

Cognitive demands of tasks in Mathematics curriculum materials: implications for the teacher's role

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Abstract: The objective of this study, which was reported in this article, was *to analyze the cognitive demands of tasks in curriculum materials and discuss implications for teacher participation in learning situations*. Using a qualitative approach, a documentary analysis was carried out in the Teacher's Manuals of two collections of materials, considering the Algebra tasks and the corresponding teaching guidelines. The analysis was guided by studies on cognitive demands and the role of the teacher in pedagogical approaches. The main results of the 667 tasks analyzed were the predominance of memorization tasks, which may imply learning based on techniques and strategies without mobilization of reasoning; and the role of reproducer, envisaged for the interactions of teachers in teaching practices, which refers to practices that disregard the role of these professionals as agents who mobilize what they know to create opportunities for learning Mathematics.

Keywords: Mathematics Education. Teacher-Curriculum Relationship. Teacher Interactions. Cognitive Demands.

Demandas cognitivas de las tareas en los materiales curriculares de Matemáticas: implicaciones para el papel del profesor

Resumen: El objetivo del estudio presentado en este artículo es *analizar las demandas cognitivas de las tareas en los materiales curriculares y discutir sus implicaciones para la participación docente en situaciones de aprendizaje*. Mediante un enfoque cualitativo, se realizó un análisis documental de los Manuales del Profesor de dos colecciones de materiales, considerando las tareas de Álgebra y sus correspondientes directrices didácticas. El análisis se orientó hacia estudios sobre las demandas cognitivas y el papel del profesor en los enfoques pedagógicos. Como principales resultados, de las 664 tareas analizadas, se identificó el predominio de las de memorización, lo que puede implicar un aprendizaje basado en técnicas y estrategias sin movilización del razonamiento, y el papel de reproductor, previsto para las interacciones de los profesores en las prácticas docentes, que se refiere a prácticas que desconsideran el papel de estos profesionales como agentes que movilizan sus conocimientos para crear oportunidades de aprendizaje de las Matemáticas.

Palabras clave: Educación Matemática. Relación Profesor-Currículo. Interacciones Docentes. Demandas Cognitivas.

Demandas cognitivas de tarefas em materiais curriculares de Matemática: implicações para o papel do professor

Resumo: *Analisar demandas cognitivas de tarefas em materiais curriculares e discutir implicações para a participação do professor nas situações de aprendizagem* é o objetivo que orientou o estudo relatado no artigo. De abordagem qualitativa, foi realizada uma análise documental nos Manuais do Professor de duas coleções de materiais, considerando as tarefas de Álgebra e as orientações de ensino correspondentes. A análise foi orientada pelos estudos sobre demandas cognitivas e papel do professor

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nas abordagens pedagógicas. Como principais resultados, das 664 tarefas analisadas, identificamos a predominância daquelas de memorização, o que pode implicar aprendizagem baseada em técnicas e estratégias sem mobilização de raciocínios e o papel de reprodutor, perspectivado para as interações dos professores nas práticas de ensino, o que remete a práticas que desconsideram a atuação destes profissionais como agentes que mobilizam o que sabem para criar oportunidades de aprendizagem de Matemática.

Palavras-chave: Educação Matemática. Relação Professor-Currículo. Interações Docentes. Demandas Cognitivas.

1 Contextualizing the study

The discussion about levels of cognitive demands in mathematical tasks implicitly includes the presence of curriculum materials in the teaching and learning processes. Before addressing the cognitive levels of tasks, how students manifest their knowledge in solving them, and the role of the teacher, it is necessary to understand curriculum materials and their relationship with Mathematics teachers.

For Remillard (2018), curriculum materials are designed to influence common classroom practices. These materials are designed to act as a guide that helps teachers plan and conduct their lessons; in other words, they have the potential to shape how teaching and learning are done. However, these materials are not solely prescriptive, like a recipe, mechanically inducing what should and should not be done. They incorporate pedagogical ideas; underlying notions that support the approach to content; and guidelines that allow teachers to explore other practices when providing learning opportunities for their students.

According to the author, using curriculum materials requires inherent skills from those who use them. They must be interpreted, as they are inert materials that come to life through those who put them into practice. This happens when the teacher, in contact with the curriculum material, provides students with an approach different from that presented in the material, when they mobilize their knowledge and beliefs to provide students with different learning opportunities.

According to Weisz (2001), teaching and learning are “two processes that communicate but are not confused: the subject of the teaching process is the teacher, while the subject of the learning process is the student” (p. 65). The teacher needs to be aware of the student's learning path, as it is with this knowledge that they will evaluate and select tasks that will enable students to progress in their learning. In this author's words, it is not the learning process that adapts to the teaching process, but the teaching process that adapts to the learning process. That is, they must interact with each other, since for one to occur, the other must also occur.

In the teaching process, the teacher must provide students with learning situations with

problems, exercises, investigation, and exploration so that they engage the use of mathematical concepts, operations, and skills to arrive at an answer or solution (Bueno, Alencar, and Oviedo, 2017; Oliveira and Lopes, 2023). We call these types of proposals tasks, which play a fundamental role in Mathematics teaching, as they are how students consolidate their learning, developing skills, and improving mathematical reasoning.

For Weisz (2001), these proposals can be “activities that represent difficult possibilities, but pose possible difficulties” (p. 67). Such opportunities can be enhanced when the teacher provides students with mathematical tasks that require different types of reasoning, allowing for greater cognitive mobilization.

