



## Communication in the Mathematics classroom: a teacher-researcher's perspective on the literature review

### Comunicação na aula de Matemática: revisão da literatura na perspectiva do professor pesquisador

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#### Abstract

This article originated from a teacher's research about her practice. It presents a literature review of research focused on communication in mathematics classrooms. The article has two aims: 1) To outline the theoretical and methodological approaches and the main results of the research in the field; 2) To analyze the meanings that the literature review acquires when developed as part of a teacher's research. The results reveal the complexity of transforming communicative processes in the mathematics classroom and the potentialities of collaboration and reflection to support these processes. The analysis shows that, when conducted as part of a teacher's research, the literature review allows to situate the new research in the field and provides relevant insights concerning the teaching practice that will be the object of analysis. Thus, one contribution of the article is outlining the potentialities of teachers' research as a way for producing valid knowledge in education.

**Keywords:** Teacher's research; Literature review; Communication in the mathematics classroom.

#### Resumo

Tendo origem em uma pesquisa desenvolvida por uma professora-pesquisadora, o artigo apresenta uma revisão sistemática da literatura com foco na comunicação na aula de matemática. O trabalho persegue dois objetivos: 1) Delinear as perspectivas teóricas e metodológicas e os principais resultados das pesquisas na temática; 2) Analisar os sentidos que a revisão de literatura adquire quando é desenvolvida no marco de uma pesquisa do professor. Os resultados apontam a complexidade da transformação da comunicação na aula de matemática e as potencialidades da colaboração e da reflexão para sustentar esses processos. A análise revelou que, na pesquisa do professor, a revisão de literatura permite situar a nova pesquisa no campo de investigação assim como dar importantes subsídios à prática de ensino que será o objeto da pesquisa. Assim, o trabalho contribui a desvendar as potencialidades da pesquisa do professor como forma de construção de conhecimento válido no campo educacional.

**Palavras-chave:** Pesquisa do professor; Revisão sistemática de literatura; Comunicação na aula de matemática.

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## Introduction

Learning and teaching mathematics within a classroom is undoubtedly a strongly communicative process. In this framework, the problem of communication in the mathematics classroom has generated numerous researches in the field of mathematics education, (Alrø & Skovsmose, 2010; Guerreiro et al., 2015; Martinho, 2009; Ponte et al., 2007; Skovsmose, 2014, among others), becoming, moreover, object of attention of curriculum documents (Menezes 2010). Thus, several authors have pointed out that the types and qualities of communication that are established in the classroom have a strong influence on the mathematical learning produced (Alrø & Skovsmose, 2010; Guerreiro et al., 2015; Freire, 2015). This perspective reveals that classroom communication is much more than a simple act in which the teacher transfers knowledge to the student; it is “a process of interaction, in which mathematical knowledge is socially constructed” (Guerreiro et al., 2015, p. 1). The importance of communication in the mathematics classroom is also highlighted in the Common National Curriculum Base (BNCC for its initial in Portuguese) when referring to its relevance for the development of the competencies of the area:

for the development of skills involving reasoning, it is necessary that students are able, in interaction with their peers and teachers, to investigate, explain and justify the problems solved, with emphasis on mathematical argumentation processes (MEC, 2018, p. 529)

Thus, based on the communicative possibilities established in the classroom, it is possible to favor mathematics teaching and learning processes permeated by argumentation, explanation, investigation, and justification. In contrast, research shows that communication in the mathematics classroom often takes a unidirectional form, dominated mainly by the teacher who, using closed questions, offers rare opportunities for students to communicate their ideas and opinions (Alrø & Skovsmose, 2010; Martinho & Ponte, 2005; Menezes, 2010; Viseu & Ponte, 2012). The disruption of this communicative dynamic and the establishment of dialogic communicative forms constitutes a great challenge for many teachers.

All these points, raised by research in the field of mathematics education, were experienced by the first author of this article, Salgado, in her position as a public-school mathematics teacher. Specifically, in the year 2019, and after several experiences of implementing tasks of investigative nature in her classroom, Salgado realized that she had difficulty in provoking discussions that would develop her students' argumentation and interpretation (Salgado, 2021). Thus, she understood that in order to meet the BNCC and the points raised by the research it was not enough to just implement investigative tasks in her classroom. She needed to learn to establish new ways to communicate with her students.

