challenging the exercise paradigm. Despite the fact that the interview is solely designed for gathering "current representations regarding the events" (Amado & Ferreira, 2013, p. 212), the use of semi-structured interviews was appropriate because it allows participants more flexibility to interact and share experiences, without being constrained by rigid questions, while still aligning with the objective of the study.

Thus, we developed an interview guide[4], which is a preliminary blueprint containing the essential questions necessary to accomplish the objectives of the research. Three main points were explored: i) aspects of mathematics classes that challenge the exercise paradigm; ii) experiences of teachers while distancing themselves from the exercise paradigm; and iii) the main hurdles and constraints faced in school pedagogical practice when attempting to deviate from this paradigm, and strategies for addressing such obstacles.

In order to further develop the investigation, particularly in terms of methodology, we conducted a preliminary pilot study (PS) to revise the interview guide according to the specific objectives of the research (Silva Filho & Barbosa, 2019). Therefore, we conducted a PS interview with a mathematics teacher based on the aforementioned guide. This enabled us to evaluate the suitability of the guide for the purpose of the study. Regarding this issue, it is important to emphasize that the PS enabled us to recognize the need for making the interview more concise and focused, particularly in terms of length.

We used the XIII National Meeting of Mathematics Education, held in 2019, as the setting for participant selection. At the beginning of our study in 2021, that event was the most current edition of the meeting, and proceedings were readily available. This decision was based on our belief that teachers who submitted and presented experience reports at the meeting wanted to address issues pertaining to mathematics education, share their experiences, and explore new approaches and perspectives for teaching. Put simply, they wished to do things differently.

In order to select participants, we initially distributed to elementary school mathematics teachers a questionnaire5, which was generated using Google Forms. We specifically targeted teachers whose experience reports were accessible from the annals of the event. As a result, we

[4] Link for interview guide:
https://drive.google.com/file/d/1gB6vMzk7iyBGxIQpBZVehBJ9u5dxWDnV/view?usp=sharing
[5] Link for questionnaire:
https://drive.google.com/file/d/1Y5ABSmMHoJjeJAutNVhkVtamQSm_tdjv/view?usp=sharing

received 106 replies. In order to address a more diverse set of teachers, we considered various factors, such as training, geographical location of professional activity, length of experience, and the particular context of their schools. It is important to highlight that our objective was not to pre-categorize participants. While research participants may have distinct and varied experiences, it is essential for them to also possess certain shared characteristics. (Amado & Ferreira, 2013, p. 214). Throughout the investigation, we consistently incorporated questions into the questionnaire to identify teachers who closely matched the intended profile. Such questions focused on the characteristics of their courses, as well as the materials and resources they used during teaching activities. Using these specific criteria, we chose fifteen individuals who were subsequently be invited to the interview.

The participants were interviewed using the Google Meet application, which facilitated the access to a greater number of teachers, hence increasing the diversity of the group. During the interviews, starting from the seventh interview, a significant saturation of the data generated was noted. After each interview, the data was transcribed, skimmed, and codified. However, upon comparing the transcribed reports from participants, no significant additional information was found. Based on that assessment, we concluded that the data generated by six mathematics teachers was adequate to achieve our goal. This enabled us to proceed to the second phase, which involved the analysis and interpretation of findings.

It is important to highlight that the investigation was conducted in accordance with the ethical parameters outlined in the self-declaration form, in which the foundations, methods and other ethical considerations inherent to the research process are listed. All participants signed the Informed Consent Form (Mainardes & Carvalho, 2019).

Six mathematics teachers participated in the present investigation. Pseudonyms were used to preserve their identities, as described in Table 1:

Table 1.
Participating teacher profiles (research data)

Name	**Initial education**	**Period of Service**	**State**
Maria	Mechanical Engineering BSc in Mathematics	10 to 20 years	Minas Gerais
Manoel	BSc in Mathematics	5 to 10 years	Paraná
Ana	BSc in Mathematics	Longer than 20 years	Bahia
Gabriel	BSc in Mathematics	Longer than 20 years	Rio de Janeiro
Cíntia	BSc in Mathematics	Longer than 20 years	Mato Grosso
Julia	BSc in Mathematics Other	5 to 10 years	Rio Grande do Norte

The data analysis process involved several steps: transcribing the interviews; reviewing the transcripts; codification of interviews; interpreting and comparing codes; grouping them into categories; and establishing the relationship between the results and existing literature. The goal was to gain theoretical insights into how teachers connect their experiences with ther learning, specifically regarding challenging the exercise paradigm.

