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Transformation of mathematical tasks: from teacher education to the classroom

Transformación de tareas matemáticas: de la formación del profesor al aula

Transformation des tâches mathématiques : de la formation de l'enseignant à la salle de classe

Transformação de tarefas matemáticas: da formação do professor à sala de aula

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Abstract

Mathematical tasks are mediational resources for teaching and learning. This study aimed to identify and describe how mathematical tasks are transformed through their implementation within the school setting. These transformations can be interpreted through Basil Bernstein's concept of recontextualization, which addresses the movement and adaptation of pedagogical texts across different educational contexts. An investigation was carried out into the implementation of tasks by Mathematics teaching undergraduate students during their practicum in high school classes, within the scope of a Supervised Practicum course. Data collection encompassed classroom observation, analysis of documents produced during the lessons and post-lesson semi-structured interviews. The results indicate a favorable environment for the development of new content when pre-service teachers allow greater student participation and encourage discussions extended to contexts related to students' reality. The findings of this research may also support teacher educators who are responsible for guiding pre-service teachers in the selection and use of mathematical tasks, aiming to highlight aspects that influence their implementation in pedagogical practice.

Keywords: Mathematical tasks, Recontextualization, Supervised practicum, Teacher training.

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Resumen

Las tareas matemáticas representan instrumentos de mediación para la enseñanza y el aprendizaje. Esta investigación tuvo como objetivo identificar y describir cómo las tareas matemáticas son transformadas a través de su uso en el entorno escolar. Estas transformaciones pueden interpretarse a partir del concepto de recontextualización de Basil Bernstein, que aborda el desplazamiento y la adaptación de textos pedagógicos en diferentes contextos educativos. Se llevó a cabo una investigación sobre la movilización de tareas por parte de estudiantes de profesorado en Matemáticas durante su período de prácticas docentes en clases de Educación Secundaria, en el marco de una asignatura de Práctica Supervisada. Para la producción de los datos, se emplearon la observación, el análisis de documentos producidos en las clases y entrevistas semiestructuradas realizadas posteriormente. Los resultados señalaron un ambiente favorable para el desarrollo de nuevos contenidos cuando el futuro docente permite una mayor participación de los estudiantes durante el uso de la tarea y favorece discusiones ampliadas relacionadas con la realidad de los alumnos. Los principios de esta investigación también pueden servir de base para los formadores de docentes que comparten la responsabilidad de orientar a los futuros profesores en la selección y utilización de tareas matemáticas, con el fin de evidenciar aspectos que interfieren en la implementación de dichas tareas en la práctica pedagógica.

Palabras clave: Tareas matemáticas, Recontextualización, Prácticas supervisadas, Formación de profesores.

Résumé

Les tâches mathématiques représentent des instruments de médiation pour l’enseignement et l’apprentissage. Cette recherche visait à identifier et à décrire comment les tâches mathématiques sont transformées à travers leur utilisation dans le contexte scolaire. Ces transformations peuvent être interprétées à travers le concept de recontextualisation de Basil Bernstein, qui traite du déplacement et de l’adaptation des textes pédagogiques dans différents contextes éducatifs. Une enquête a été menée sur la mobilisation des tâches par des étudiants en formation initiale de mathématiques durant leur période de stage en classes de lycée, dans le cadre d’un cours de Stage Supervisé. La production des données a reposé sur l’observation en classe, l’analyse de documents produits pendant les cours, ainsi que sur l’analyse d’entretiens semi-directifs réalisés a posteriori. Les résultats ont mis en évidence un environnement favorable au développement de nouveaux contenus lorsque le futur enseignant permet une plus grande participation des élèves lors de l'utilisation de la tâche et autorise des discussions élargies à des contextes liés à leur réalité. Les principes issus de cette recherche peuvent également servir de fondement aux formateurs d'enseignants, coresponsables de l'accompagnement des futurs professeurs dans le choix et l'utilisation des tâches mathématiques, dans le but de mettre en lumière les aspects qui influencent la mise en œuvre de ces tâches dans la pratique pédagogique.

Mots-clés : Tâches mathématiques, Recontextualisation, Stage supervisé, Formation des enseignants.

Resumo

Tarefas matemáticas representam instrumentos de mediação para o ensino e a aprendizagem. A pesquisa objetivou identificar e descrever como tarefas matemáticas são transformadas por meio de seus usos no ambiente escolar. Essas transformações podem ser interpretadas por meio do conceito de recontextualização de Basil Bernstein que aborda o deslocamento e a adaptação de textos pedagógicos em diferentes contextos educacionais. Uma investigação foi realizada sobre a mobilização de tarefas por licenciandos em Matemática durante o período de regência nas aulas de turmas do Ensino Médio, no contexto de uma componente curricular de Estágio Supervisionado. Para a produção dos dados, foram empregadas a observação e a análise de documentos produzidos nas aulas, além da análise de entrevistas semiestruturadas ocorridas à posteriori. Os resultados apontaram um ambiente favorável para o desenvolvimento de novos conteúdos quando o licenciando permite maior participação dos estudantes durante o uso da tarefa e autoriza discussões ampliadas a contextos relacionados com a realidade deles. Os princípios da pesquisa também podem subsidiar formadores de professores corresponsáveis pelas orientações sobre a escolha e utilização de tarefas matemáticas por licenciandos, no intuito de evidenciar aspectos que interferem na implementação dessas tarefas na prática pedagógica.

Palavras-chave: Tarefas matemáticas, Recontextualização, Estágio supervisionado, Formação de professores.

Transformation of mathematical tasks: from teacher education to the classroom

The research presented in this article aimed to identify and describe how mathematical tasks are transformed through their implementation in school contexts, focusing on Mathematics teaching undergraduates' supervised practicum. The central concept of recontextualization, as proposed by Bernstein (2000), addresses the shifting and adaptation of pedagogical texts across different educational contexts. The justification for this research lies in the need to deepen the understanding of how pre-service teachers implement and transform mathematical tasks, considering classroom interactions and dynamics.

