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Teacher Discourse and Metacognition in Inquiry-Based Mathematics Teaching in the Amazon

Discurso docente e metacognição no ensino investigativo de matemática na Amazônia

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Abstract

This study analyzes the relationship between teacher-monitor discourse and the manifestation of metacognitive incidents in an Inquiry-Based Teaching Sequence (IBTS) in Mathematics developed in a Science Club in the Amazon region. The study is grounded in the perspective of metacognition as a process of monitoring and regulating thinking. A qualitative approach was adopted, based on content analysis of discursive interactions recorded through audio, video, and transcriptions. The units of analysis consisted of speech turns produced by students and teacher-monitors, categorized according to a specific analytical framework. Results indicate that approximately 33% of students' utterances presented evidence of metacognitive incidents, with predominance of confirmation and lower occurrence of monitoring and conceptual change. Discursive strategies such as prompting, scaffolding, revoicing, and counterposition contributed to the mobilization of metacognitive processes, especially in more advanced stages of the inquiry activity. The findings suggest that teacher discourse plays a significant role in

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promoting metacognition, although its effectiveness depends on didactic conditions and the ways classroom interactions are conducted.

Keywords: Metacognition. Inquiry-based teaching. Teacher discourse. Mathematics education. Dialogic interactions.

Resumo

Este estudo analisa a relação entre o discurso do professor monitor e a emergência de processos metacognitivos em uma Sequência de Ensino Investigativa (SEI) de Matemática, desenvolvida em um Clube de Ciências na Amazônia. O estudo fundamenta-se na perspectiva da metacognição como processo de monitoramento e regulação do pensamento. Adota abordagem qualitativa, com análise de conteúdo das interações discursivas registradas por meio de áudio, vídeo e transcrições. A unidade de análise corresponde aos turnos de fala de alunos e professores monitores, categorizados conforme instrumento analítico específico. Os resultados indicam que aproximadamente 33% das falas dos alunos apresentam indícios de incidentes metacognitivos, com predominância de confirmação e menor ocorrência de monitoramento e mudança conceitual. Os dados indicam que estratégias discursivas, como instigação, fornecimento de pistas, reespelhamento e contraposição, contribuem para a mobilização de processos metacognitivos, especialmente nas etapas mais avançadas da atividade investigativa. Conclui-se que o discurso do professor monitor desempenha papel relevante na promoção da metacognição, embora sua efetividade esteja associada às condições didáticas e à forma de condução das interações em sala.

Palavras-chave: Metacognição. Ensino investigativo. Discurso docente. Educação Matemática. Interações dialógicas.

1. Introduction

Over the past decades, the field of education has intensified its critique of traditional pedagogical practices, particularly those centered on the transmission of content and students' passive participation in the learning process. Such practices have revealed limitations with regard to the development of more complex cognitive competencies (Darling-Hammond et al., 2020). In this context, there is an increasing need for pedagogical practices that promote student agency and more meaningful learning experiences (Valente, 2020).

Within this context, metacognition has emerged as a central concept, as it enables students not only to learn but also to reflect on how they learn by monitoring, evaluating, and adjusting their cognitive strategies, as initially proposed by Flavell (1979). It constitutes a fundamental component in the development of meaningful and lasting learning, as it involves individuals' ability to understand and regulate their own thought processes (Panadero, 2022).

In Mathematics Education, this need becomes even more evident, given the persistence of mechanistic approaches that emphasize the reproduction of procedures and results. This scenario calls for approaches that value inquiry, dialogue, and the construction of meaning (Boaler, 2022). From this perspective, inquiry-based teaching emerges as a potentially powerful approach, as it promotes students' active participation and the collaborative construction of knowledge, fostering processes of argumentation and reflection (Artigue; Bloch, 2021).

However, for such practices to be effective, the teacher's role is crucial, particularly with regard to the discursive interactions established in the classroom. Teacher discourse constitutes an important mediating element in the learning process and may foster the development of metacognitive processes (Rocha; Malheiro, 2018).

In the context of the Amazon, investigating educational spaces that move beyond the constraints of the traditional classroom becomes particularly relevant. The Science Club constitutes one such non-formal educational setting, in which experimentation and inquiry serve as foundations for knowledge construction (Malheiro, 2016). It is within this environment that the present study is situated, focusing on the implementation of an Investigative Teaching Sequence (ITS) addressing geometric concepts with sixth-grade students (Silva, 2021).

Thus, considering the potential of inquiry-based activities for the development of metacognition in Mathematics Education, this study aims to analyze how teacher-monitor[1] discourse, within the context of an Investigative Teaching Sequence (ITS), contributes to the emergence of metacognitive manifestations in students' utterances and, consequently, to their learning. The study is grounded in the assumption that the central problem underlying this investigation concerns the influence of teacher-monitor discourse on students' cognitive activity. Accordingly, the study seeks to answer the following research question: **How does teacher-monitor discourse enable dialogic interactions that foster evidence of metacognition among students during the implementation of a Mathematics Investigative Teaching Sequence (ITS)?**

According to Locatelli (2014), metacognitive incidents occur when students interrupt the flow of a task to evaluate their own thinking, either to confirm a successful strategy or to review and correct an unsuccessful course of action. From this perspective, the present study analyzes how teacher-monitors' discourse fosters the construction of dialogic interactions capable of promoting such metacognitive manifestations in activities developed within the context of the Science Club.

2. Metacognition and Learning

The concept of metacognition, initially proposed by Flavell (1979), refers to individuals' knowledge about their own cognitive processes, as well as their ability to monitor and regulate these processes. This concept encompasses metacognitive knowledge, which concerns awareness of strategies, tasks, and personal characteristics, and metacognitive regulation, which involves processes such as planning, monitoring, and evaluation. In contemporary

[1] In the Science Club, the term *teacher-monitor* refers to undergraduate and graduate students from different academic programs who conduct educational activities with the children participating in the Club, referred to as *clubistas*.

approaches, this conception has been expanded through its articulation with self-regulated learning, highlighting its role in the development of more effective and intentional learning processes (Panadero, 2022).