Presentation of Data

It is crucial to underscore that the inclusion of a teacher's reported experience in a particular category does not preclude the possibility that another teacher may have had comparable experiences and suit the same category, despite the absence of such information in this text. Thus, teachers' reports are illustrative of the way through which they associate their experiences with changes in patterns of participation in pedagogical practice geared towards challenging the exercise paradigm.

The data was organized into four distinct categories: "Experiences in educational contexts", "Experiences with collective projects", "Experiences in classroom situations", and "Experiences in familial contexts". These categories refer to the experiences teachers have undergone, which are commonly linked to transformations in their practice, specifically in relation to challenging the exercise paradigm. The first category examines how individuals establish connections between their experiences in both initial and ongoing education settings. The second category pertains to teacher involvement in collective endeavors, whether institutional or not, that share common objectives and interests, with the intention of creating possibilities to challenge such paradigm. The third category comprises experiences encountered within the pedagogical practice in school, which played a significant role in altering their patterns of engagement in that activity. In the fourth and final category, participants indicated

that specific personal experiences, including familial environment and personal preferences and affections, have contributed to the development of their mathematical knowledge and its potential. However, instruction is not the primary goal.

Teachers express apprehension regarding moving away from conventional methods of teaching mathematics in the classroom. Manoel, Julia, and Cíntia indicated their utilization of technological resources in the classroom to promote student engagement. Both Ana and Maria use supplementary materials in addition to the textbook to actively engage students in the management of mathematics tasks. Like Ana, Gabriel aims to comprehend the emotional makeup of students in order to increase the relevance of mathematics in distinct real-life situations.

The teachers do not perceive challenging the exercise paradigm as something natural, separate from their own experiences. The interviews indicate that the participants associate this challenge with a succession of experiences, which result in a shift in their teaching practice.

Experiences in educational contexts

Participants in the study reported the influence of both their initial and ongoing education environments on their teaching practices. Cíntia found that some experiences during her early education, prior to starting her teaching job, to be significant in her shift away from the traditional exercise paradigm. She highlighted the significance of her experiences while pursuing her teaching degree in mathematics and emphasized how she proactively seized every opportunity provided by the course.

> So, I had a lot of material while working towards that degree. Going back to trigonometry, I recall that we left the classroom. Let's measure the width of the river; and headed down there. Let's figure out the flow, and we headed down there. Whenever possible, I'd make the most of such situations. (Cinthia, teacher)

Júlia states that her participation in the Institutional Teaching Initiation Scholarship Program (*Programa Institucional de Bolsas de Iniciação à Docência - Pibid*) during her undergraduate studies in mathematics was a significant milestone in her professional development. The teacher emphasized that the experience was particularly significant as it provided her with the chance to engage with mathematical modeling:

> As a scholarship holder, I had an amazing time at PIBID during my undergraduate studies. After dividing the class into groups, the supervisor had each group work on a project. Mine was a game. After that, I started working with mathematical modeling, a field in which I am still passionately interested. Thus, I had an extremely interesting experience at PIBID, at the time. (Julia, teacher)

Julia views her academic experiences while obtaining her master's degree as being significant to her departure from conventional teaching paradigms. She asserts that obtaining a master's degree has significantly altered her approach to teaching mathematics:

> During the investigation conducted as part of my master's degree program, I observed that the implementation [of the research proposal] resulted in a greater sense of purpose among students. They displayed more enthusiasm while addressing problems and generated more thought-provoking questions in the classroom. All these factors contributed to the development of a teacher who is very pragmatic and adept at providing depth and significance to inquiries. (Julia, teacher)

Gabriel highlights how engaging with colleagues, actively sharing information with other teachers, participating in groups, and attending researcher meetings are experiences that foster transformative change:

> So, on the financial front, working with ENEM[6] we published this book, Financial Mathematics in Elementary School: A Practical and Visual Approach. In other words, these gatherings gave us the chance to share knowledge and discover some of the projects being developed around Brazil. (Gabriel, teacher)

The teachers proposed that the varied settings of both initial and continuous education may provide opportunities which serve as foundations for changes in teaching practice. Despite occasional divergence between professional practice and institutional education, teachers acknowledged that these contexts have a significant impact on their activities. This influence can manifest through academic research, collaboration with colleagues, and access to new strategies. Consequently, teachers may deviate from traditional approaches to understanding and teaching mathematics and instead embrace innovative practices.

Experiences with Collective Projects

Joining the *Fundão* Project of the Federal University of Rio de Janeiro was a crucial turning point for Gabriel, as it prompted him to reconsider his teaching approach and distance himself from traditional methods and the exercise paradigm. His participation in the *Fundão* Project at UFRJ had a significant impact on his perspective and behaviors as a mathematics teacher.