In the field of teacher education, it is necessary to understand the movement of texts from training environments to school contexts (Grilo *et al*., 2020; Prado *et al*., 2020). This movement can be interpreted through the concept of recontextualization (Bernstein, 2000), which inspires – directly or indirectly – studies that contribute to enhancing the understanding of mathematical knowledge mobilized in school teaching practice (Moreira & Ferreira, 2021). Bernstein (2000) defines the process of moving or relocating a text across different contexts as recontextualization.

Studies in the field of Mathematics Education that explore the notion of recontextualization have contributed to advances in teacher education (Aguiar & Oliveira, 2017; Grilo *et al.*, 2020; Lima & Oliveira, 2021; Prado *et al*., 2020). Aguiar and Oliveira (2017) analyzed perspectives on the conceptualization of curricular materials proposed by Remillard (2005) and presented a new conceptualization termed *recontextualizing the text*, arguing that curricular material must be considered in relation to pedagogical practice. The study by Prado *et al.* (2020) emphasizes that teachers tend to recontextualize texts that regulate not only the behavior of symbols and words – referring to written representations of the material – but also students' actions, thereby establishing control over official texts.

From Bernstein's perspective, texts – present in curricular materials – represent a form of social relationship that is visible, palpable and material, and may designate any pedagogical representation: spoken, written, visual or spatial (Bernstein, 1990). Texts compose mathematical tasks, which can be understood as "resources that teachers use to explore mathematical concepts and/or procedures to engage interactively with students or a request for students to do something" (Margolinas, 2013, p. 10, our translation).

Tasks are fundamental mediational resources for Mathematics teaching and learning. They can suppress or guide actions within the contexts in which they are used, posing challenges to teachers' professional practice (Ponte, 2014). Studies have expressed concern regarding the use of tasks, from their design and adaptation (Gusmão & Font, 2020; Vieira *et al.* 2019) to their implementation in initial teacher education (Marins *et al*., 2021; Matos *et al.*, 2020) and continuing education contexts (Aguiar *et al.*, 2021; Jesus *et al.*, 2018).

When designing or adapting a task, it is fundamental for teachers to reflect on how it can be developed in the classroom and to consider possible interventions and interactions with students (Araujo & Pazuch, 2019). The use of tasks in training settings can develop skills in pre-service teachers, such as: selecting tasks that are challenging and engaging for students: anticipating possible solutions; explaining class dynamics; monitoring task development; selecting solutions to be discussed; establishing a sequence that enables a logical progression of ideas; maintaining a supportive environment for discussing mathematical ideas and connecting students' responses (Marins *et al.*, 2021).

On the other hand, tasks are relocated and used within school settings. Characterizing classroom cultures and sharing teachers' ways of acting in response to students' behavior during task implementation may be a potential pathway for designing tasks. Studies have shown that undergraduates and teachers in continuing education programs need to appropriate tasks with regard to students' solutions, reflecting on didactical possibilities (Homa *et al*., 2023). Another study identified gaps in teacher training concerning the ability to assess and adapt tasks for classroom use (Cyrino & Estevam, 2023). Thus, we understand it is necessary to expand studies that analyze the implementation of tasks and the ways in which the texts they contain are transformed in school settings.

Transformations that tasks undergo when relocated to classroom contexts can be interpreted through the concept of recontextualization (Bernstein, 2000), which consists in the ways in which texts are appropriated and relocated from one context to another; this concept has consistently proven useful when investigating transformations occurring across different instances of educational reality (Santos, 2003). A mapping of publications in the field of Science and Mathematics teaching grounded in Bernstein's theory, spanning from 2003 to 2021, concluded that research has predominantly focused on in-service teacher practice, highlighting gaps in initial teacher education (Santos *et al.*, 2024).

In this article, we analyze how two Mathematics teaching undergraduate students recontextualize mathematics tasks when implementing them in the classroom. These students were enrolled in a Supervised Practicum course that included classroom teaching as a mandatory component. In the next section, we discuss concepts from Bernstein's theory (2000) and their connection to the mathematical tasks used in the study, which guided the methodological framework, data description and analysis, and the discussion of the results – all of which are addressed in the subsequent sections. Finally, we present this study's conclusions, limitations and contributions to the field of Mathematics Education.

Recontextualization of mathematical tasks

The understanding of the concept of recontextualization, developed by Basil Bernstein (2000), refers to ways of disseminating information that regulates pedagogical communication through the pedagogic device. This device consists of a set of three hierarchically interrelated rules – distributive, recontextualizing and evaluative –, which respectively guide the fields of production, recontextualization and reproduction.

Distributive rules organize knowledge by structuring it differently across social groups based on cultural selections occurring within specific contexts. Recontextualizing rules are related to pedagogic discourse, specifically to the incorporation of knowledge into school disciplines, and regulated by official communication within the school context. Evaluating rules are linked to ways of organizing and developing pedagogical practices within the spatial and temporal dimensions of school (Galian et al., 2021).

With regard to recontextualizing rules – which will be discussed further in this article – , Bernstein understands pedagogic discourse as rules that position and relate instructional and regulatory discourse, which is a social construction. At university, for instance, the professor assumes the role of positioning curricular content for a group of students. However, in this movement, there is a selective appropriation of what will be communicated in this academic context; thus, the content is recontextualized.

Studies have employed the notion of recontextualization to reinterpret relationships established among teachers, pre-service teachers and curricular materials (Campos & Araújo, 2019; Eugênio, 2017). Campos and Araújo (2019) concluded that, although students engaged with conceptual approaches in a theoretical Physics course taught in parallel with experiments conducted in the instructional laboratory, they were unable to apply the concepts studied in theoretical classes to the experimental activity. They exhibited uncertainties, dilemmas, questions and anxiety when attempting to represent the data obtained during the experiment. In this case, it is possible to consider that the students had difficulty recontextualizing knowledge from the theoretical classes to the experimental activities.