When implemented in the classroom, tasks must require varying degrees of mental effort and the cognitive skills necessary for their resolution. That is, they must rely on different cognitive levels, from memorization to more complex processes that allow for the development of the ability to make meaningful connections. To achieve this, the teacher must intentionally plan, evaluate, and select tasks, as they can be adapted to require different levels and develop skills, making them an important pedagogical tool for the learning process.

Lesson planning and delivery rely on curricular materials, whether Teacher's Manuals or Student's Books. These materials are used in most public schools to promote learning. As Perovano (2022) points out, “in most public schools, books occupy a prominent position, as they are the foundation upon which teachers build their teaching and learning processes” (p. 24).

In Brazil, the evaluation and distribution of curriculum materials, such as textbooks, are the responsibility of the National Textbook and Didactic Material Program (PNLD) as a public policy. According to Perovano (2022), it is due to this distribution policy that a large volume of textbooks is made available to teachers and students. The Teacher's Manual provides specific information and guidance for teachers, such as teaching guidelines, explanations of content approaches, suggestions for presenting activities, and suggestions for interventions in tasks.

Although teachers interpret the curriculum materials that support their practice, this interpretation will actually occur in the classroom. According to Brown (2009), “all teaching involves a process of design in which teachers use curriculum materials in unique ways as they craft instructional episodes” (p. 18).

When interacting with materials to plan instruction, teachers need to be aware of the different ways these materials present learning guidelines and situations, whether through graphs, illustrations, diagrams, tables, or teaching guidelines. These and other visual resources

help explain concepts and facilitate teachers' understanding of the content, enabling them to read and interpret what the material provides, and evaluate, select, and implement tasks. In Brown's words (2009),

understanding how teachers use curriculum resources to craft instruction requires being explicit about the representations curriculum materials use to communicate concepts and actions, being attentive to the ways in which teachers perceive and interpret these representations, and understanding how these representations can constrain and afford teacher practice. (p. 18)

In this sense, among the resources, we can say that curriculum materials support teachers' practice, incorporate curricular and pedagogical innovations, addressing content from a conceptual, didactic, and methodological perspective, varying approaches and levels of complexity; they present the structure of the lesson and incorporate the type of teacher participation.

As part of a larger research project, the stud⁴ presented here aims *to analyze the cognitive demands of tasks in curriculum materials and discuss implications for teacher participation in learning situations*. In the following sections, we present the cognitive levels in mathematical tasks, the methodological design of the study, and the analysis, concluding the article with considerations.

2 Levels of cognitive demands

Teachers rely on curriculum materials designed to support their teaching practices, but they need to critically and appropriately read these tools. These materials have their own structures and conventions that directly affect the teacher's understanding and pedagogical approach. They have a way of organizing and presenting the content to those who use them. These include the sequence of content, section and chapter titles and subtitles, explanatory texts, visual resources such as graphs and tables, glossaries and footnotes, bibliographical references, exercises and problem situations, practical tasks, teacher tips, assessments, review questions, and more.

For Remillard (2018), curriculum materials are designed to provide information, suggestions, and guidance that aid in curriculum development; in other words, they are intended

⁴ The article is part of Rocha's master's dissertation (2025), developed in the Research Group on Curriculum in Mathematics Education (GPCEEM), defended in the Postgraduate Program in Education at the State University of Montes Claros, Brazil, organized in a multipaper format, written by the first author, supervised by the second author and co-supervised by the third author.

to guide actions and decision-making. We can think of these materials as an extension of the teacher's pedagogical strategies, since this is the tool most frequently used for lesson planning. Teachers select and adapt these materials to align with their teaching objectives and the needs of their students.

Curriculum materials present teachers and students with an essential tool for the learning process: mathematical tasks. They serve as a challenging resource, allowing students to mobilize concepts or form new ones. Tasks should cover a variety of content, from elementary approaches to requiring more complex reasoning. Stein and Smith (2009) state that the nature of the task influences the type of reasoning required to solve it.

When students engage in tasks that require different types of reasoning, they develop their mathematical skills and logical thinking skills. They also develop their problem-solving abilities, which aids decision-making and promotes a more meaningful understanding of concepts and definitions. Therefore, it is important that mathematics instruction provides students with opportunities to engage with tasks that require different types of reasoning.

Students need to solve challenging mathematical tasks that lead them to explore different strategies and approaches, engaging different mathematical reasoning styles. Depending on the task, students may engage logical, deductive, inductive, algebraic, geometric, statistical reasoning, or a combination of these.

Silver and Smith (1996) state that the mathematical tasks students engage in determine not only what they learn, but also how they think, develop, use, and make sense of Mathematics. In this sense, it is important to consider the cognitive level of the tasks assigned to students, especially those presented in curriculum materials. Stein, Grover, and Henningsen (1996) argue that there are tasks that engage students on a superficial level and those that engage them on a deeper level, requiring interpretation, flexibility, resource management, and meaning construction. In other words, there are tasks that require students to have a high cognitive level and tasks that require a low cognitive level. This suggests that the tasks implemented in class have a direct impact on students' learning situations.

According to Stein and Smith (2009), tasks constitute the foundation of student learning. According to these authors, tasks that require a memorized, rote procedure provide a certain type of opportunity for students to reason. On the other hand, tasks that provide situations that lead them to think conceptually, encouraging them to make connections, represent a different type of opportunity for mathematical reasoning.

Mathematical tasks can be classified according to the cognitive demands they place on

students. The classification we use here follows that presented by Stein and Smith (1998). The authors classify tasks as lower-level cognitive tasks — *memorization* and *procedures without connections* — and higher-level cognitive tasks — *procedures with connections* and *doing mathematics*.