[6] *Encontro Nacional de Educação Matemática*, the most significant event devoted to mathematics education in Brazil, congregating scholars, researchers, teachers, as well as undergraduate and postgraduate students.

> The professor who participated in my exam board invited me to join a project called *Fundão* at UFRJ, the aim of which is to study elements of teaching practice that may improve the approach to certain themes. So, our first theme was geometry, which was the subject of my thesis [...]. Therefore, the difference for me came at the moment that [...] I also joined *Fundão* project. (Gabriel)

Maria, however, explains that while she had previously attempted to appreciate the social aspects of mathematics and its teaching, it was not until the end of her course when she started working as a substitute teacher at the pedagogical center of the Federal University of Minas Gerais, where she taught students from first to ninth grade, that she had a greater level of exposure to non-traditional teaching methods. For both Maria and Gabriel, the contact served as the initial step in questioning the traditional classroom exercise paradigm.

> I completed my undergraduate course and became a substitute teacher at UFMG's pedagogical center. Wow, it was a perfect teaching laboratory of the College of Education. There you did not give a traditional lesson. You had to explore the topic, and there were teachers from the School of Education who guided us. We did our own planning, but we did everything together with them. So, it was really nice because we used a textbook, but we could explore different activities with the students. (Maria, teacher)

Under the same perspective, Ana points out how her experiences at the Educational Technology Center (NTE), a branch of the National Program for Information Technology in Education (PROINFO), led to a transformation in her teaching practice, particularly regarding the opportunity to work with teacher education at the time:

> My time at the Educational Technology Center was very enriching. I had the chance to learn about postgraduate courses, specializations. I completed four of them [...]. I worked there for fifteen years, and I can tell you that it provided me with an extensive repertoire [...]. I grew both professionally and in terms of quality. I could recognize my role and importance as a teacher at that stage. I demanded a lot of myself during training. As the teachers were from different areas, I did not work only with mathematics. I had to perform in an interdisciplinary and even transdisciplinary manner while attempting to introduce technology into the classroom. We developed a course that used learning objects in class, an audio and video course at school, because the idea was not to employ technology only for the sake of using technology. (Ana, teacher)

Following this line of thought, Gabriel, in his own way, also highlighted the importance of contact with other mathematics teachers who also challenge the exercise paradigm to continue moving away from traditional patterns of teaching:

> Another interesting practice that made me change, that is, not really change, but reinforce, took place after 2018, when other colleagues and I set up a group called

> "*Respire Educação e Cultura*" (Breathe Education and Culture),which means, whenever possible, keep in mind and use in class the constant and direct exchange of information with other teachers [...]. (Gabriel, teacher)

The participants consider their engagement in collective projects to be significant, as these initiatives serve as catalysts for initiating or reinforcing changes in practice. Teachers' accounts indicate that these projects offer opportunities for teacher learning by challenging the exercise paradigm. This is achieved through the exchange of experiences and knowledge, as well as by addressing shared interests, problems, and objectives of teachers.

Experiences in Classroom Situations

Júlia explained that her experiences in school pedagogical practice, particularly while interacting with students, were the starting point for a transformation in her approach to teaching mathematics. According to her, when she began her career, her classes still relied on conventional teaching methods. Only when her students posed specific questions did the situation undergo a transformation, prompting her to incorporate problem-solving exercises into her lessons, in an attempt to establish a stronger connection between the subject matter she was teaching and the real-life experiences of her students. According to her statement:

> I started in a very traditional way, indeed. That is how we are usually taught, and we end up reproducing this way of teaching, until we learn to look for something new. Then, at that time, ten years ago, I remember students often asking: "What will I need this for? How will I put it to use?" [...]. And I looked for more practical applications, and the students stopped asking these questions, because they already knew where to use such applications. I always start a lesson with an issue, something they deal with on a daily basis. Then, instead of asking questions, they try to solve the problem somehow. That is the main change I see." (Júlia, teacher)

Similarly, Manoel relates his experiences in classroom teaching practice to the challenge of the exercise paradigm. He acknowledges that specific attitudes in the classroom, particularly in terms of interacting with students, have prompted him to use novel approaches to teaching mathematics.

> I think students have to trust you. Sometime ago, I had cases of mistakes that I made and improve on them. I used to be a teacher who would ask a question and, if students gave the wrong answer, I'd make fun of them. Then, I realized that the students did not come back to me. I lost those students because of a joke that only I thought was funny. So, this is how you ruin your work because of a little thing. (Manoel, teacher).