Although metacognition is often defined as "thinking about one's own thinking," this formulation is insufficient to encompass the complexity of the concept. Metacognition is not directly observable; rather, it is a construct inferred from discursive and behavioral manifestations. This characteristic underscores the importance of analyzing classroom interactions as a privileged context for understanding the relationship between metacognition and learning (Rocha; Malheiro, 2019). In this sense, metacognition plays a significant role by enabling students not merely to perform tasks, but also to reflect on their own problem-solving processes, evaluate strategies, and reorganize their approaches. This dynamic contributes to the development of intellectual autonomy and to the construction of more meaningful learning, as students come to understand not only what they learn, but also how they learn (Locatelli, 2014).

When learning is understood as an active and reflective process, metacognition can be regarded as a mediating element in knowledge construction. Situations in which students are encouraged to articulate, justify, and revise their reasoning foster not only conceptual understanding but also the development of more sophisticated cognitive strategies, thereby contributing to learning (Darroz et al., 2018). In the educational context, this discussion is closely connected to pedagogical practices that value student agency and teacher mediation. From this perspective, learning is not reduced to the assimilation of content but involves processes of reflection and regulation of thought, in which metacognition plays a central role by enabling students to understand and reorganize their own cognitive strategies (Valente, 2020).

However, the development of these processes does not occur spontaneously and depends on specific instructional conditions. In Mathematics Education, inquiry-based practices are particularly relevant because they create opportunities for students to formulate hypotheses, test strategies, and discuss results, thereby fostering both conceptual learning and metacognitive development (Boaler, 2022).

Within this context, studies on Investigative Teaching Sequences (ITS) indicate that teachers' discursive mediation plays a fundamental role in articulating metacognition and learning. By employing strategies that encourage students to make their thinking explicit, teachers may foster the emergence of metacognitive incidents, which constitute evidence that students are reflecting on, evaluating, and reorganizing their learning processes throughout the activity (Silva, 2021).

2.1 Metacognitive Incidents in the Educational Context

In the educational field, metacognition has been widely discussed as a fundamental element for understanding learning processes and has been increasingly incorporated into pedagogical practices that value students' reflection and autonomy. From its initial formulations to more recent approaches, there has been a shift from an emphasis on learning outcomes toward the cognitive processes underlying them, particularly in problem-solving contexts (Rosa, 2011). Within this framework, metacognition can be examined through specific manifestations referred to as metacognitive incidents, understood as moments in which students explicitly express, verbally or behaviorally, processes of monitoring, evaluation, or regulation of their own thinking. Such incidents provide access to cognitive dimensions that generally remain implicit, enabling researchers to examine how students organize, monitor, and adjust their strategies throughout an activity (Locatelli, 2014).

These manifestations are directly related to the dimensions of metacognitive knowledge and control, as they involve both awareness of what one knows and the ability to intervene in one's own learning process. By justifying their answers, raising questions, or reviewing their approaches, students demonstrate not only conceptual understanding but also the development of self-regulatory thinking skills (Panadero, 2022). In educational contexts, metacognitive incidents may take different forms, such as confirmation of reasoning, monitoring through questioning, identification of errors, and changes in strategies. These manifestations may reflect different levels of cognitive elaboration, with those involving the revision and restructuring of thought being particularly relevant because they provide evidence of more complex learning processes (Locatelli, 2014).

The analytical relevance of these incidents lies in their capacity to provide access to the dynamic process of knowledge construction, shifting the focus of analysis from the final outcome to the path followed by the student. This perspective contributes to a broader understanding of learning by considering not only whether an answer is correct or incorrect but also the strategies mobilized throughout the activity (Darroz et al., 2018). However, the emergence of these incidents does not occur in isolation, as it is directly related to the interactional conditions established within the learning environment. Situations that foster dialogue, questioning, and active participation tend to increase opportunities for the externalization of thought, thereby enhancing the emergence of metacognitive manifestations (Rocha; Malheiro, 2018). In this regard, the analysis of metacognitive incidents constitutes a relevant means of understanding how learning is constructed in investigative contexts, particularly when articulated with discursive interactions. Investigating such manifestations makes it possible not only to deepen the theoretical understanding of metacognition but also to identify elements that may contribute to the enhancement of pedagogical practices in Mathematics Education (Silva, 2021).

In light of these considerations, the analysis of metacognitive incidents in this study focuses on identifying students' discursive manifestations in problem-solving situations, particularly those that provide evidence of confirmation, monitoring, and changes in strategies. Such manifestations are understood as indications that students are reflecting on their own thought processes, even when this occurs partially or in an unsystematic manner. Thus, by examining interactive episodes within the context of an Investigative Teaching Sequence (ITS), the study seeks to understand the extent to which such evidence emerges in students' utterances and how it is articulated with learning processes in Mathematics (Silva, 2021).

2.2 Investigative Teaching and Discursive Interactions

Investigative teaching constitutes a pedagogical approach that shifts the focus from content transmission toward students' active participation in the construction of knowledge. From this perspective, learning is understood as a dynamic process in which students are encouraged to formulate hypotheses, test strategies, and reconstruct their ideas based on the interactions established throughout the activity (Boaler, 2022). This approach entails a shift in the role attributed to error: rather than being interpreted as failure, error is understood as a constitutive element of the learning process. By making their attempts and misconceptions explicit, students render their ways of thinking visible, creating opportunities for reflection, revision, and conceptual advancement, thereby contributing to more meaningful learning (Locatelli, 2014).