Son and Kim (2015) state that tasks that require students to analyze mathematical concepts or allow them to solve complex problems are considered cognitively demanding, or *high-level cognitive tasks*. Conversely, *low-level cognitive tasks* are *undemanding*, relying on memorization and repetition — that is, they offer fewer opportunities for students to engage in cognitive processes. For them, “the types of tasks that involve different levels of cognitive demands largely determine students' learning opportunities” (Son and Kim, 2015, p. 492). Table 1 presents the levels of cognitive demands of mathematical tasks, providing a comprehensive overview of the characteristics of each.

Table 1 – Characteristics of mathematical instructional tasks

<p><i>Lower-level demands (memorization):</i></p> <ul style="list-style-type: none"> ▪ Involve either reproducing previously learned facts, rules, formulas, or definitions or committing facts, rules, formulas or definitions to memory. ▪ Cannot be solved using procedures because a procedure does not exist or because the time frame in which the task is being completed is too short to use a procedure. ▪ Are not ambiguous. Such tasks involve the exact reproduction of previously seen material, and what is to be reproduced is clearly and directly stated. ▪ Have no connection to the concepts or meaning that underlie the facts, rules, formulas, or definitions being learned or reproduced. <p><i>Lower-level demands (procedures without connections):</i></p> <ul style="list-style-type: none"> ▪ Are algorithmic. Use of the procedure either is specifically called for or is evident from prior instruction, experience, or placement of the task. ▪ Require limited cognitive demand for successful completion. Little ambiguity exists about what needs to be done and how to do it. ▪ Have no connection to the concepts or meaning that underlie the procedure being used. ▪ Are focused on producing correct answers instead of on developing mathematical understanding. ▪ Require no explanations or explanations that focus solely on describing the procedure that was used. <p><i>Higher-level demands (procedures with connections):</i></p> <ul style="list-style-type: none"> ▪ Focus students' attention on the use of procedures for the purpose of developing deeper levels of understanding of mathematical concepts and ideas. ▪ Suggest explicitly or implicitly pathways to follow that are broad general procedures that have close connections. ▪ to underlying conceptual ideas as opposed to narrow algorithms that are opaque with respect to underlying concepts. ▪ Usually are represented in multiple ways, such as visual diagrams, manipulatives, symbols, and problem situations. Making connections among multiple representations helps develop meaning.. ▪ Require some degree of cognitive effort. Although general procedures may be followed, they cannot be followed mindlessly. Students need to engage with conceptual ideas that underlie the procedures to complete the task successfully and that develop understanding.

Higher-level demands (doing mathematics):

- Require complex and nonalgorithmic thinking—a predictable, well-rehearsed approach or pathway is not explicitly suggested by the task, task instructions, or a worked-out example.
- Require students to explore and understand the nature of mathematical concepts, processes, or relationships.
- Demand self-monitoring or self-regulation of one's own cognitive processes.
- Require students to access relevant knowledge and experiences and make appropriate use of them in working through the task.
- Require students to analyze the task and actively examine task constraints that may limit possible solution strategies and solutions.
- Require considerable cognitive effort and may involve some level of anxiety for the student because of the unpredictable nature of the solution process required.

Source: Smith and Stein (1998, p. 348)

Analyzing how levels of cognitive demands relate to mathematical tasks and the types of reasoning involved enables Mathematics teachers to create learning situations based on existing knowledge and relationships with curriculum materials. Thus, teachers can plan and select mathematical tasks that encourage students to develop different types of reasoning, according to the learning objectives and expectations of each grade level. Furthermore, teachers can assess the level of difficulty and complexity of the tasks, as well as the degree of autonomy and creativity they require from students.

In the following section, we present the methodological procedures, which allow us to understand the approach taken in this study.

3 Methodological design

Research emerges from the researcher's curiosity and experience; that is, it emerges from a critical eye on their own reality and social interactions. According to Soares (2020), initially, we are confronted with a doubt, a problem, and these begin to challenge us. The challenge of developing classroom work, followed by the experience with private tutoring, has always been evident. Also evident is the availability of curriculum materials to guide Mathematics planning and teaching practices.

These materials play an important role in creating situations that guarantee students' right to learn. Similarly, research on teaching guidelines and resources in Teacher's Manuals is important; these elements, along with other aspects, can contribute to the type of teacher participation in teaching practices. This refers to the role teachers are expected or suggested to assume when implementing tasks. According to Fiorentini and Lorenzato (2012), research is a process of study that consists of the disciplined pursuit of knowledge or understanding about a phenomenon, problem, or issue in reality or present in the literature, which concerns the

researcher. That is, based on questions and objectives, one sets out in search of knowledge that can produce answers.

Research in Mathematics Education is essential to this educational field, as it explores new pedagogical possibilities, new ways of teaching and learning; analyzes teaching materials, curriculum, educational technologies, etc. Research and its results contribute to improving the quality of education, as well as influencing new educational policies that aim to promote a more inclusive and democratic Mathematics Education.

Considering the proposed objective of the study presented here, the research is configured with a qualitative approach. For Fiorentini and Lorenzato (2012), this approach refers to the senses and meanings that can be attributed to the phenomenon under investigation, since the focus of analysis is on understanding subjective aspects. The qualitative approach allows us to analyze, understand, and discuss the extent to which teacher participation may be affected by the level of cognitive demands of mathematical tasks and by teacher guidance texts.