While analyzing a group of teachers designing curricular material on ratio between quantities, Prado *et al.* (2020) inferred that the development of the material encompassed a process of recontextualization, as the teachers drew on references from academic Mathematics and educational research, suggesting a reorganization of how mathematical concepts are approached in the school setting. Thus, through the concept of recontextualization, we understand that teachers select what to communicate and how to do it in distinct pedagogical practices.

In this study, we understand pedagogical practice as the relationship that may occur between parents and children, teachers and students, doctors and patients, among others, within a particular social context for cultural production and reproduction (Bernstein, 2000). In pedagogical practice in the classroom, what can be communicated and how it could be done will be established through the relationship between teacher and students, which as defined by Bernstein through the concepts of classification and framing.

Classification refers to the content that is transmitted – that is, what can be communicated – and varies between strong and weak depending on the degree of content insulation within communicative relations. In the school context, when Mathematics teachers do not establish connections with other fields of knowledge – such as Physics, the Arts, or even real-life contexts –, Mathematics is insulated, and its classification is considered strong. Framing concerns the way in which the content positions teachers and students. If students participate actively when content is developed, framing is weak. On the other hand, when the teacher does not allow any form of interference from students during the explanation of the content explanation, framing is considered strong.

The study conducted by Lima and Oliveira (2021) analyzed a pedagogical action involving a mathematical task in a school setting. It presented variations in framing, alternating between moments of strong framing – with teacher control – and situations involving greater student participation and interferences – weak framing. On the one hand, the teacher maintained full control through a sequential and reproductive approach to the mathematical task during their explanation, while students listened attentively and received help from the teacher. On the other hand, there was a shared pedagogical action, with students expressing their own strategies to solve the proposed mathematical task. The authors concluded that this openness in communication can contribute to enhancing student learning.

Other studies have prompted important reflections to support promising pedagogical practices based on the use of mathematical tasks (Aguiar & Oliveira, 2014, 2017; Enríquez, Oliveira & Valencia, 2018). These studies demonstrate that teachers engage in the recontextualization of texts embedded in tasks in order to fulfill principles of pedagogical practice (Aguiar & Oliveira, 2014; Prado *et al.*, 2020). This suggests that understanding the essential elements of mathematical texts requires comprehending their implementation within school pedagogical practices.

An example of task transformation within the school context was observed in a study by Aguiar and Oliveira (2014), in which teachers altered the nature of a task by making it more open-ended. They justified this decision based on students' lack of perquisite knowledge and issues related to the academic calendar. The investigation highlighted that teachers recontextualized tasks in response to demands that emerged during their implementation in the school setting. Another study emphasized that teachers may modify the way a task is implemented depending on circumstances presented by the context (Enríquez, Valencia, & Oliveira, 2018).

Proposing tasks and guiding their solution in the classroom constitute the primary form of teaching Mathematics (Ponte, 2014, 2005). This statement reinforces the central role of tasks in Mathematics teaching and the teacher's importance in selecting, presenting and monitoring tasks in the school context. Smith and Stein (1998) classified mathematical tasks into four distinct categories required from students, identified as memorization, procedures without connections, procedures with connections, and doing mathematics. The authors argue that a task's demand may be altered depending on how it is approached by the teacher during classroom practice. This transformation may compromise student learning, as the task's demands are diminished.

Skovsmose (2000) contrasts exercises with landscapes of investigation and encourages teachers to navigate between these two possibilities toward designing investigative tasks that enable students to have greater autonomy in the construction of knowledge. Biotto Filho et al. (2016) considered the proposal put forward by Skovsmose and suggested the insertion of two new fields: controlled inquiry and landscapes for action. In controlled inquiry, the teacher encourages students to conduct investigations that are monitored, systematized and guided by a clearly established goal that cannot be modified. In landscapes for action, Mathematics classes offer open pathways for students to engage with problems related to the school and the community they are part of, in order to develop actions aimed at contributing to their transformation.

Mathematical tasks are designed while considering distinct scenarios. Observing these environments through Bernstein's lenses means understanding that teachers will have their control (framing) over the task strengthened or weakened as they navigate between exercises and potential landscapes for action. The selection of content included in tasks and opportunities to connect Mathematics to other fields of knowledge define classification as strong or weak; the latter is determined by the viability of relationships between Mathematics and other fields of knowledge. When planning a classroom task, it is important to consider that the specificities of the context will require transformations in the material (Gomes & Oliveira, 2024), which we understand as recontextualizations.

Investigating these transformations is encouraged by researchers who state the importance of considering pedagogical practice in light of the changes imposed by the real conditions of the environments in which mathematical tasks are implemented (guiar & Oliveira, 2017). The authors add that teachers can only recontextualize tasks within environments in which they participate. Thus, school settings constitute a formative space for (future) teachers (Prado et al., 2020) as they reflect on how transformations occur. This confirms the need for further studies that investigate the characteristics of pedagogical practice developed by educators who teach Mathematics through the implementation of mathematical tasks (Lima & Oliveira; 2021).

In this sense, understanding transformations of mathematical tasks within the school context not only addresses a need highlighted by researchers, but also guides the methodological direction of this investigation. Analyzing the pedagogical practices developed by undergraduate students enables us to explore how these transformations occur in authentic teaching contexts, fostering reflection on the characteristics of pedagogical practice that emerge through the use of mathematical tasks. This perspective grounds the methodology adopted in this study, which focuses on lessons taught by two undergraduate Mathematics teaching students within a real school environment, creating opportunities to examine how task recontextualization contributes to teacher education. The following section provides further details on the research context and methodological procedures.

Context and methodological procedures

In line with our proposed objective, we investigated lessons taught by two undergraduate Mathematics teaching students who implemented two distinct mathematical tasks. The students were enrolled in a Supervised Practicum course and were fulfilling their teaching practicum by teaching Mathematics lessons to 1st- and 2nd-year high school classes at a public school in the state of Bahia, Brazil.