Faced with this challenge, she decided to focus her master's thesis on the analysis of the forms of communication that were established between her and her students, when she invited them to participate in a landscape of investigation focused on Financial Education. Thus, the present article originated from a research developed by a teacher-researcher, Salgado, under the supervision of Leticia, the second author of this article. The research

assumed, initially, that mathematical communication in the classroom is a process of face-to-face social interaction based on communicative exchanges among students and between students and the teacher. Thus, the research did not include other perspectives on communication also used in mathematics education, such as semiotic and those related to the use of technological tools. It is important to say that we, the authors, participated in the Saturday Group (GdS, initials in Portuguese), a collaborative group integrated by “Basic School teachers, pre-service teachers, postgraduates, and University Educators, interested in studying, sharing, discussing, investigating, and writing collaboratively about the practice of teaching and learning mathematics in schools” (Carvalho, Longo & Fiorentini, 2013, p. 7). Thus, the research that gave rise to the present article was developed from our participation and collaboration in two communities that establish strong relationships between school and university: the GdS and the Professional Master's Program in School Education offered by the School of Education (State University of Campinas).

Being a process of intentional, planned, and methodical study about a problematic issue of his teaching practice in school, Salgado's research can be characterized as a teachers' research (Fiorentini & Lorenzato, 2012). Being an investigative process, teachers' research involves four main moments: the formulation of the problem and the research questions; the collection of elements that allow answering the questions; the interpretation of the information collected, and the dissemination of the results (Ponte, 2002). One of the quality criteria proposed for teachers' research is dialogic quality, which examines whether the research has established dialogues with other authors in the community of reference (Ponte, 2002). Thus, this article originates from the first phase of the research, when Salgado initiated a systematic review of the literature to find out what other authors have studied about communication in the mathematics classroom.

In recent years, several authors have pointed out the potential of research on teaching practice within professional development initiatives such as professional master's degrees (Cevallos & Passos, 2012; Losano & Fiorentini, 2021; Pires & Iglioni, 2013; Sousa, 2013). When teachers from school and university collaborate to develop research on teaching practice in these spaces, both have the opportunity to "resignify the discourses and practices coming from the classroom and the academic community and to produce continuities and ruptures with the practices coming from the world of mathematics teaching in school" (Losano & Fiorentini, 2020, p. 388). These potentialities bring to the forefront the need to better understand what the epistemological and methodological characteristics of teachers' research are and what are its similarities and differences with other types of research. According to Ponte (2002),

There is still a long way to go before this type of research can assert itself, deepening its epistemological foundation, perfecting its quality criteria and, above all, showing with good examples its value and potential as an instrument of professional development, of educational change, and as a way to build valid knowledge about education (p. 23).

This paper aims to contribute to this debate by analyzing the role of literature review

in teacher's research. According to Becerra (2004), the literature review is a fundamental step in formulating the research problem in any investigation. The author emphasizes that the role of the literature review can be understood on three major levels. First, it allows the researcher to appropriate the knowledge already produced around the topic he or she wishes to investigate. Second, it is an opportunity to investigate one's own field of research, delimiting the theoretical and methodological perspectives and approaches used by other authors who have researched the subject. Third, the literature review is a "starting point for the unprecedented" (p. 39), that is, an opportunity for the researcher to establish a new path that, considering the knowledge already accumulated, seeks unprecedented answers that "generate possibilities of an expanded future in the investigative scenario" (p. 29). Considering that Becerra's characterization was developed in relation to academic research, it is possible to formulate some questions such as: when it comes to teachers' research, does literature review acquire the same meanings? Does (some of) it (they) takes on new dimensions? Is it possible to suggest new meanings for the literature review in this type of research? In this paper we seek answers to these questions based on Salgado's experience as a teacher-researcher.

In summary, this work pursues two main goals located on different planes. On a first level, it aims to conduct a systematic literature review of scientific articles focusing on communication in the mathematics classroom. Such a review seeks to outline which theoretical and methodological perspectives have been employed to investigate communication in the mathematics classroom and to present the main research findings. In a second level, the article aims to analyze the meanings that the literature review acquires when it is developed in the framework of a research conducted by the teacher about his/her own practice.