Therefore, it is evident that teachers view the classroom as a significant setting for implementing changes in their school practices. Although institutional educational frameworks offer valuable assistance in altering the methods teachers use, the transformation process heavily relies on classroom practice. This is because educators must address several factors that may not be addressed in the predictability of initial and/or continuing education. In these circumstances, teachers emphasize the significance of engaging with students and their environment as a crucial factor to be considered, particularly to ensure that mathematics and mathematics teaching are meaningful to students.

Experiences in Familial Contexts

Additionally, there are experiences which correspond to personal traits of the respondents, such as, their preferences and inclinations. The familial context in which they were raised also plays a significant role. In this sense, Ana describes how she took advantage of characteristics from her own affective universe, which, in a way, helped her challenge the paradigm of exercise. Her passion for crafts further enhanced her habit of encouraging her students to interact, produce, and materialize their knowledge:

> I also worked with the students on cross stitch, which is an embroidery technique, because it is a straightforward math problem; it is flat and represents the entire Cartesian plane. But why? I already work with crafts, so I'm not unfamiliar with it. It is a component of my universe [...] And it was easier because I enjoy doing crafts. (Ana, teacher)

Similarly, Cíntia also explains how her experiences in the community where she studied and where her father worked were important to develop a certain sensitivity to what she calls "living mathematics" and to facilitate changes in practice:

> My father owned a sawmill, and there was a school nearby that belonged to the community, but my parents owned the land. And in this school, where classes were multi-graded, everyone was together. We learned things too, because the sawmill had steam engines, boilers and wood. My father even calculated the cubage of wood, and I hung out with him. So, I learned this living mathematics little by little. I think this has always been part of my life (Cíntia, teacher).

For Maria, the fact that her mother was a history teacher was significant to help her develop a more "human" view of mathematics and mathematics teaching, which was crucial to change her professional practice:

> And my mother was a history teacher. She had this great social awareness. She had this mobilization. I like mathematics, but I like mathematics that is not hard mathematics, but rather human mathematics. (Maria, teacher)

In this context, the participants explained that there are also experiences that extend beyond interactions in educational institutions or academia. These experiences, considered "personal", can lead to a challenge of the exercise paradigm, revealed as a change in practice. Teachers acknowledge that their emotional experiences, family background, and personal life journeys influence their perspectives on mathematics and their teaching methods. These factors shape their professional practice by motivating them to challenge conventional teaching approaches.

Discussion of Findings

Based on the categories outlined in the previous section, the teachers described their experiences in different social contexts. First, the accounts enabled us to recognize the presence of two distinct categories of experiences which prompt the challenge of the exercise paradigm: *experiences for school pedagogical practice and experiences in school pedagogical practice*. The initial set of experiences concerns engaging in social practices outside of traditional educational practices, resulting in changes to the level of involvement of mathematics teachers in the aforementioned social practice, hence promoting the learning of teachers. The reports suggest that while the experiences of teachers in one context cannot be directly applied to others, they can impact on other situations of individual involvement, “especially when questioning and reinterpreting the practices of each person's original communities" (Crecci & Fiorentini, 2018, p. 277). This set comprises circumstances encountered during initial and/or ongoing teacher education, where the objective is to adequately prepare the individual for professional practice, as well as those that occur beyond the institutional and academic spheres, where such a goal is not apparent.

Beyond the confines of academic institutions, the professional practice of teachers is impacted by their education, which is socially and culturally constructed (Crecci & Fiorentini, 2018; Miranda, 2015; Pita, 2020; Polizelli, 2019; Pompeu, 2013). In this regard, Skovsmose (2023) contends that the life experiences of mathematics teachers are pivotal, as they influence their perspective on mathematical knowledge and teaching. Teachers do not engage in school

processes impartially (Pompeu & Chacón, 2019). The relationship discussed here has a significant influence on how teachers engage in pedagogical practices within school. This influence can either involve questioning or perpetuating the exercise paradigm, as highlighted by Cíntia, Adriana, and Maria in reference to their ‘experiences in familial settings”. This demonstrates the interrelationship of mathematics with “various social practices that have distinct goals and purposes”. Consequently, it enables “the improvement of learning experiences by engaging with diverse social practices” (Pompeu, 2013, p. 311).