Within investigative teaching, discursive interactions play a central role, since it is through dialogue that students express, confront, and reorganize their ideas. In this sense, discourse is not restricted to the communication of answers but constitutes a space for the shared construction of meaning, in which different perspectives are negotiated and re-signified (Rocha; Malheiro, 2018). In this context, the teacher's role shifts from a transmissive position toward a mediating function involving the creation of conditions that foster students' active participation. This mediation is enacted through intentional discursive strategies, such as prompting, providing cues, revoicing, and counterpositioning, which contribute to broadening and deepening students' thinking (Rocha; Malheiro, 2019).

Providing cues makes it possible to guide students' reasoning without anticipating answers, thereby stimulating cognitive autonomy. Prompting, through open-ended questions, promotes problematization and encourages students to make their ideas explicit. Revoicing enables the reorganization of students' discourse, fostering awareness of their own thinking. Counterpositioning, in turn, challenges immediate responses, encouraging students to review and refine the strategies they have adopted (Rocha; Malheiro, 2019). These discursive strategies contribute to the development of a pedagogical environment that fosters not only conceptual learning but also metacognitive processes. When encouraged to justify, revise, and reformulate their ideas, students may begin to monitor and regulate their own thought processes, revealing the articulation among discourse, interaction, and learning (Valente, 2020).

Thus, investigative teaching, combined with intentional discursive practices, constitutes a potentially productive context for the emergence of metacognitive incidents. This articulation suggests that metacognition does

not develop in isolation but is constituted through pedagogical interactions and is directly influenced by the ways in which the teacher organizes and conducts classroom dialogue (Silva, 2021).

Based on this theoretical framework, the present study analyzes the discursive interactions established during the implementation of an Investigative Teaching Sequence, considering the role of the teacher-monitor's discursive strategies in creating conditions conducive to student participation. Accordingly, classroom episodes are examined in which interventions such as prompting, providing cues, revoicing, and counterpositioning are evident, with the aim of understanding how such strategies contribute to making students' thinking explicit. The analysis of these interactions makes it possible to examine the extent to which teacher discourse fosters the emergence of metacognitive incidents, thereby articulating processes of inquiry, dialogue, and learning within the context of Mathematics Education (Silva, 2021).

3. Methodology

The present study adopts a qualitative research approach, incorporating quantitative elements related to the identification and quantification of metacognitive manifestations (Flick, 2009). It is also characterized as participatory research, given the researcher's active involvement in the setting under investigation and her participation in the development of the activities (Brandão, 2006). The empirical corpus was generated through observation notes, audio and video recordings, and photographic records, thereby providing multiple sources of documentation for the activities. The discursive interactions were fully transcribed and constituted the primary material for analysis.

Data analysis was based on Content Analysis, following Bardin (2016), and was conducted in three stages: pre-analysis, exploration of the material, and treatment and interpretation of the results. This procedure enabled the organization, categorization, and interpretation of the data in accordance with the research objectives. For the analysis of discursive interactions, the analytical instrument proposed by Rocha & Malheiro (2018) was adopted. This instrument enables the examination of teacher discourse in relation to manifestations of self-regulation in students' utterances and was articulated with the contributions of Locatelli (2011, 2014) and Locatelli & Alves (2018).

The study was conducted in a Science Club located in the Northern region of Brazil, characterized as a non-formal learning setting in which sixth-grade students from public schools participate. The activities took place on Saturdays, from 8:00 a.m. to 10:30 a.m., in a setting selected because it favors investigative practices and greater methodological flexibility.

The participants were identified using alphanumeric codes to preserve their anonymity. The student participants were identified as A1 to A8 and organized into two teams: the Triangle Team (A1–A4), mediated by PM1 and PM2, and the Rectangle Team (A5–A8), mediated by PM3 and PM4. In accordance with the ethical requirements of the study, all participants and their legal guardians signed the respective informed consent and assent forms.

Table 1 presents the characteristics of the student participants, while Table 2 presents the characteristics of the teacher-monitors.

Table 1 – Characteristics of the sixth-grade students who participated in the proposed activity

Identification	Age	Sex
A1	10	F
A2	10	M
A3	10	M
A4	11	F
A5	10	F
A6	10	M
A7	10	M
A8	10	M

Source: Researcher (2021)

Table 2 presents the characteristics of the teacher-monitors who participated in this study.