Within this framework, the study considers the analysis of documentary sources, specifically Teacher's Manuals for Mathematics curriculum materials, characterizing a documentary analysis. According to Sá-Silva, Almeida, and Guindani (2009), documentary research is characterized as a procedure that uses methods and techniques to capture, understand, and analyze a variety of documents. According to them, it uses materials that have not yet received analytical treatment; that is, documentary research is based on materials that have not yet been subjected to analysis with a scientific connotation.

For data collection, two collections of Mathematics curriculum materials from the 6th to 9th grades of Middle School were selected, as shown in Table 2. We chose this teaching stage because we work as private tutors, since the greatest demand is from students in grades 6-9. The number of students varies depending on the semester, with some students taking classes throughout the entire academic year, while others seek private lessons solely to reinforce the content before exams. We chose these two collections because they are the ones used by the majority of students taking private lessons with us. To this end, we considered the editions evaluated and distributed by the 2024 edition of the National Book and Teaching Material Program.

These are updated materials, developed based on the provisions of the *Base Nacional Comum Curricular* [Common National Curriculum Base — BNCC] (Brasil, 2017). The Teacher's Manuals were chosen because these materials, in addition to reproducing pages from the Student's Book, also provide guidance for teachers on planning and developing teaching

practices.

Table 2 – Identification of the collections analyzed

ID	Collection	Authors	Publisher	Year of Publication
CM	A Conquista da Matemática [<i>The Conquest of Mathematics</i>]	José Rui Giovanni Júnior	FTD	2022
MR	Matemática e Realidade [<i>Mathematics and Reality</i>]	Gelson Iezzi, Osvaldo Dolce and Antônio Machado	Saraiva	2022

Source: Own elaboration based on data from each collection

Still based on students in the context of private lessons we teach, the analysis of the tasks considers Algebra, as it is the thematic unit they experience the greatest difficulty learning and the greatest need for clarification.

In the following section, we will analyze the Teacher's Manuals from both collections, focusing on the tasks proposed to students and the teaching guidelines for teachers, based on two categories: *levels of cognitive demand in mathematical tasks* and *the role of the teacher*.

4 Analysis

In the Teacher's Manuals, the analysis refers to the resources for implementing the teaching proposals for the Algebra thematic unit, considering tasks, teacher guidelines, and descriptions that characterize the role of teachers in implementing the tasks. Within the tasks, the approach to algebraic content was examined, covering different types: problems, exercises, exploratory-investigative activities, games, among others.

Additionally, special attention was paid to the specific guidance texts for teachers, which are incorporated into the Manuals along with the tasks and presented in an L format, which corresponds to the arrangement, in the Teacher's Manual, of the teaching instructions for the tasks, visually shaped like the letter L.

The *L format*, in the Teacher's Manuals, refers to a specific visual arrangement of the teaching instructions. In this configuration, the instructions for teachers are presented around the page, forming the letter L. This generally means that the instructions occupy the side and bottom margins of the page, while the main content, such as the tasks or activities intended for students, remains centered. This format makes it easier for teachers to consult the guidelines simultaneously while implementing tasks in class, allowing for an integrated view of the content and the guidelines for its approach.

In both collections of curriculum materials (Table 2), the tasks were mapped based on

the skills prescribed in the Base Nacional Comum Curricular (BNCC) for each grade in Middle School. The tasks' statements were carefully read to identify evidence that allowed for the classification of the types of cognitive demands, based on the theoretical framework. Similarly, and considering the corresponding teaching guidelines, we sought evidence to characterize the intended role that teachers assume when implementing the tasks in the classroom. In the *A Conquista da Matemática* (CM) collection, 394 tasks were identified; in the *Matemática e Realidade* (MR) collection, 270 tasks were identified. In total, 664 tasks were mapped.

We will now analyze the Teacher's Manuals for both collections, focusing on the tasks assigned to students and the teaching guidelines for teachers, based on two categories: *levels of cognitive demands* and *the role of the teacher*.

4.1 Levels of cognitive demand in mathematical tasks

Of the total tasks mapped, we classified 237 tasks as memorization tasks — 113 in CM and 124 in MR. The classification considered the cognitive characteristics and mathematical reasoning required of students in their resolution. It is important to note that, in these tasks, the focus is on the mobilization of already formed concepts, requiring the student to employ procedures — expressions, formulas, rules — and the already formed concepts. Furthermore, the task statements clearly reflect the reproduction of the tasks, leaving the student with no doubt about the expected procedures. The statements are objective and direct.

It is worth noting that the mapping of the tasks for later analysis was based on the belief that providing students with tasks that encompass different levels of mathematical reasoning facilitates learning with greater understanding, as well as the mobilization and development of mathematical reasoning. The tasks illustrated in Figures 1 and 2 were classified as memorization tasks, both presenting common characteristics in the sense of being low cognitive demand.

Figure 1 – Example of a memorization task

1. It is known that a and b are two natural numbers such that $a \times b = 237$.
What is the value of the expression $b \times a$?

Source: *A Conquista da Matemática* (6th grade, p. 53)

Stein and Smith (2009) argue that, in tasks with reduced-level approaches, students engage with many similar situations. That is, tasks with this characteristic are presented in greater numbers compared to other levels. Undoubtedly, by providing students with tasks with similar situations, repetition or patterns are observed, which can influence student learning and induce a certain type and level of mathematical reasoning.

Figura 2 – Example of a memorization task

21. If $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$, calculate the value of x for $a = 1$, $b = 5$ and $c = 6$.