### **Methodological Choices: the study's trajectory**

According to GEPFPM (2018, p. 241), systematic literature review is a qualitative research modality "used when the researcher seeks to systematize the results (i.e., the knowledge) produced in a particular field of study or research theme over a period of time." Thus, this approach seeks to reveal the dimensions of a given problem that have been highlighted or privileged in scientific productions at a given time and place, highlighting both the advances made and possible gaps that demand new investigations. When embarking on this investigative effort, the researcher "is driven by the challenge of getting to know what has already been built and produced, and then seeking what has not yet been done" (Ferreira, 2002, p. 259). In our case, we intended to build a panorama of research around communication in the mathematics classroom, in order to locate the research that Salgado was starting, as well as identify what could be the new contributions that such research could bring to the field of mathematics education.

For the development of the systematic literature review we adopted "a methodical and rigorous process of searching and selecting primary sources, collecting data/information, analyzing/interpreting, and systematizing and producing integrative syntheses of the evidence

found" (GEPFPM, 2018, p. 235). We describe such process below.

### *Construction of the documentary corpus*

The starting point for conducting a literature review is the establishment of a question that will guide the search and selection of the *corpus*. In our case, the question was formulated as follows: what do the scientific articles published in the period 2007-2021 tell us about communication in the mathematics classroom? We chose to build our documentary *corpus* from the articles included in the Scielo Library<sup>3</sup>, because it is an open-access electronic library that incorporates scientific journals published in several Iberoamerican countries and is supported by several national and international institutions for scientific development.

The definition of the studies that would be included in the *corpus* was conducted in three phases: *search, first selection, and second selection*. The first phase consisted of a search for articles published in Scielo, written in Portuguese or Spanish, by combining the keywords "Communication", "Mathematics", "Teacher" and "Communication in the classroom". In total, three searches were performed. Table 1 shows the total number of articles found in this first phase<sup>4</sup>. It is important to note that many articles appeared on multiple occasions, so that the results of each search were not disjoint.

Table 1: Productions found in the search phase

Keyword used	Step 1: Search
Communication, Mathematics, Teacher.	16
Communication, Classroom, Mathematics.	14
Communication, Math.	65

Source 1: Prepared by the authors

In *the first selection*, we read the titles and abstracts of all articles, selecting those that were specifically linked to communication in the mathematics classroom. Thus, we eliminated all articles that took Information and Communication Technologies as the object of study, as well as those belonging to other areas of education that had been shown as results in the previous phase. As a result of this work, we selected only eleven articles.

Considering the goal of Salgado's research, in the second selection we chose articles

<sup>3</sup> Scielo – Scientific Electronic Library Online: <https://scielo.org/>

<sup>4</sup> The search for articles was conducted on two occasions. The first in March 2020, when Salgado was writing the literature review chapter of his dissertation. At that time, the period from 2010 to 2020 was considered. In June 2021, when this article was being written, we felt the need to conduct a new search in order to consider possible new publications and expand our repertoire. So we conducted the search again, this time extending the period until 2021. The results we show in this article correspond to this second search.

that brought an analysis of dialogues between teacher and student and/or between the students themselves when they were working around a mathematical task in the classroom. This meant excluding articles that considered communication in virtual environments. In addition, we disregarded papers in which future teachers analyze dialogues between a teacher and his/her students captured through videos or audio recordings as part of an activity within pre-service education. To make the selection we read the methodology and analysis sections of the eleven articles selected in the previous stage, and some articles had to be read in their entirety. In this phase we chose six articles.

Finally, we decided to include in the *corpus* three more papers, two articles published in journals - Planas and Iranzo (2009) and Martinho (2013) - and one book chapter - Ponte, Pereira and Quaresma (2017) - with which we had previously had contact. The main reasons justifying the inclusion of these works are: they meet the criteria applied to select articles in the Scielo base; they appear cited in other articles consulted, and/or they analyze aspects of communication in the classroom that had not been addressed in the previously selected articles.

With this, we gathered nine articles to compose our *corpus*: Ferruzzi and Almeida (2012, 2015); Martinho (2013); Milani (2020); Planas and Iranzo (2009); Ponte, Pereira and Quaresma (2017); Ponte et al. (2007); Ribeiro, Carrillo and Monteiro (2012), and Serrazina and Ribeiro (2012).

### *Analytical Procedures*

The analytical process began with the reading, in full, of all articles. Then, we searched the articles, considering their objectives, context, theoretical perspective, methodological perspective, and the main results of each research. This first analytical step allowed us to understand the paths taken by each author and to delineate the contributions of each article.