The findings indicate the significance of offering alternative methods for engaging in relevant social activities during initial education. Participating in activities that are not traditionally considered exercise can help teachers in training expand their perspective and contemplate their future professional practice (Milani & Silva, 2018). Furthermore, the participants emphasize the need for education, whether initial or continuous, that is more focused on the specific aspects of teaching and the school environment. Such training should be “in line with the latest requirements and constant need for improvement” (Frei et al., 2023, p. 4). Under this perspective, when recounting their experiences in collective projects, teachers emphasized the significance of forming groups to exchange experiences, expertise, and teaching methods in mathematics. This facilitates diverse approaches to engaging in pedagogical practice for both teachers and students. According to Crecci and Fiorentini (2018, p. 2), the organization of teaching communities can influence professional development and “lead to various approaches to how to teach and be a teacher”. Hence the importance, for example, of establishing joint collaborative and investigative activities "among educators, elementary school teachers and future teachers, involving systematic analyses of problems and practices of teaching and learning mathematics, both at school and in classroom settings" (Fiorentini, 2013, p. 935).

The term *experiences in school pedagogical practice*, in turn, refers to the socially mediated processes of participation of mathematics teachers in this social practice, which foster transformations in the participation pattern (Wenger, 1998). In line with the findings of Polizeli (2019), the teachers' responses revealed that the educational process extends to their daily lives, encompassing their professional practice and subsequent reflections regarding such practice.

The classroom, which serves as an environment in which experiences and knowledge can be shared and expanded, contributes "to learning taking place through the interactions among the individuals involved" (Rodrigues, 2019, p. 21). The very challenge to the exercise paradigm is primarily directed at the teacher's daily classroom practice, as it pertains to the recognition and appreciation of the individual experiences and backgrounds of students (Miranda, 2015; Skovsmose, 2023). Therefore, engagement with students is crucial in order to provide them with new avenues for involvement in educational practices, particularly in terms of a more contextualized comprehension of mathematical content.

Dessa forma, as categorias expostas auxiliam na compreensão do caráter dinâmico e social do processo de aprendizagem do professor que ensina Matemática. Em consonância à teoria de Lave e Wenger (1991) e Wenger (1998), bem como ao que postulam Borko (2004) e Vilas Boas e Barbosa (2016), os dados indicam, assim, que a aprendizagem docente não consiste em um processo isolado e individual, mas sim em uma atividade coletiva em que os professores se engajam em práticas variadas e compartilhadas.

Hence, these categories help us understand the ever-changing and communal essence of learning processes among mathematics educators. According to the theories of Lave and Wenger (1991), and Wenger (1998), as well as the ideas proposed by Borko (2004), Vilas Boas and Barbosa (2016), the data suggests that teacher learning is not a solitary and personal endeavor, but rather a collaborative activity in which teachers participate in diverse and shared practices.

Final Remarks

The purpose of this investigation was to determine how mathematics teachers relate individual experiences to their professional development, specifically regarding changes in their engagement in school pedagogical practice in response to the exercise paradigm. We have identified two distinct categories of experiences that give rise to the challenge of the exercise paradigm: experiences for school pedagogical practice, which pertain to the socially mediated processes of engaging in diverse social practices that impact the professional performance of

teachers; and experiences in school pedagogical practice, which are associated to this particular social practice and impact the teaching methods employed by mathematics teachers.

From this, it is evident that while there are no strict models to adhere to, there are valuable experiences that can be critically absorbed by teachers, potentially guiding them to depart from the exercise paradigm. The experiences of teachers and the environments in which they develop can shape their understanding of mathematics and how they teach it. As a result, this might influence their engagement in teaching practices.

Thus, we believe that the findings underscore the significance of emphasizing teaching experiences in and for educational practice, which can be implemented through multiple methods. Within the realm of initial education, the creation of activities that recognize and integrate the experiences of future teachers can empower them to improve their individual skill sets and broaden the range of opportunities and approaches for engaging in pedagogical practice as educators. Regarding continuing education, it is reasonable to promote the establishment of teacher learning communities that focus on various forms of professional development. These communities would provide a platform for sharing experiences, knowledge, and teaching methods, particularly in relation to practical teaching experiences in schools. Conversely, in the realm of academia, it would be beneficial to conduct research on how particular experiences of teachers influence their approach to teaching mathematics. This can inspire the development of innovative pedagogical approaches which are more suited to the demands and complexities of modern education.

Therefore, the previously mentioned emphasis on appreciating the experiences of teachers in the aforementioned dimensions may motivate them to participate in multiple aspects of school pedagogical practice. This becomes especially pertinent when considering the challenge to the exercise paradigm, which encompasses a process in which teachers may face numerous institutional, curricular, cultural, or training-related obstacles.

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