Source: Matemática e Realidade (8th grade, p. 94)

A positive influence can be cited as the fact that, when exposed to memorization tasks, students are able to recognize similar properties and procedures, which can lead them to develop problem-solving strategies by identifying important variables, which can promote understanding of the content involved. On the other hand, observing repetition in tasks can lead to demotivation for problem-solving, reducing student participation and engagement in class. Therefore, it is up to the mathematics teacher to observe students' interaction with memorization tasks and make interventions and recommendations to ensure that learning is not compromised.

In the *procedures without connections* tasks, the mapping allowed us to count 105 tasks — 63 in CM and 42 in MR. Classification was possible due to their common characteristics, such as unambiguous statements; a focus on describing the procedure; a lack of requirement for explanations; or the presence of procedure-focused explanation requests. Furthermore, in some situations, the tasks lack any connection to the concepts or meanings related to the procedure used. It is important to note that the classified tasks focus on producing correct answers, not allowing the student to mobilize or develop reasoning about the resolution process. Figures 3 and 4 illustrate this type of task.

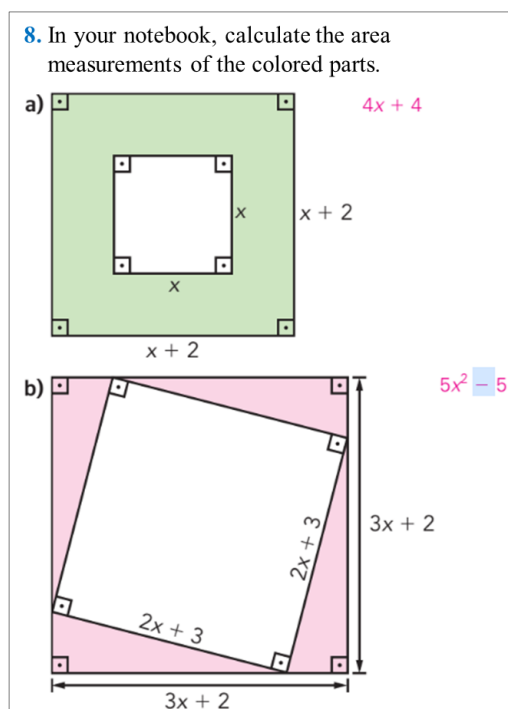
Figure 3 – Example of a procedures without connections task

2. Verify that:
- a) 5 is a root of the equation $4x - 7 = x + 8$
 - b) 10 is a root of the equation $7x + 30 = 10x$
 - c) -6 is a root of the equation $3x - 1 = 11 + 2x$
 - d) -2 is a root of the equation $y^2 - 8 = 2y$

Source: A Conquista da Matemática (7th grade, p. 145)

Note that in the two unconnected procedural tasks, the statements do not emphasize connections with other concepts and uses. Furthermore, when mapping the tasks at this level, we observed common terms and expressions, in which it is necessary to develop, or create, a structured and well-defined method — *determine, verify, indicate, do, understand, apply*, among others, as exemplified in Figure 4.

Figure 4 – Example of a procedures without connections task



Source: Matemática e Realidade (9th grade, p. 53)

It's worth mentioning that, in tasks at this cognitive level, students are asked to present the solution step-by-step. To this end, instructions are presented in the statement; checklists are requested; the focus is on the solution procedure; and they require solution steps focused on algorithms. We have observed that tasks with these characteristics provide students with opportunities to develop specific skills, such as following instructions, using sequences and step-by-step ideas, in addition to enabling them to implement and practice repeated procedures, which can help them feel confident in solving unrelated procedural tasks.

On the other hand, it is important that these tasks be implemented in a quantity similar to that of other cognitive levels so that, when exposed to them, students are better able to form underlying concepts and develop varied reasoning. It is up to the teacher to diversify teaching strategies, integrating different types of tasks so that all cognitive levels are covered in the lessons, which influences the learning process.

When mapping the *procedure with connection* tasks, we found 168 tasks — 129 in CM and 39 in MR. This cognitive level requires students to employ procedures and algorithms in a contextualized manner, connecting and relating them to more general concepts. Analyzing these tasks, we observed that they focus their resolution on procedures and enable students to understand the underlying concepts.

Procedure with connection tasks are those that require students to mobilize concepts

that justify certain procedures. This means that, even though the task requires procedures to be followed, the student must reflect mathematically to proceed with the solution. It is worth mentioning that the tasks classified at this level challenge students, so that they not only perform calculations or follow solution steps, but also understand the meanings underlying the procedures. As an example, we present the tasks illustrated in Figures 5 and 6.

Figure 5 – Example of a procedure with connection tasks

9. The area of the colored triangle inside the following rectangle can be represented by the monomial:

a) $12,5x$. c) $12,5x^2$. e) $6,25$.
 b) $6,25x$. d) $6,25x^2$.

Source: A conquista da Matemática (8th grade, p. 141)

These tasks (Figures 5 and 6), as well as the others mapped in both collections, are those that, in addition to asking the student to perform a procedure, also teach how to perform it; show why it is done and how it can be applied. These tasks not only teach, reinforce, or request specific procedures, but also show how these procedures relate to broader contexts.

Figure 6 – Example of a procedure with connection tasks

7. What numbers should we color in squares A, B, and C so that the sums of the numbers in the horizontal rows and vertical rows are all equal to 1000?

A 229	B 771
771	C 229

Source: Matemática e Realidade (6th grade, p. 109)

Tasks at this level feature characteristics such as contextualization, problem-solving, and investigation-exploration, which can be observed in the incorporation of terms such as *apply*, *analyze*, *solve*, *adapt*, *relate*, *justify*, and others. We emphasize the importance of teachers balancing the teaching of procedures in terms of quantity, as it is necessary to educate and prepare students not only to follow steps and rules, but also to provide opportunities for them to understand the underlying principles of these procedures.