Table 2 – Characteristics of the teacher-monitors

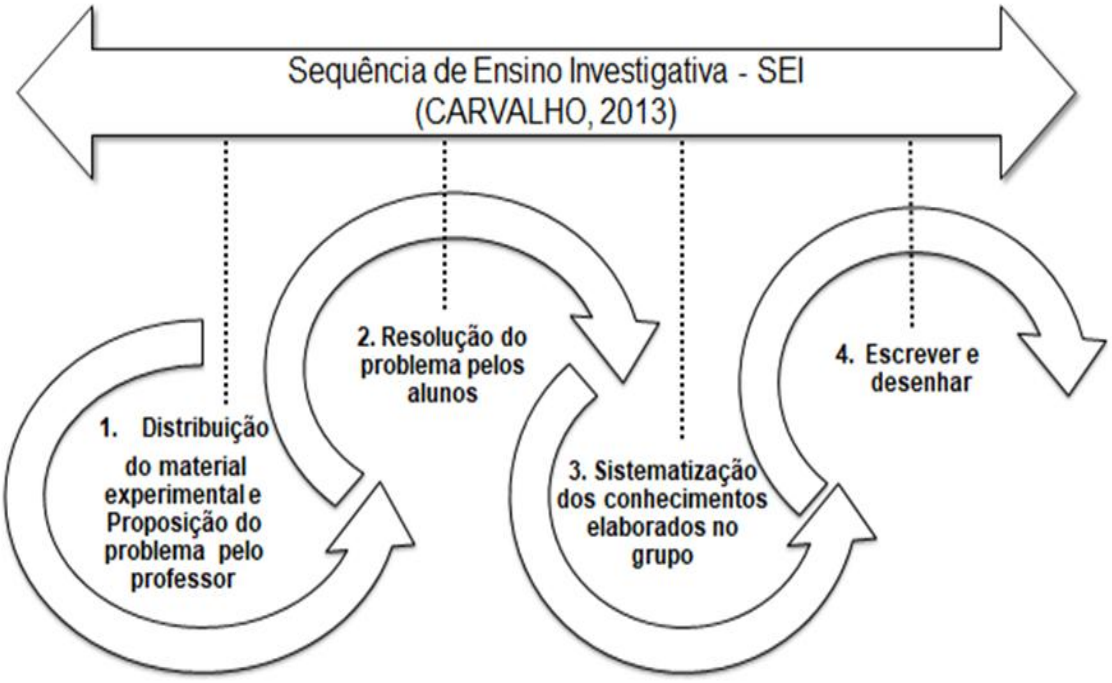
Research participant	Initial teacher education – Undergraduate degree	Time as a teacher-monitor in the Science Club (years)
PM1	Mathematics	6
PM2	Natural Sciences / Physics and Mathematics	4
PM3	Physical Education / Pedagogy	4
PM4	Physics	6

Source: Researcher (2021)

To achieve the research objectives, an Investigative Teaching Sequence (ITS), grounded in Carvalho (2013), was designed and implemented. The sequence was structured into four stages: (i) problem presentation; (ii) group problem solving; (iii) collective systematization; and (iv) individual recording. The sequence was designed to investigate evidence that investigative activities in Mathematics foster dialogic interactions and the emergence of metacognitive incidents, particularly through teacher-monitor discourse.

During the implementation of the ITS, students were encouraged to discuss fundamental concepts of Geometry, such as point, line, and plane. At a later stage, these discussions were expanded to include concepts from Solid Geometry, promoting connections between different levels of abstraction and the understanding of geometric concepts. To this end, we adopted the framework proposed by Carvalho (2013), which is organized into four stages, as shown in Figure 3.

Figure 1 – Investigative Teaching Sequence Based on Four Stages



Source: Adapted from Carvalho (2013).

The following section presents descriptions of these stages.

Stage 1 – Distribution of the Experimental Materials and Presentation of the Problem by the Teacher

At this stage, the teacher organizes the class into small groups, distributes the materials, presents the problem, and checks whether all groups have understood the problem to be solved (Carvalho, 2013). It is important for the teacher to ascertain whether the students have understood the question in order to provide appropriate support at this stage, while taking care not to provide the solution to the problem. It is noteworthy that students' questions should be addressed with further questions rather than direct answers. The teacher should neither provide solutions nor demonstrate how to manipulate the materials to obtain the solution to the problem (Silva, 2021).

Stage 2 – Students' Problem-Solving Stage

At this stage, the focus is not on the concept to be taught, but rather on the manipulative actions that provide students with conditions to formulate hypotheses—that is, ideas for solving the problem—and to test these hypotheses by putting their ideas into practice (Carvalho, 2013). Therefore, what matters are the students' actions: what they manipulate, how they manipulate it, and how they interact with their peers in order to find the desired solution. Even when students initially arrive at an incorrect answer, the process remains relevant because it is through such attempts that they may eventually arrive at the correct answer.

Considering that students have opportunities to construct knowledge through their hypotheses and ideas when these are experimentally tested and prove successful (Carvalho, 2013), students should remain organized in groups during this problem-solving stage. Group work facilitates communication, particularly because this stage involves testing whether ideas and strategies are correct or incorrect. Students are therefore more inclined to communicate with one another, and the teacher should allow them sufficient freedom to conduct their own tests. The teacher's role at this stage is to move among the groups to check whether students have understood the proposed problem and whether they clearly understand what is being asked of them, while allowing them to work independently.

Stage 3 – Systematization of the Knowledge Developed in the Groups

After completing the proposed activity and finding a solution to the problem, the materials are collected to minimize distractions. The teacher then encourages students to leave their group arrangement and form a circle, in which they share the knowledge they have acquired through a broader collective discussion. The question posed by the teacher is: "How did you manage to solve the problem?" The teacher seeks to encourage student participation and lead students to become aware of what they have done. This stage represents the transition from manipulative action to intellectual action (Carvalho, 2013).

For this reason, it is essential to use problematizing and exploratory questions that engage students and encourage them to provide concise and coherent answers, thereby eliciting justifications or causal explanations that promote scientific argumentation.

Stage 4 – Writing and Drawing in Relation to Everyday Life

This is the stage of individual systematization of knowledge. During problem solving, students engage in social learning, first by discussing with their peers and subsequently with the entire class under the teacher's supervision (Carvalho, 2013). At this point, students are expected to express, through drawings and/or writing, the knowledge that was systematized during the previous stages.

The Proposed Investigative Teaching Sequence: Geometric Representations

The ITS, entitled *Geometric Representations*, addressed the concepts of point, line, and plane, which were subsequently expanded to include concepts from Solid Geometry. The activity began with the song *Aquarela*[2] as a strategy for engaging students, followed by the presentation of the problem: "How many lines are needed to build a

[2] **Music available at:** https://www.youtube.com/watch?v=IG1ZU56tsdo. **Accessed:** April 29, 2026.

castle using sticks and modeling clay?" Students manipulated concrete materials, tested hypotheses, shared their strategies, and recorded their conclusions through drawings and written descriptions.