Ethical aspects were addressed in accordance with Resolution No. 510 of the Brazilian National Health Council of April 7, 2016. This study composes the empirical component of the research project titled *Tarefas Matemáticas e seus Usos Operados por Licenciandos no Estágio de Regência*, which was registered with the Research Ethics Committee of the School of Nursing at the Federal University of Bahia (CEPEE.UFBA), under protocol no. 5.987.372/2022 (CAAE – 62964422.9.0000.5531), and approved on April 6, 2023.

Regarding the ethical principles of the research, appropriate care was taken to protect the identity of those involved by using pseudonyms to refer to the undergraduate students, taking into account the risks involved. The study was conducted with informed consent from the participants – undergraduate students, high school students and practicum supervisors –, ensuring impartiality and equity in classroom observation and interviews carried out by the researcher. Furthermore, participants' autonomy was respected, and they were allowed to make choices throughout the investigation. The research objectives and procedures were presented to all participants – supervisors, undergraduate students and high school students –, who were invited to participate voluntarily by signing a Free and Informed Consent Form (FICF).

Undergraduate student Rafael implemented a task focused on the properties of quadrilaterals, while undergraduate student Olavo applied a task involving the maximum and minimum values of a second-degree polynomial function. Each task was implemented over two class sections, each lasting fifty minutes. During the four observed classes – two 100-minute combined classes per undergraduate student –, the practicum supervisor, who was the regular teacher of the high school classes, was present.

To analyze how the tasks were transformed into pedagogical teaching practices in Basic Education, we conducted an empirical study in which the data were analyzed using concepts from the theory proposed by Bernstein (2000, 2003). The ways in which undergraduate students selected, proposed and organized the tasks in the classroom provide information on how undergraduate and high school students participated in the development of the task. This information was interpreted through the concepts of recontextualization, classification and framing.

Drawing on concepts from Bernstein's theory, we employed the internal language of description to understand how mathematical tasks were used and transformed by the undergraduate students in the school setting. The analysis of what occurred in the classroom provided information on the external language of description, which, in turn, generated insights on how theory and practice reinforce each other, revealing details about important aspects of the theory.

The methodological approach adopted was qualitative because by investigating the process of transformation of mathematical tasks, we aimed to understand meanings attributed to aspects of social life that are difficult to quantify (Creswell, 2007). For data production, we employed observation, document analysis and a semi-structured interview. Class observation and document analysis enabled us to analyze the data on how the undergraduate students implemented the mathematical tasks in the classroom. The interview provided complementary information on the decisions they made during task implementation.

Data were recorded through researchers' field diaries and video recordings. The semi-structured interview, with questions aligned to the objectives of the study, revealed information about how the undergraduate students justified their choices and approached mathematical tasks in the classroom. When necessary, we also analyzed additional materials adopted in the observed activities, such as slides prepared by the undergraduate students and materials produced by students from the observed classes during task development. Throughout this text, we use the terms *undergraduate student* or *intern* to refer to the participants Olavo and Rafael.

Data presentation and analysis

This section presents excerpts from the analyzed data to support our trajectory toward the research objective. Drawing inspiration from the study by Enríquez et al. (2018), we adapted analytical categories, renaming them as *task introduction, task development* and *task socialization and systematization* in order to organize the lesson moments in which transformations in the mathematical tasks implemented during Rafael's and Olavo's classes could be identified. In certain sections of the analysis, we include excerpts from the interview conducted after the implementation of the tasks so as to add complementary insights that enrich the research.

Recontextualizations in Rafael's task implementation

Rafael selected a task titled *Exploring Quadrilaterals,* which was suggested by the internship supervisor and made available on the website of the Observatório da Educação Matemática (OEM) research group. It is worth noting that the supervisor was a member of the group, and the authors of this study are currently affiliated with it. The task was chosen to introduce the topic of quadrilaterals and features six distinct quadrilaterals, which should be explored based on their characteristics. The information gathered should be recorded in the chart presented in Figure 1, as follows:

Figure 1.

Excerpt from the task selected by Rafael (https://educacaomatematica.ufba.br)

TRANSLATION – FIGURE 1

1. Observe the attached sheets and analyze the quadrilaterals. Then, complete table 1 below by marking with an X the characteristics that apply to each quadrilateral:

	CHARACTERISTICS	QUADRILATERALS					
		1	2	3	4	5	6
Angles	a. All angles are right angles.						
	b. No angle is a right angle.						
	c. Opposite angles have the same measure.						
	d. Only two angles are right angles.						
Sides	e. All sides have the same measure.						
	f. All sides have different measures.						
	g. Only two sides have the same measure.						
	h. Two pairs of opposites have the same measure.						
	i. Two pairs of sides are parallel.						
	j. Only two sides are parallel.						
	k. Parallel sides have different measures.						
	l. Parallel sides have the same measure.						
	NAME OF THE QUADRILATERAL						

In addition to the initial question presented in Figure 1, the task includes a second item that compares pairs of quadrilaterals – square and rectangle; rhombus and parallelogram; rectangle and parallelogram – and analyzes characteristics shared by each pair. The third and final item of the task asks which quadrilaterals share the greatest number of common characteristics.

During the task introduction, Rafael referred to content previously studied in earlier classes – angles and triangles –, suggesting a relationship with the topic that would be studied next. He distributed rulers and protractors and asked students to work in groups of three. Rafael read the entire task aloud and checked whether students had understood it up to that point. Next, using slides, he presented the definition of a quadrilateral, its components – vertices, sides, angles and diagonals – and provided examples of quadrilaterals, such as square, rectangle and rhombus.

The steps involved in the task introduction reveal a relationship between the intern and the students in which the former maintained full control over the actions – he selected, directed and indicated the early stages of task execution. This first stage indicates that the presentation, student organization, selection of supporting materials, and initial guidance of the task were not shared with students, which characterizes strong framing, with control clearly concentrated in the hands of the intern.