Regarding the tasks at the *doing mathematics* level, 154 were mapped — 89 in CM and 65 in MR. This type of task does not present predictable procedures for resolution, nor do they include instructions to be followed. They explore reasoning, which allows students to develop and express their ideas and notions cognitively. To solve them, students must understand the nature of the concepts, be exposed to relevant experiences, and make appropriate use of their knowledge to develop strategies, perceive properties and relationships, and make discoveries.

Indeed, it is important in the classroom context that tasks at this level be provided to students, as they allow them to participate in the learning process and be the authors of their own knowledge. The doing mathematics level can be exemplified in the tasks presented in Figures 7 and 8.

Figure 7 – Example of a doing mathematics task

A restaurant has x 2-seat tables, y 4-seat tables, z 6-seat tables, and 2 8-seat tables. Write an algebraic expression in your notebook to calculate the maximum number of customers the restaurant can accommodate simultaneously.

Source: Matemática e Realidade (7th grade, p. 184)

Figura 8 – Example of a doing mathematics task

Observe the statement: All roots of the equation $x^2 + \frac{2}{x^2} = 3$, with $x \neq 0$, are real numbers. Is this statement correct? Justify.

Source: A Conquista da Matemática (9th grade, p. 112)

As can be seen, at the *doing mathematics* level, the tasks require students to employ more than just commonly used procedures. In addition to using theorems, operations, and strategies, the emphasis is on developing procedures, which requires creativity and the mobilization of diverse knowledge. These tasks require students to perform calculations, manipulate equations, interpret graphs, perform generalized operations, and use diagrams. Furthermore, they require precision in the procedures to reach the solution.

These types of tasks included the use of terms such as *solving*, *calculating*, *finding*, *demonstrating*, and *proving*. In teaching practices, teachers must diversify their approach to include doing mathematics tasks, as they provide students with the understanding and formation of concepts, as well as a learning process that is not focused on the repetition of procedures.

The mapping of mathematical tasks, considering the analysis based on the levels of cognitive demands, revealed a total of 664 tasks. Of these, approximately 36% were classified as *memorization*. *Procedure without connection* tasks account for approximately 16%, while *procedure with connection* tasks account for approximately 25% of the total. *Doing mathematics* tasks account for 23% of the analyzed set. These data are organized in Table 3 and

provide an overview of the distribution of different levels of cognitive demands in the tasks analyzed.

Table 3 – Number of mapped and analyzed tasks

Level of cognitive demand	A Conquista da Matemática [CM]				Matemática e Realidade [MR]			
	6th grade	7th grade	8th grade	9th grade	6th grade	7th grade	8th grade	9th grade
Memorization	3	10	31	69	4	32	33	55
Procedure without connection	0	6	36	21	0	20	17	5
Procedure with connection	4	19	60	46	5	9	7	18
Doing Mathematics	5	19	49	16	25	25	3	12

Source: Own elaboration based on task mapping

It is pertinent to consider that these data provide relevant information regarding how the analyzed Teacher's Manuals, considering different levels of reasoning, approach mathematical tasks, highlighting the diversity of tasks and varying their cognitive demands. It is clear that the main focus is on memorization tasks, which suggests information retention. That is, these tasks require students to recall formulas, facts, and definitions without necessarily understanding their underlying meanings. We emphasize that, although memorization tasks are important in the learning process, a pedagogical approach focused solely on this level limits students' reasoning and interferes with learning development.

On the other hand, the considerable presence of procedure with connection and doing mathematics tasks indicates that the analyzed Teacher's Manuals demonstrate a promotion of understanding of concepts and their application in various situations, whether in the context of Mathematics, another discipline, or some social aspect. When we, Mathematics teachers, implement mathematical tasks, we provide students with a process of understanding mathematical concepts, which aids reflection and decision-making, empowering them to solve different types of tasks within the context of problem-solving.

In short, providing students with instruction based on a variety of tasks, with diverse cognitive levels, recognizes that learning Mathematics goes beyond performing calculations or exploring memorized procedures, but also understanding the ideas, concepts, and definitions connected to those calculations and procedures. Furthermore, as students are given opportunities to solve different tasks, they gain confidence and increase their ability to face challenges.

In the following section, we examine the type of teacher participation that is expected or evidenced in the presentation of tasks or in the corresponding teaching guidelines.

Participation refers to the expected role teachers will play in implementing the tasks in teaching practices.

4.2 Role of the teacher

This category addresses the different roles teachers can assume when implementing the tasks proposed in the curriculum materials, also considering the respective teaching guidelines incorporated in the Teacher's Manual, which may include: *transmitter*, *reproducer*, *facilitator*, and *coordinator*.

These roles are inspired by the study by Remillard and Kim (2020). These authors state that this set of roles considers how teachers facilitate student engagement with the class, their own learning, and the materials available. Terms and expressions such as *observe task execution*; *encourage students*; *guide*; *ensure*; *explore with students*; *request*; *verify*; *review*; *suggest*; *allow*; and *show* were indicators of the types of roles we identified in the two collections analyzed — *A Conquista da Matemática* (CM) e *Matemática e Realidade* (MR).

As a *transmitter*, the teacher conveys what they know as they lead the class. Furthermore, they present procedures, explain ideas or concepts, and provide answers. For Remillard and Kim (2020), it is in this dimension that the teacher models, explains, and guides students through the steps and procedures. In this dimension, the primary source of knowledge is the teacher.