Stage 1

The first stage of the ITS consisted of presenting an investigative problem: "How many lines are needed to build a castle using modeling clay and toothpicks?" This question aimed to stimulate the construction of three-dimensional geometric structures, using the toothpicks to represent edges and the modeling clay to represent vertices. As emphasized by Carvalho (2013), initial problematization is fundamental for introducing students to the content and mobilizing investigative thinking.

Photograph 1 shows the different types of materials used to carry out this activity. The materials provided were modeling clay, toothpicks, and a piece of Styrofoam to serve as a base. It should be noted that the Styrofoam could be used or omitted, since constructions made with toothpicks and modeling clay do not necessarily require a supporting base.

Photograph 2 – Materials Used for the Geometric Representations Activity

Source: Researcher (2021)

Stage 2

In the following stage, the students were organized into groups and began manipulating the materials provided, exploring their characteristics and possible uses. At this point, different attempts to solve the problem were observed, initially involving two-dimensional constructions, followed by a progression toward three-dimensional structures. Error played a relevant role in this process and was understood as a constitutive part of learning, allowing students to test hypotheses and adjust their strategies (Carvalho et al., 2009).

During this stage, the role of the teacher-monitor proved essential, both in ensuring that the students understood the proposed activity and in encouraging the participation of all students. Interaction among the students and encouragement to verbalize the strategies they employed contributed to the externalization of their thinking, fostering the identification of metacognitive elements (Malheiro, 2016).

Stage 3

During the systematization stage, the groups were invited to present their constructions and explain the procedures they followed to solve the problem. This moment enabled the reorganization of ideas and the sharing of knowledge through questions that encouraged reflection on the strategies employed (Carvalho et al., 2009).

During the second meeting, the concepts previously addressed were revisited with the support of videos on points, lines, and geometric figures, including *Introdução à Geometria – Ponto, Linha e Reta*[1] and *As Formas Geométricas – Vídeos Educativos para Crianças*[2]. The latter presents the characteristics of the main geometric figures. The videos addressed fundamental geometric concepts and contributed to students' understanding (Silva, 2021).

Next, the activity progressed to the study of geometric solids through the use of nets made of cardstock. The students were organized into groups and invited to assemble different solids, such as cubes, pyramids, cones, cylinders, and prisms, establishing relationships between plane and solid figures. This stage enabled students to understand that solids can be constructed from two-dimensional figures, as well as to identify elements such as vertices, edges, and faces. Connections with everyday life were explored by associating geometric solids with objects from students' daily lives, such as boxes, bottles, and dice, thereby contextualizing the concepts addressed. According to Carvalho et al. (2009), connecting school knowledge with everyday experiences contributes to the construction of broader meanings.

Stage 4

Finally, during the writing and drawing stage, the students were invited to record their experiences with the activity, describing the problem, the strategies they used, and the solutions they found. This stage is fundamental for consolidating learning, as it enables students to organize their ideas and make their procedures explicit (Malheiro, 2016). In addition, the records were produced in the classroom while the students were still engaged in the activity, enhancing the expression of their experiences (Carvalho et al., 2009).

Analysis of the Dialogic Interactions Involved in Problem Presentation and Material Distribution

For the analysis, the speaking turns were organized according to the sequence of interactions, and episodes of greater relevance to the research objectives were selected. The teacher-monitors' utterances were categorized according to the instrument proposed by Rocha & Malheiro (2018), while the students' utterances were analyzed for the presence of metacognitive incidents, classified as confirmation, monitoring, positive change, and negative change, following Locatelli (2011, 2014). A synthesis of these categories is presented in the following table.

Table 3 – Adapted Instrument for the Analysis of Teacher Discourse

Categorization of Teacher Discourse					
Rhetorical Argumentation					
Exposition			Contextualization		
Socratic Argumentation					
Cueing	Revoicing		Reformulation		Elucidation
Dialogic Argumentation					
Prompting	Counter-positioning	Organization	Recapitulation	Redirection	Evaluative Talk

Source: Rocha & Malheiro (2018)

The students' utterances were analyzed based on Locatelli (2011) and Locatelli & Alves (2018), whose studies address metacognition. For this purpose, four categories were adopted to identify possible evidence of metacognitive incidents in the students' utterances: **confirmation, monitoring, positive change in opinion (+), and negative change in opinion (–).**

- **Confirmation:** refers to an utterance that confirms an aspect of the student's reasoning or strategy.
- **Monitoring:** refers to an utterance expressed in the form of a question or inquiry, indicating that the student is monitoring their own reasoning.
- **Positive change (+):** refers to an incident in which the student changes their opinion or strategy in a direction that is considered favorable to learning.
- **Negative change (–):** refers to an incident in which the student changes their opinion or strategy in a direction that is considered unfavorable to learning.

Table 4 presents an example of how each speaking turn was analyzed.

Table 4 – Categories for Classifying the Nature of Metacognitive Incidents

Speaking Turn/Student	Metacognitive Incident
52/A2: (shows the modeling clay stretched out on the plane and says): "That, this here."	Confirmation
2/A1: "Hmm, could it be 50?"	Monitoring
34/A3: "Because if you put it upright, the 'thing' will fall."	Positive Change (+)
64/A2: "Like this, a line." (gestures with their hand over the structure)	Negative Change (–)

Source: Researcher (2021)

4. Results and Discussion

For presentation purposes, representative excerpts of the interactions were selected, while preserving the identification of speaking turns, students (A1–A8), and teacher-monitors (PM1–PM4). The complete corpus is available in the research transcripts; only excerpts with greater analytical relevance are presented here. The analysis of the data, based on the Content Analysis proposed by Bardin (2016), showed that the discursive interactions established throughout the Investigative Teaching Sequence (ITS) favored the emergence of metacognitive manifestations in students' utterances. Through the categorization of the transcripts, 83 speaking turns containing evidence of metacognitive processes were identified out of a total of 255 analyzed turns, corresponding to approximately 33% of the interactions.