Another aspect observed was that the intern decided to advance the definition, the presentation, the elements that compose quadrilaterals, and the examples. We understand that advancing these steps impacted the task implementation stage, as it lost the exploratory characteristic that could have engaged students in initial reflections on the properties of quadrilaterals. This emphasizes the intern's control over the task and its recontextualizations, as it limited students' opportunities to engage in investigation.

Regarding the task development stage, we highlight a moment in which Rafael advanced conclusions that could have been developed by the students. The first situation occurred immediately after the task was presented, when Rafael asked the students:

> *Rafael: Have you identified which figure is the square and which one is the rectangle?*
> *Supervisor: Slow down, Rafael. Let's fill in the table together.*

In the dialogue, it is possible to notice the supervisor's concern with following the planned sequence of the task in order to ensure that all stages were gradually fulfilled. Nevertheless, the undergraduate student advanced the names of the shapes before the students could analyze their properties and establish the relationship between those properties and their definitions and names.

Thus, we identified a recontextualization of the task by the intern, as he inverted the ordered prescribed in the material when implementing it in the school context. This recontextualization suggests that the intern attributed meaning to the characteristics of quadrilaterals based on their names, which may lead students toward a memorization process rather than the development of new concepts related to figure properties.

During task socialization and systematization, when Rafael prompted the students to share the conclusions they had reached after filling in the table, he decided to ask for the names of the quadrilaterals before discussing their characteristics in terms of sides and angles. This shift highlights a memorization-oriented strategy, as it defines and names the quadrilaterals before identifying and understanding their properties.

Another noteworthy aspect of task socialization and systematization was the undergraduate student's failure to initiate any problematization. While students where sharing their results, the intern did not guide them in identifying regularities in the table they had filled in. At that point, the supervisor intervened: *Rafael, there's something really interesting here: every quadrilateral marked under letter C is also marked under item H.* Next, she addressed the whole group: *"Guys, have you noticed that every quadrilateral marked under item C is also marker under item H? That is, the quadrilaterals with opposite angles of equal measure also have opposite sides of equal measure"*. However, Rafael did not make any additional comments regarding the problematization initiated by the supervisor. He simply continued correcting the task.

The situations that occurred during task socialization and systematization reveal how the intern modified the characteristics of the task, which could have engaged students in an investigative process involving the analysis of quadrilateral properties and problematizations around shared characteristics among some figures – for instance, the similarities between the rectangle and the square, or between the square and the rhombus. The recontextualization carried out by Rafael altered the nature of the task, which originally had an investigative character, but whose implementation in the classroom presented features of a mere exercise, in which students responded to the intern's prompts in a direct and mechanical manner.

During the interview carried out after the task was completed, when Rafael was asked about the development of the class, he answered:

> I liked my class. The beginning was hard… when we start a class, we don't really know what we're doing, but from the middle on, I was a little calmer. This is a criticism of myself. I rushed the class a little. A lot! (Excerpt from the interview)

The excerpt from the interview shows that the undergraduate student was aware that the pace of the class, especially at the beginning, was rushed; thus, it did not foster student participation. Throughout the entire development of the task, we observed that the intern asked questions but did not wait for the students to answer them.

> Rafael: In the second item, the square and rectangle… what aspects do they share and what's the only different thing between them?
> Students: All sides have 90 degrees.
> Rafael: No. All sides of the square are equal. In the rectangle, if you observe all of its sides, they're not equal.
> Students: No, the angles.
> Rafael: They're equal.
> Rafael: If we observe closely, the square and rectangle are very similar. As for the square, the only difference is that all its sides are equal. What about the rectangle?
> Students: No.
> Rafael: Just two.

The undergraduate student conducted the task without considering students' responses. He asked questions which he answered himself, only leaving space for students to complete his sentences after the answer had already been given. This emphasizes the intern's strong control over the task and a recontextualization through the transformation of an investigative task into an exercise, as he eliminated student participation and did not use their discourse to identify potential questions. Furthermore, there was a conceptual error in the intern's attempt to differentiate the square from the rectangle. The task requested reflections and comments about similarities between the figures, but by affirming that the rectangle had only two equal sides, the intern ruled out the possibility that the square could also be a rectangle.

Recontextualizations in Olavo's task implementation

The task selected by Olavo is titled *Cake Sale Price* and appears in a textbook written by Dante and Viana (2020), which was adopted by the school and suggested by the internship supervisor, one of the authors of this article. The intern decided to modify the task for classroom implementation, and his adapted version is displayed on the right side of Figure 2, while the original task appears on the left.

Task selected by Olavo

Preço de venda de um bolo

Uma doceria quer dar um desconto no preço dos bolos. Para isso, decide fazer um teste para observar como ocorre o rendimento. O dono da loja percebe que, vendendo o bolo a 60 reais, ele geralmente vende, por dia, 12 bolos. A cada 5 reais de desconto que ele dá por bolo, ele passa a vender mais 2 bolos por dia.

Além disso, ele sabe que ao multiplicar a quantidade de bolos vendidos pelo preço de venda, o resultado é o valor total arrecadado nas vendas, e que não vale a pena vender o bolo por menos de R$ 10,00.

Em docerias e em outros empreendimentos, a definição do preço de venda ideal de um produto para maximizar lucros envolve vários conhecimentos algébricos.

a) Com um colega, copie e complete a tabela a seguir no caderno e faça algumas simulações de quanto a doceria iria faturar a cada 5 reais de desconto dado no preço do bolo: 5 reais, 10 reais, 15 reais, 20 reais, e assim sucessivamente.