In the analysis, we cataloged 105 tasks indicating the role of teachers as transmitters in CM and 308 tasks in MR. The largest presence is in the 8th-grade CM volume, with 49 tasks, and in the 7th-grade MR volume, with 36 tasks. The lowest indication is present in the 6th-grade volumes of both collections, with 4 tasks in CM and 14 tasks in MR. The following guideline exemplifies the teacher as transmitter:

Develop the proposed examples in detail with the students, asking them about each step of the factoring process by grouping. Observe how the students respond to these questions related to the factoring process and, if necessary, suggest additional examples, allowing time for them to try to find the solutions on their own. (*Matemática e Realidade*, 9th grade, p. 62)

The highlighted excerpt clearly demonstrates the perceived role of the teacher in the classroom. By suggesting tasks in which teachers assume the role of transmitters, the Manuals ensure that students receive information in a structured and standardized manner. Furthermore, teachers with the autonomy to organize the tasks can implement them gradually, facilitating student understanding and learning. On the other hand, it is important to ensure that students

do not become spectators of the content, lacking interaction, which can influence their engagement with the learning process.

It is important to emphasize that a teacher-centered approach has its advantages in that the teacher can address the content clearly and in great detail. However, it is important to consider the disadvantages regarding student engagement. As transmitters, teachers can restrict students' skill development. Hence, a balanced approach is important, with strategies that encourage student participation and engagement in class.

Regarding the role of *reproducer*, 127 tasks were identified in CM and 152 tasks in MR. The highest number of tasks related to this role is found in the 9th-grade volume of CM, with 47 tasks, and in the 9th-grade volume of MR, with 52 tasks. The lowest number of tasks was found in the 6th-grade volumes of both collections, with 1 assignment in CM and 19 tasks in MR.

In this type of role, teachers are the ones who lead the class, reiterating information, procedures, and answers contained in the supporting materials. In this regard, Remillard and Kim (2020) consider the curriculum material, whether the Teacher's Manual or the Student's Book, to be the source of knowledge. Furthermore, according to them, it is the text that demonstrates, explains, and guides students through concepts and procedures; teachers are responsible for reiterating the information presented in the text, ensuring that students understand what is written and proposed in terms of tasks.

Furthermore, the authors argue that the role of reproducer is similar to that of transmitter, as in both, teachers' participation involves providing information to students. Even though teachers rely on the text as a support, they are the ones who ensure that students understand the information contained in the material. In the following excerpt, it is possible to observe that the material requires the teacher to consider what is described in the task statement, which highlights the focus on putting into practice what is presented in the material, with the teacher acting as transmitter.

In activities 1 through 3, emphasize that the number mentioned in the statement should be understood as something generalized — that is, any number, whose value doesn't initially matter. In activity 4, it's important to emphasize that different quantities, in this case, tables with different capacities, should be represented by different letters. (Matemática e realidade, 7th grade, p. 184).

In the context of the *facilitator* role, teachers involve students in correction and discussion, asking questions or requesting explanations. Furthermore, they facilitate student

interaction with each other and with the task and underlying content; they also intervene when necessary, providing important information and pointing out possible errors or guiding students to perceive properties and relationships. Teachers are the ones who explain ideas and concepts, informing students of their answers.

In the analysis of the Manuals of both collections, we identified 108 tasks in CM and 50 tasks in MR, totaling 158 tasks in which teachers' role as facilitators is considered. We also observed that the highest number of tasks is present in the 8th-grade CM volume, with 45 tasks, and in the 9th-grade MR volume, with 20 tasks.

Remillard and Kim (2020) emphasize that this role positions teachers in a more dialogical dimension, that is, teachers and students are at the center of dialogue, conversation, and discussion. Furthermore, it involves shaping classroom interactions, encouraging students to share their thoughts and solutions, with teachers' role being to guide the learning process.

The following excerpt exemplifies the facilitator role. It demonstrates the teacher's guiding role in organizing conversations and discussions about expressions, suggesting further study if questions remain.

Algebraic expressions can be classified according to the number of terms. Discuss with students the need to simplify expressions, as we can only classify an expression if it is reduced, that is, we must first group similar terms. If they have questions, suggest they look up the prefixes “mono”, “bi”, “tri”, and “poli” in the dictionary and redo the activities, thus seeking interdisciplinarity with the Portuguese Language curriculum. (Matemática e Realidade, 7th grade, p. 190)

In the words of Remillard and Kim (2020), it is through the facilitator role that teachers shape classroom interactions with a series of structured questions designed to stimulate student reasoning or expected responses.

The *coordinator* role, as understood by Remillard and Kim (2020), is also dialogic in nature. Teachers' task is to create an environment in which students model, explain, and discuss strategies, as a community of inquirers. Teachers play a facilitator role, participating less in the discussion, creating the opportunity for students to be the agents, as the following excerpt illustrates.

Encourage mathematical investigation and argumentation as an active methodology in constructing solutions. Ask students to present their results. Thinking about the algorithm used in this procedure fosters computational thinking, as it explores not only the use of the calculator, but also argumentation and investigation. (Matemática e Realidade, 7th grade, p. 184)

In the excerpt, we can observe guidance in which the teacher is described as a coordinator, since the activity suggests that the student use mathematical reasoning and research to solve the task. In this type of situation, the teacher participates by facilitating dialogue with the student.