These data reveal the presence of processes involving the monitoring, evaluation, and regulation of thinking, indicating that the dialogic interactions mediated by teacher-monitor discourse contributed to the mobilization of metacognitive strategies within the investigative context. Such manifestations were observed primarily at moments when students were prompted to reflect on their actions, review strategies, and justify their procedures, as evidenced by the episodes analyzed.

These findings indicate that the investigative environment, together with the teacher's discursive mediation, contributes significantly to the development of metacognition by creating conditions that enable students to reflect on their own cognitive processes. To better understand the dynamics of the interactions analyzed, the data were organized according to the stages comprising the Investigative Teaching Sequence (ITS), as proposed by Carvalho (2013).

These stages—problem presentation, student problem solving, collective systematization, and individual systematization (writing and drawing)—structure the development of the activity and guide both the teacher's actions and the students' forms of participation. In this study, these stages were adopted as organizational categories for the analysis, allowing us to examine how, at each stage of the ITS, teacher-monitor discourse is articulated with dialogic interactions and the manifestation of metacognitive incidents.

Stage 1: Problem Presentation

The analysis of the initial stage of the investigative sequence, corresponding to problem presentation, showed that the teacher-monitors' discourse was predominantly characterized by the strategies of prompting, providing cues, redirection, and exposition, according to the adopted categorization.

Exposition was present during the initial moments, particularly in the introduction of the activity and the presentation of the guiding question, functioning as a structuring element of the investigative process. By revisiting the song used as an initial motivational resource, which had been introduced at the beginning of the activity to stimulate students' curiosity and introduce elements related to forms and structures found in everyday life, the teacher-monitor provided a contextualization that fostered student engagement. By implicitly referring to constructions and geometric forms, the song was incorporated into the sequence as a starting point for problematization, establishing connections between mathematical content and the students' cultural context.

This revisiting, articulated with the investigative nature of the activity, enabled students to reconsider their initial understandings and engage more actively in the discussions, highlighting the potential of playful and contextualized resources to foster dialogic interactions. This movement is consistent with Compiani (1996), who emphasizes the role of problematization as a strategy for mobilizing thought. The strategies of prompting and providing cues were the most recurrent throughout this stage, demonstrating the teachers' concern with encouraging student participation and guiding their reasoning without anticipating answers. Prompting was manifested through questions and encouragement intended to promote interaction and student engagement with the activity. Providing cues, in turn, helped guide students' thinking, particularly when they experienced difficulties in identifying the materials or understanding the proposed task.

Redirection, in turn, was used to bring students' attention back to the focus of the activity, ensuring that they remained attentive to the central problem. This strategy proved important given the need to maintain the organization of the activity and ensure students' understanding of the proposed task. Regarding metacognitive manifestations, the results indicate a low incidence at this initial stage, with only one episode identified and classified as monitoring. This incident occurred when one of the students presented an initial hypothesis concerning the number of lines required to construct the castle, evidencing an initial process of reflection on the proposed task (Locatelli, 2014).

The predominance of direct and descriptive responses from the students, such as identifying the materials or repeating the guiding question, indicates that, at this point, the students were still in the process of understanding the activity. This behavior may be associated with the initial phase of the investigative sequence, in which students tend to display greater shyness and less elaborated cognitive responses, as discussed by Carvalho et al. (2009), who emphasize the role of the problem as a gradual stimulus for students' engagement in action.

Thus, although the discursive strategies were fundamental to the organization and conduct of the activity, the problem-presentation stage still showed limited mobilization of metacognitive processes. This aspect can be observed in speaking turn 2, when, in response to the question posed by teacher-monitor PM1, "So, have you thought about how many lines we need to make a castle?", student A1 responds, "Hmm, could it be 50?" This utterance indicates an initial monitoring process in which the student attempts to anticipate an answer, albeit in an uncertain and minimally elaborated manner. However, the low frequency of this type of manifestation suggests that, at this initial point, the students were not yet sufficiently engaged in more sustained reflective processes.

This finding reinforces the understanding that the development of metacognition occurs progressively and is strengthened during later stages of the activity, particularly when students begin to manipulate materials, test hypotheses, and discuss their strategies

Stage 2: Students' Problem Solving

Stage 2 revealed the process of problem solving undertaken by students working in groups, with mediation by the teacher-monitors, making it possible to analyze both the teachers' discursive strategies and the occurrence of

metacognitive incidents during the investigative activity. This process can be observed, for example, when the teacher-monitor asks, “How did you solve it?” (speaking turn 193), encouraging the students to make their strategies explicit. In response, student A5 states, “I said we should work as a team... then we reached the result” (speaking turn 194), evidencing a metacognitive incident of confirmation by recalling and justifying the strategy adopted by the group. Situations such as this demonstrate that discursive interaction, mediated by guiding questions, facilitates the externalization of students’ thinking, making it possible to identify processes of monitoring, evaluation, and validation of strategies throughout problem solving.

Overall, the teacher-monitors’ discourse proved essential to students’ cognitive development, with recurring use of strategies such as **providing cues, prompting, counterpositioning, and remodeling**. These strategies contributed to guiding students’ reasoning, encouraging participation, and eliciting cognitive conflicts that supported the reconstruction of ideas. This finding is consistent with Monteiro and Teixeira (2004), who argue that teacher interventions based on problematization and the counterposition of ideas promote the cognitive confrontation necessary for meaningful learning.