Receita em função do desconto no preço do bolo

Desconto (em R$)	Preço do bolo (em R$)	Quantidade de bolos vendidos	Receita (em R$)
0,00	60,00	12 + 0 = 12	12 · 60 = 720,00
5,00	55,00	12 + 2 = 14	14 · 55 = 770,00
10,00	50,00	12 + 4 = 16	16 · 50 = 800,00
15,00			
20,00			
25,00			
30,00			
40,00			
50,00			
5x	60 – 5x	12 + 2x	

Task modified by Olavo for classroom use

Quantidade de Descontos	Preço do Bolo Após o Desconto	Quantidade de Bolos Vendidos	Receita(R$)
0	60 - 0	12 + 0	60*12 = 720
1	60 - 5 = 55	12 + 2 = 14	55*14 = 770
2			
3			
4			
5			
6			
7			
…			
x			

Figure 2.

Original task (Dante & Viana, 2020, p.78) and modified task (research data, 2023)

TRANSLATION – FIGURE 2

Task Selected by Olavo

Cake Sale Price

A bakery wants to offer a discount on the price of its cakes. To do this, it decides to run a test to observe how revenue is impacted. The shop owner notices that when each cake is sold at 60 reais, he usually sells 12 cakes per day. For every 5-real discount given per cake, 2 more cakes are sold per day.

Additionally, he knows that by multiplying the number of cakes sold by the sale price, the result is the total sales revenue, and that it's not worth selling each cake for less than R$10.00.

a) With a classmate, copy and complete the table below in your notebook and run some simulations to check how much the bakery would make with each 5-real discount on the cake price: 5 reais, 10 reais, 15 reais, 20 reais, and so on.

Revenue as a Function of the Cake Price Discount

Discount (in R$) | Cake Price (in R$) | Number of Cakes Sold | Revenue (in R$)

(Text under the picture)

In bakeries and other businesses, defining the ideal sale price of a product to maximize profits involves various forms of algebraic knowledge.

Task modified by Olavo for Classroom Use

Number of Discounts | Cake Price After the Discount | Number of Cakes Sold | Revenue (R$)

The context of the task encompasses discounts, selling prices and revenue related to cake sales. The task was implemented in a first-year high school class to introduce the concept of quadratic functions. When we compare the original task with its adapted version, it is possible to identify alterations in the first row, fourth column and last row. During the interview, when Olavo was asked about the reasons behind replacing *Discount* with *Number of Discounts*, and *Cake Price* with *Cake Price After the Discount*, he stated:

> (...) the table in the textbook doesn't specify very well which is the independent variable and what is the domain value, so I decided to use the first column as the number of discounts applied to the original cake price. Therefore, if the discount is applied only once, that'll be 5 reais; if it's applied twice, 10 reais, and so on. (Excerpt from the interview)

By modifying the task, Olavo performed a recontextualization aimed at clarifying the information for students, thereby defining the values attributed to the variable x in relation to the number of discounts. Moreover, for the same purpose, the undergraduate student renamed the title of the second column to Cake Price After the Discount to explicitly indicate the moment at which the price is being calculated. According to Bernstein's studies, these recontextualizations may lower the task introduction level, requiring less autonomy from students to understand information, thus strengthening the intern's control over the task and characterizing a strong classification.

On the other hand, removing the expressions that determine cake prices and the number of cakes sold as functions of x – the number of discounts – results in a greater demand on students to determine these expressions. We understand that these changes recontextualize the task in terms of its solution, enhancing student autonomy in finding the expressions, and reduce framing, as the intern's level of control over the task is lowered. This shift tends to make the task more investigative when employed in the classroom.

During task introduction, Olavo read it aloud and exemplified the situation by citing the case of a student in the class:

> Olavo: Multiplying the number of cakes sold by selling prices will give us the value generated by sales – that is, the revenue. For example, let's talk about Ana Julia here. She sells her truffles here in the classroom. I'm just giving an example. In this case, she multiplies the truffle price by the number sold to obtain her revenue.

Olavo recontextualized the task by referring to the reality of a student in the class to communicate the intended idea. We understand that the undergraduate student recontextualized the task in its use in order to make it more meaningful by sharing a real situation experienced by a student in the group.

During task development, as students filled in the table, some of them discovered the mathematical expressions that determine cake prices after the discount and the number of cakes as functions of x – the number of discounts. In this case, there was a recontextualization of the original task, as these expressions were provided as data in the original task, and during its implementation, they were discovered by the students.

The implementation of the recontextualized task contributed to students engaging in an investigation supervised and guided by the teacher toward a pre-established objective – determining the expressions that represent cake prices and the number of cakes sold –, as suggested by Biotto Filho et al. (2016). During the investigation, the students participated actively and, as a consequence, Olavo exercised weak control over the progression of the task.

Furthermore, during the task development stage, intern Olavo collaboratively filled in the table on the whiteboard with the students, as illustrated in Table 1.

Table 1.

Whiteboard records written by undergraduate student Olavo to develop the task titled Cake Sale Price (research data, 2023)

Number of Discounts	New Cake Price	Number of Cakes Sold	Revenue (R$)
0	60	12	60.12=720
1	60-5=55	12+2=14	55.14=770
2	60-10=50	12+4=16	50.16=800
...			
X	60-5x	12+2x	(60-5x)(12+2x)

After filling in the table, Olavo made the following remark to the class:

> Olavo: some of you are having difficulty with polynomial operations. Some are not sure about polynomial multiplication. We can only multiply this [referring to the element in the sixth row, fourth column of Figure 2] if we apply the distributive property. I'll write this multiplication on the board for you. Let's multiply these two functions: price and numbers of cakes sold. The product of these two functions will give us the function that generates the revenue, right?

During the situation described above, whose objective was for students to determine the expression for the revenue, Olavo needed to intervene by finding the product of the expressions for cake prices and numbers of cakes sold. As Olavo identified that many students were having difficulty performing a product of polynomials, he needed to do the multiplication for them. In this situation, we understand that the task underwent a form of recontextualization through the transference of the multiplication of expressions, which should have been performed by the students, but was instead done by the intern.

After the table had been filled in, there were questions to be answered as part of socialization and systematization. One of the questions sparked a discussion among the class, contributing to the understanding of new mathematical concepts that were being developed through the task – growth, decrease and maximum values of a second-degree function.