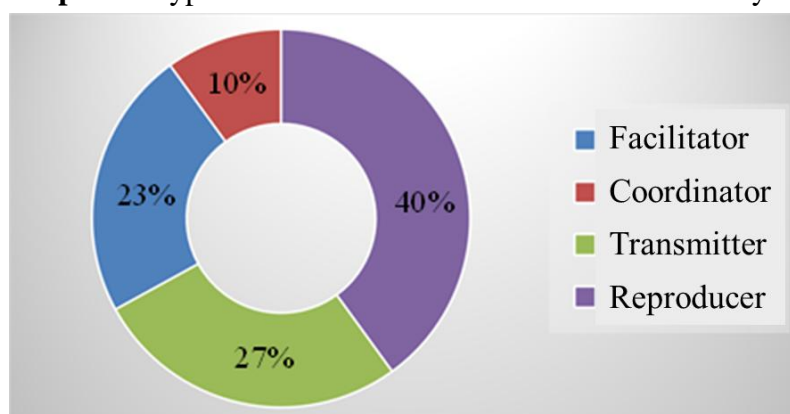
In the tasks analyzed, it was possible to observe a small number of tasks that converge towards this type of role. In the CM collection, there are 46 tasks, and in MR, there are 24 tasks. The largest presence was identified in the 6th-grade CM volume, with two tasks, and in the 8th- and 9th-grade MR volumes, both with two tasks.

By assuming the role of coordinator, teachers encourage students to explore the tasks, stimulating the attribution of meaning and significance to the underlying situations and content, encouraging them to make connections or overcome difficulties in the resolution process. By assuming this role, teachers allow students to be the primary source of knowledge.

Consequently, we see that the role teachers play in the classroom has multiple functions. They are transmitters when they present concepts and procedures; they are reproducers when they reinforce the content, using the Manual as support; they become facilitators when they create an environment for exploration; and they are coordinating teachers when they allow students to organize tasks collaboratively.

Graph 1 shows how the tasks are distributed across the two collections, considering the role teachers are expected to play when implementing them in the classroom. This analysis allows us to understand how each collection guides teaching practice, highlighting different approaches and levels of teacher involvement in developing teaching proposals.

Graph 1 – Type of teacher role in the two collections analyzed



Source: Own elaboration

All these roles that teachers can play in the classroom allow them to observe the student as a whole, considering not only their academic background, but also their social, physical, emotional, and cognitive development. This makes it possible to integrate all dimensions to

promote learning processes with greater meaning and significance.

5 Considerations

With the aim of *analyzing the cognitive demands of tasks in curriculum materials and discussing implications for teacher participation in learning situations*, the study presented in this article shed light on the role of active teacher participation in Middle School. This participation is related to the roles these professionals are led to assume in accordance with recommendations and guidelines incorporated into Teacher's Manuals. It also concerns how they mediate students' task resolutions; the interventions they are guided to make; and the encouragement of critical and collaborative participation of students in the Mathematics learning process.

To this end, an analysis of the levels of cognitive demands in mathematical tasks was conducted in eight volumes of Teacher's Manuals from two collections of curriculum materials, focusing on the implications of these levels for the learning process. In the tasks assigned to students, the degrees of cognitive complexity they demand were identified and discussed, from memorization tasks to mathematical tasks. During the analysis, it was possible to reflect on how cognitive levels can impact the development of students' skills; teachers, as agents responsible for the teaching process, can implement tasks considering homogeneous approaches, thus promoting more meaningful learning processes and enabling students to develop and mobilize diverse mathematical reasoning.

It is important to note that, by diversifying the cognitive levels of mathematical tasks, teachers provide students with different learning opportunities, impacting the development of mathematical skills and reasoning. During class, by adapting tasks to students' understanding levels or by proposing tasks that require different types of reasoning, teachers provide support in implementing tasks that require less cognitive effort, while also encouraging students to develop autonomy with more challenging tasks.

It is in the process of evaluating, selecting, and implementing various tasks that teachers play different roles, from facilitating the understanding of elementary concepts to coordinating student discussions. Undoubtedly, we emphasize the importance of teachers promoting pedagogical flexibility, as this adaptive approach tends to facilitate more relevant learning, focused on concept formation. This can impact how students view the role of mathematics not only in solving tasks, but also as a promoter of reasoning development.

In teaching practices, there must be interaction between teacher and student, and

between both and the tasks to be implemented. Teachers need to interact with their students to understand their learning difficulties, as well as their individual strengths; and they need to interact with mathematical tasks to select those that stimulate students' knowledge and reasoning. It is through these interactions that the teaching and learning processes occur.

Teachers play a fundamental role in student learning. In the classroom, they are responsible for assessing, selecting, and implementing tasks. Therefore, it is important that students have the opportunity to solve different types of tasks, with varying cognitive levels, since exposure to different cognitive levels will imply different reasoning and learning. To this end, reading and interpreting teaching guidelines, as well as evaluating and selecting tasks in Teacher's Manuals and curriculum materials, can provide teachers with insight into differentiated approaches, allowing them to broaden their understanding of Mathematics teaching and the learning it entails.

The analysis and the results presented can be considered a starting point for understanding the role of students in solving tasks; more importantly, they can be used to understand how the different roles teachers can assume enable different modes of student participation, engagement with task resolution, and the development of autonomy in the learning process.

The study allows us to reflect on the need for mathematics teachers to vary the types of tasks they provide to students. There must be a continuous process of reflection on teaching practice and the use of curricular materials, especially when considering materials as a source of knowledge not only for students, but also as a resource that can help teachers build knowledge and expand their understanding of mathematics and its teaching.

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