With regard to **metacognitive incidents**, manifestations of **confirmation, monitoring, and strategy change**, both positive and negative, were identified. In the Triangle Team, 11 incidents were recorded across 34 speaking turns analyzed, whereas 10 incidents were observed in the Rectangle Team across 23 speaking turns. These data indicate that, throughout the activity, students began to reflect on their own actions, monitor their thinking, and reformulate strategies in an attempt to achieve the proposed objective, evidencing significant metacognitive processes within the context of investigative learning.

Initially, the students experienced difficulties in understanding the proposed task, which consisted of constructing three-dimensional structures using toothpicks and modeling clay to represent elements of Solid Geometry. Their initial attempts focused on two-dimensional representations, revealing limitations in their understanding of three-dimensionality. In addition, mistakes were observed in the use of the materials, such as inserting toothpicks into the modeling clay without an evident structural function, which compromised the stability of the constructions.

This situation began to change as a result of teacher mediation. When questioned about the role of the materials, as when the teacher-monitor asked, “What were the lines for?” (speaking turn 173), the students began to reorganize their ideas. Progressively, they understood that the toothpicks represented lines and that the modeling clay functioned as a connecting element between them, serving as vertices. This reconfiguration of their understanding enabled the construction of more stable three-dimensional structures, indicating progress in the articulation between practical action and conceptual understanding.

Regarding interaction among the students, low participation and a predominance of brief responses were initially observed. However, throughout the activity, student engagement increased, particularly as a result of the teachers’ interventions, which encouraged collaboration and the exchange of ideas among group members. This movement reinforces the importance of dialogic mediation, in which the teacher organizes and guides interactions in order to foster the collective construction of knowledge, as discussed by Monteiro and Teixeira (2004).

The **elucidation** strategy, identified at specific moments during the activity, also proved relevant by clarifying ideas that were not yet fully comprehensible to the students, corroborating the perspective of Rocha and Malheiro, who emphasize the importance of teacher interventions aimed at conceptual clarification in investigative contexts. On the other hand, some limitations were identified, such as the absence of systematically developed prior knowledge of geometric concepts and the need for greater clarity in formulating the problem situation. These aspects may have influenced students’ initial difficulty in understanding the proposal and progressing more autonomously. This finding is supported by Barbosa (2019), who emphasizes that students bring diverse knowledge and experiences with them, which need to be considered and mobilized before investigative activities are proposed.

Thus, it can be concluded that dialogic mediation, grounded in intentional discursive strategies, was fundamental to promoting metacognition and supporting students’ learning. The investigative activity proved effective in enabling a transition from intuitive conceptions to more elaborated understandings, particularly regarding the development of initial notions of Solid Geometry.

Stage 3: Systematization of the Knowledge Developed in the Groups

Stage 3: Episode 1 – Triangle Team

In the analysis of Episode 1 (speaking turns 162–192), there was a predominance of teacher-monitor discursive strategies associated with dialogic and Socratic argumentation, particularly prompting, providing cues, organization, and revoicing, as evidenced in the interactions established with the students. Prompting appears as a mechanism for initiating dialogue, as in speaking turn 162, when teacher-monitor PM1 states: "Okay, let's go. You can talk. Feel free to talk about what you did." In response, in speaking turn 164, student A2 describes the process undertaken: "I took the modeling clay, turned it like this (...) and put the toothpick inside. A3 did it lying down and it didn't work... then we saw that it had to be like this," evidencing a process of revisiting the action and recognizing errors and adjustments, thereby characterizing a metacognitive incident of confirmation.

Providing cues is also present in the interaction, as in speaking turn 163, when PM1 asks, "How did you start?", prompting the students to make the initial process explicit. This strategy reappears in speaking turn 181: "What method did you use to count?", directing the students' reasoning toward the systematization of the strategy adopted. Organization of thought can be observed in speaking turn 165, when PM1 asks, "But how did you understand that it had to be like this?", encouraging the students to structure their ideas. In this context, in speaking turn 166, student A4 responds, "We had the modeling clay to stick the toothpicks together," evidencing a functional understanding of the materials and constituting another confirmation incident.

Revoicing, in turn, appears when the teacher revisits and validates the students' utterances, as in speaking turn 171: "To connect the toothpicks, and what were the toothpicks?" and in speaking turn 185: "Counting together, right?", reinforcing and reorganizing the students' discourse. Despite these interactions, most of the students' responses remained limited to short and minimally elaborated statements, such as "To connect the toothpicks" or "The lines," indicating limited explicit articulation of metacognitive processes. This scenario suggests that, although the teacher's discourse supports participation and the organization of reasoning, the process of cognitive monitoring remains incipient, indicating the need for strategies that promote greater reflective depth.

Stage 3: Episode 2 – Rectangle Team

In Episode 2 (speaking turns 193–235), greater dynamism was observed in the interactions, with a predominance of discursive strategies associated with dialogic and Socratic argumentation, including prompting, providing cues, revoicing, organization, counterpositioning, and remodeling. Prompting was evident from the beginning of the interaction, as in speaking turn 193, when teacher-monitor PM3 asks, "How did you solve it?", followed by speaking turn 195: "How did you start?" In response, in speaking turn 194, student A5 states, "I said we should work as a team... and we

reached the result," evidencing a metacognitive incident classified as confirmation, as the student recalls and validates the strategy adopted by the group.

Providing cues was used to guide the students' reasoning, as in speaking turn 197: "How were you using the modeling clay?" and speaking turn 203: "And what are lines for you?", leading students to articulate concepts and procedures explicitly. This strategy became more pronounced in speaking turn 216: "How did you reach the conclusion that it was 97?", encouraging reflection on the problem-solving process. Revoicing appeared as a means of validating the students' responses, as in speaking turn 222: "Conclusion" and speaking turn 228: "We need to, right?", reinforcing and reorganizing the students' utterances. Organization of discourse occurred when the teacher structured the students' thinking, as in speaking turn 207: "Do you already have a concept of what a line is?"