> Olavo: What have you noticed about the growth of revenue as the number of discounts increases?
> Student A: Revenue increases, then decreases.
> Olavo: Because the revenue begins to decrease after a certain point.

Student B: As you're giving discounts, the number of cakes is basically tied to the amount of discount. So, if you keep giving discounts, you'll end up at a loss.
Olavo: That's a good explanation.
Student B: The secret is to set a high price because customers usually try to haggle and haggle...
Supervisor: But there should be a limit to haggling. Otherwise, you'll...
Student B: Yes, there's a limit.
Olavo: …you'll reach a point in which giving further discounts isn't viable anymore. If you keep doing it, giving a discount here [referring to the task], you'll eventually reach a moment when the cake price will be zero.
Student C: Exactly.
Olavo: So, there has to be a limit to the discount you can give. All right, the next question is about the maximum discount. What's it?

During the discussion with the class, a student extended the conversation beyond the task by reflecting on a potential situation experienced by a retailer, and intern Olavo allowed the discussion to go beyond the task. We consider that there was a recontextualization movement driven by the students and authorized by the intern, in which a student gave a general example of a negotiation between a retailer and a customer. Through this addition, many students understood that there should be a limit for price reductions in order to ensure profitability for the retailer.

The data presentation and analysis identified and described moments in which interns Rafael and Olavo recontextualized texts embedded in mathematical tasks by appropriating them within the school context. Task transformations were observed from the moment they were selected by the undergraduate students through to their implementation in the classroom, across different stages: task introduction, development and, finally, socialization and systematization. In the following section, we will discuss the results.

Discussion of results

In order to analyze how mathematical tasks are recontextualized during their implementation in school settings, we began by examining the selection of tasks by the undergraduate students and employed the following categories to identify and describe the transformations undergone by the texts embedded in the selected tasks: task introduction, task development, and task socialization and systematization.

Although Rafael selected a task with exploratory characteristics and decided to organize students into groups of three to foster small-group discussions during the task introduction, he prematurely advanced characteristics of quadrilaterals that could have been investigated by the students during task development, which characterizes a transformation of the task. This corroborates the findings published by Aguiar and Oliveira (2014), who identified alterations in the nature of a task during its implementation. It was originally intended to allow students to present different solutions, but the teachers ended up determining the procedures for solving the tasks. Such phenomenon – observed both by the aforementioned authors and in this research – demonstrates that tasks are not always implemented as initially planned (Lithner, 2017).

The development of the task in Rafael's class generated situations in which he prematurely advanced mathematical information and conclusions that could have been developed by the students, thereby suppressing the task's investigative characteristic. During task implementation in pedagogical practice, teachers sometimes modify the nature of a task by assuming that students lack experience with investigative tasks (Aguiar & Oliveira, 2016).

During the socialization and systematization of the task titled *Exploring Quadrilaterals,* intern Rafael did not provide opportunities for students to problematize the characteristics of the shapes. Rather, he asked questions that he himself answered, thus maintaining control over the task with little student participation or interference, which characterizes strong framing at this stage. Similar results were identified by Prado *et al.* (2020), who concluded that, through the recontextualization of texts, teachers reinforced their control over task implementation in the school context by adopting strategies and making decisions that regulate students' actions.

In the case of intern Olavo, the selection and implementation of the task initially led to modifications that contributed to student engagement in mathematical investigation processes, encompassing a real-life situation: the intern cited a student in the group who sold truffles during class breaks. This result aligns with findings published by Milani (2020), who also conducted research with undergraduate Mathematics teaching students. The author emphasizes that, for undergraduate students to transform a textbook task in the classroom in ways that foster an investigative environment, the task must resonate with the realities of basic education students.

During Olavo's task development, to find the expression for revenue based on the total number of discounts in cake sales, he needed to perform a product of polynomials on the board because he noticed that the students were struggling with polynomial expressions. This type of task recontextualization was also identified in another study, in which the authors argue that such transformations occur in order to make the task more accessible to students (Grilo *et al.*, 2020).

The task socialization and systematization stage conducted by Olavo was marked by a productive discussion between him and the students on important concepts related to the mathematical content being addressed: growth, decrease, and the maximum value of second-degree polynomial function. This result contrasts with research conducted by Enríquez, Valencia and Oliveira (2018) on teachers employing teaching strategies that did not focus on the construction of the different concepts embedded in the task, thereby hindering students from exploring different underlying concepts in the proposed tasks.

The data produced during the research enabled the identification of different transformations of mathematical tasks carried out by interns within the school context. Intern Rafael prematurely advanced conclusions that could have been developed by the students and decided to strengthen the framing of the task almost the entire time, which limited student participation throughout task introduction, development, and socialization and systematization.

In contrast, Olavo recontextualized the task in the classroom so as to enable student participation. Such engagement tended to grow and mobilize students' development of new mathematical concepts when Olavo created space for them to go beyond the task through the discussion of situations related to their realities. We infer that when the intern exerts less control over the task, students are consequently able to participate more actively throughout its implementation, which enables them to build new mathematical knowledge.

The data produced enabled a contrastive analysis, as the undergraduate students exhibited antagonistic characteristics in the transformation of tasks across the observed stages. Although both selected investigative tasks and organized the class into small groups, one of them chose to advance concepts and conclusions himself, maintaining strong control over the task, whereas the other intern weakened his level of control, allowing students to participate in discussions throughout task introduction, development, and socialization and systematization.

While reflecting on the concept of classification, in relation to the possibility to connect the task to reality and/or other fields of knowledge, we also identified opposite paths as a result of one undergraduate student's decision not to link the task to reality (strong classification), while the other intern connected the task to a real truffle sale situation involving a classmate (weak classification). Connecting the task to a student's everyday experience fostered a discussion on important mathematical (increasing and decreasing functions; maximum value of functions) and extra-mathematical (profit, revenue and product cost) concepts.

With regard to the transformation of mathematical tasks, the research showed that strengthening classification and framing requires undergraduate students to provide concepts and advance conclusions, whereas weakening classification and framing enables greater student participation in the construction of concepts throughout the involved stages. This result complements findings by Milani (2020), who highlighted appealing to the reality of basic education students as a strategy for transforming an exercise into an investigative task.

We build on the previously mentioned findings by emphasizing the need for interns/undergraduate students to weaken their control over the task as a way to foster student participation and preserve the investigative characteristics of a task. Studies in the field of Chemistry Education have offered similar contributions, emphasizing the importance of implementing pedagogical practices that promote greater student participation in classroom discussions, resulting in more horizontal relationships between teachers and students (Silva et al., 2024).

Conclusion

Through analyzing how mathematical tasks are recontextualized in their implementation in the school context, we identified a favorable environment for developing new content when the intern allows greater student participation and authorizes discussions extended to contexts related to their reality. We consider that ensuring student participation and establishing connections to their reality across all stages (introduction, development, and socialization and systematization) could be a pathway for implementing mathematical tasks in the school context.

The research introduced new discussions in the field of initial teacher education and enhanced the understanding of the use and transformation of mathematical tasks when implemented in the classroom. While theoretical frameworks have indicated a gap between task designers' intentions and how tasks were implemented in the classroom (Lithner, 2017; Smith & Stein, 1998), we have contributed new elements regarding the nature of such transformations. The elements made explicit in a mathematical task and the way in which the topic is approached in it foster the construction of new concepts and connections between mathematics and real-life situations when interns allow greater student participation. In contrast, possibilities are diminished when undergraduate students retain control over the mathematical task, thereby advancing conclusions and providing solutions themselves, rather than enabling students to take a prominent role in the activities proposed by the task.

A summary of the results allows us to categorize transformations of mathematical tasks based on the variation between little or strong connection of mathematics with real-life situations (strong or weak classification) and control over the task by the teacher or students (strong or weak framing). We adopted the title "Precipitating the Mathematical Task" when teachers take control over the task, advance concepts and enable little or no connection between mathematics and real-life-situations (strong classification and framing), and we applied the title "Fostering the Mathematical Task" to situations in which teachers allow students to take a central role and reach their own conclusions regarding the mathematical task. In this case, it is possible to establish connections between mathematics and real circumstances. These ideas have been systematized in Figure 3, as follows:

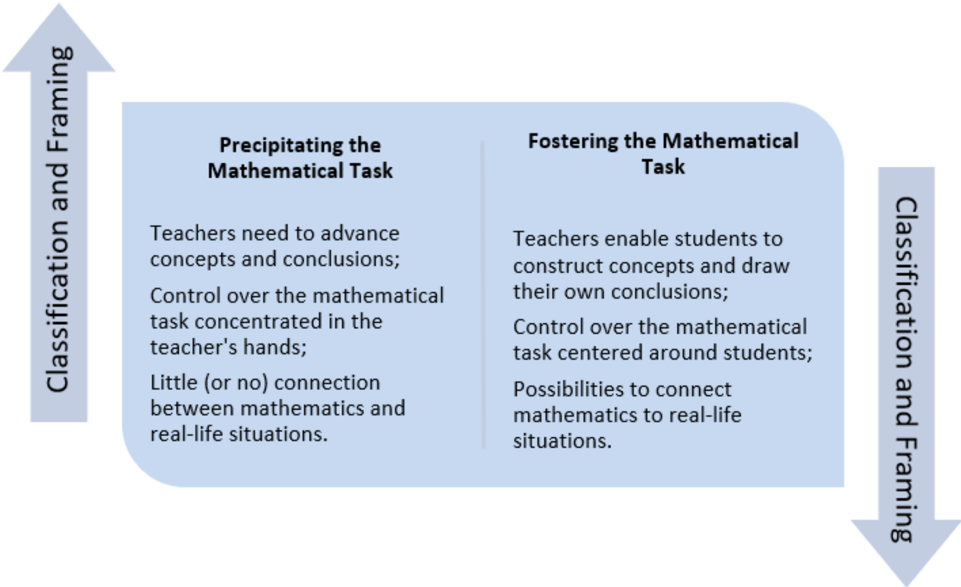

Figure 3.

Transformations of Mathematical Tasks

It is not about eliminating the gap between how tasks are designed and how they are transformed in the diverse contexts in which they are used, because Bernstein shows us that tasks are recontextualized through their use in pedagogical practices. This historically constituted a colonizing stance, reducing (pre-service) teachers to technicians tasked with implementing what curricular material writers have conceived (Barbosa & Oliveira, 2018). This study demonstrated the importance of understanding how transformations may occur in the implementation of mathematical tasks.

It is pivotal to emphasize that variations in classification and framing are possible, such as a strong classification combined with weak framing. In this case, we could consider a task within the context of pure mathematics (strong classification) that allows for active student participation during its implementation in the classroom (weak framing). A study that employed a mathematical task on identifying patterns in a triangular grid (pure mathematics context) concluded that the students were able to find the next terms of a recursive sequence (control over the task centered around the students) (Elias et. al., 2023).

Transformations of tasks involving (pre-service) teachers in basic education contexts are far from over, and additional relevant elements regarding how these transformations occur may emerge in research on mathematical tasks in teacher education. When teachers (or undergraduate students) assume their roles as teachers and learners in the classroom, numerous transformations can be mobilized in tasks based on relationships established within the classroom context, enabling the identification of other forms of recontextualization of mathematical tasks.

In this direction, the principles of this study may also support teacher educators responsible for guiding interns in the selection and use of mathematical tasks in the classroom, aiming to highlight aspects that impact the implementation of tasks in pedagogical practice. Thus, understanding the principles that guide the nature of transformations of mathematical tasks can be pivotal in legitimizing their importance as a resource to enhance student learning and drive large-scale change in initial teacher education.

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