The use of counterpositioning and remodeling is also noteworthy, as in speaking turn 214: "And then? After that, you counted and how many did you get?" and speaking turns 218 and 220: "Were they the same or different?"; "We need to do it a third time...". These strategies prompted students to revise their ideas and apply greater rigor to their reasoning. Regarding metacognitive incidents, greater diversity was observed. In speaking turn 198, student A7 states, "Everyone was doing it their own way... then we started doing it together," evidencing confirmation by recognizing the change in strategy. Monitoring is evident in speaking turn 232, when A7 asks, "To know things?", expressing doubt and seeking validation. In speaking turn 234, by stating, "If we do something wrong, we can fix it," the student demonstrates a positive change, indicating a restructuring of thinking based on reflection on error.

These data indicate that, in this episode, teacher discourse—particularly through strategies such as counterpositioning and remodeling—not only increased student participation but also fostered the emergence of more elaborated metacognitive processes, especially at moments when students were encouraged to revise strategies and justify their responses. This highlights the importance of teacher mediation in promoting reflection on one's own thinking.

Stage 4: Writing and Drawing

In the "writing and drawing" stage, understood as the moment of individual systematization of knowledge, according to Carvalho (2013), students were invited to record their understandings of the activity through writing and drawing. This stage facilitates the explicit articulation of students' thinking and enables the identification of evidence of metacognitive processes, as discussed by Rosa (2011).

The analysis of the monitoring forms revealed a predominance of **confirmation-type metacognitive incidents**, particularly in responses related to the strategies employed, the materials used, and connections with everyday situations. Students A1, A3, and A5 demonstrated the ability to revisit actions performed during the activity, recognize strategies that had been successful, such as teamwork and organization of the materials, and establish relationships with prior knowledge, including geometric shapes and everyday situations.

On the other hand, difficulties were observed in accurately identifying the name of the activity and formulating the proposed problem, suggesting possible limitations in the process of deeper reflection on the objectives of the task.

In addition, the limited evidence of monitoring and the absence of negative changes may indicate that more complex dimensions of metacognition, such as regulation and critical evaluation, have not yet been fully developed, as pointed out by Flavell (1979).

Overall, this stage contributed to consolidating learning related to geometry and collaborative work, while also enabling students to externalize their understandings. However, the data indicate that metacognitive manifestations remain concentrated at more descriptive levels, reinforcing the importance of pedagogical practices that encourage deeper reflection, monitoring, and regulation of one's own thinking.

5. Concluding Remarks

The present study aimed to analyze how teacher-monitor discourse, within the context of an Investigative Teaching Sequence (ITS), enables dialogic interactions capable of fostering the emergence of metacognitive incidents in students' utterances. The analysis indicates that this relationship is consistently manifested in the data examined, although not homogeneously and amid tensions inherent in the teaching and learning process.

Overall, the findings show that teacher discourse, when grounded in strategies such as prompting, providing cues, revoicing, and counterpositioning, creates favorable conditions for students to externalize aspects of their thinking, thereby enabling the emergence of metacognitive incidents. In this regard, the research question is addressed by demonstrating that these intentionally guided dialogic interactions act as facilitating conditions that enable students to monitor, confirm, or reformulate their ideas throughout the activity.

However, the results also reveal important limitations. The predominance of confirmation-type metacognitive incidents suggests that, although students are able to validate the reasoning they have constructed, they still experience difficulties in progressing toward more complex forms of thought regulation, such as systematic monitoring or critical revision of strategies. This points to a possible predominance of metacognitive manifestations at more descriptive levels, which do not always reflect a deeper reflective process but, in some cases, may represent the reproduction of responses guided by teacher discourse.

Furthermore, it was observed that metacognition is not always fully verbalized, which imposes limitations on the analysis itself. Moments of silence, brief responses, or hesitations indicate that metacognitive processes may have occurred without being explicitly articulated. This aspect reveals a relevant methodological challenge: reliance on oral language as the primary source of evidence of metacognition may constrain the understanding of the phenomenon, making it necessary to employ multiple instruments for data collection and analysis.

The individual systematization stage, through "writing and drawing," proved particularly important in this context, as it provided access to records that did not emerge during oral interactions. Nevertheless, it also revealed weaknesses, particularly students' difficulties in accurately articulating the proposed problem or conceptually systematizing

the activity undertaken. This suggests that, although there were advances in the construction of meaning, gaps remained in the formalization of knowledge.

Another critical point concerns the role of the teacher-monitor. Although their interventions were fundamental to promoting interactions, at certain moments, excessive intervention or overly directive guidance may have limited students' autonomy, reducing the space available for the spontaneous development of strategies. This finding reinforces the need to strike a balance between mediation and openness to students' thinking, which is central to the effective development of metacognition.

Thus, it can be concluded that investigative teaching, combined with intentionally structured teacher discourse, constitutes a potentially favorable environment for the emergence of metacognitive processes. However, such processes do not manifest themselves linearly, nor can they be fully captured solely through observable discursive interactions. Metacognition therefore emerges as a complex, situated, and only partially accessible phenomenon, requiring analytical caution and methodological refinement.

The study points to the need for further investigation into the conditions that foster more elaborated metacognitive manifestations, as well as into teacher education for work in investigative contexts. It also highlights the importance of expanding strategies that encourage students to make their thinking explicit, reducing reliance on immediate responses and promoting greater intellectual autonomy. In this regard, the relationship among teacher discourse, dialogic interaction, and metacognition remains a fertile yet insufficiently explored field, requiring further research that is more theoretically refined and methodologically diverse.

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