In turn, the study of the articles allowed us to delineate categories to group them. From these categories, besides highlighting thematic or methodological tendencies present in the *corpus*, we could identify more clearly how each of the papers could contribute to Salgado's research. We grouped the papers into two categories. On the one hand, two papers dealing with the communication established in the classroom of novice teachers<sup>5</sup> (Milani, 2020 and Ponte et al., 2007) and, on the other, seven papers focusing on the experienced teachers<sup>6</sup> (Ferruzzi & Almeida, 2012; Ferruzzi & Almeida, 2015; Martinho, 2013; Planas & Iranzo 2009; Ponte, Mata Pereira & Quaresma, 2017; Ribeiro, Carrillo & Monteiro, 2012; Serrazina & Ribeiro, 2012). In turn, the second category was divided into two subcategories: three papers that bring analyses on the communication throughout a whole classroom activity and four papers that focus the analyses on the communication developed in a specific part of

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<sup>5</sup> A novice teacher is one who is experiencing his/her first five years as a teacher.

<sup>6</sup> An experienced teacher is one who has been teaching for more than five years.

the mathematics lesson.

In the next section, we present the analysis of the articles organized according to the categories and subcategories listed above. In order to achieve the first objective of this article, we present an interpretative synthesis of each article, describing the objectives, the context, the theoretical and methodological perspectives, and the main results of each research.

### **Key highlights from the literature review focusing on communication in the mathematics classroom**

#### *Research that focusses on pre-service education and novice teachers*

Ponte et al. (2007) investigated how newly qualified teachers orient communication in their classrooms and what difficulties they face. Using a qualitative approach, the authors observed the classes of 12 novice teachers who taught in the 1st, 2nd, and 3rd cycles of basic education in Portugal<sup>7</sup>. Two interviews were also part of the data collected. The first one of a reflective nature, was about lesson planning and how it actually happened. The second one focused on the professional trajectory of novice teachers and their perspectives on teaching-learning.

The authors decided to privilege three perspectives related to communication. Firstly, *communication as a tool for teacher regulation*, focuses on the moments when the teacher poses questions that propitiate the development of the student's orality in the classroom, for example, "What will the surfaces of a cube look like?", "Why don't they roll?". With this, (s)he opens space for the student to express her ideas and be able to construct his own reasoning to solve a given situation. Secondly, the *development of students' communicative skills* (oral and written). It refers to the way the teacher welcomes the students' insecurities and helps them become stronger and move forward during the learning process. Thirdly, *communication as a support for the development of mathematical meanings and ideas*, focuses on moments of socialization. Such moments allow groups of students to present the reasoning they have constructed to develop a given classroom task. In this way, the teacher gives students the opportunity to discuss and argue with each other, defending their own ideas and questioning those of others.

From this analysis, Ponte et al. (2007) realized that the newly trained teachers involved in the study "recognize, in one way or another, that they play a key role in regulating communication in the classroom" (p. 68). However, not all of them realized the importance of encouraging their student to expose their thinking with challenging questions that stimulate mathematical thinking, thus allowing them to identify students' learning and difficulties. The authors concluded that novice teachers understood that communication is a skill that needs to be developed in students.

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<sup>7</sup> In Brazil, these cycles correspond to the 1st to the 9th grades of elementary school.

Based on research that aimed to understand the process followed by pre-service teachers to learn to dialogue with their students in the context of teaching practicum, Milani (2020) discusses several interpretations for the concept of dialogue arising both from theoretical perspectives and from the empirical data she collected. Participants in this qualitative research included two interns, the school-teacher and the researcher who acted as a teacher educator supervising the teaching practicum at the university. The research was developed in the state of São Paulo (Brazil). Milani collected data of two kinds. First, what the author called *research data*, correspond to episodes from the teaching practice of the trainees in which they tried to dialogue with their students based on investigative activities. Secondly, moments of reflection that took place during supervising meetings attended by the trainees, the schoolteacher, and the teacher educator. This data was called *data about data*.

To theorize about the concept of dialogue, the author takes the perspective proposed by Alrø and Skovsmose (2010). According to this view, dialogue is a form of communication with specific characteristics and that occurs in certain learning environments, the landscapes of investigation. The main result of the research is the construction of several interpretations for the notion of dialog. *Dialogue as inquiry* is the first of these. This interpretation highlights that being engaged in a dialogue involves investigating - in which hypotheses can be explored and discoveries made - taking risks - since dialogue is unpredictable and requires testing and rehearsing new possibilities - and promoting equity - which means knowing how to deal with differences in perspectives fairly. The second interpretation is *dialogue as participation*, in which dialogue is interpreted as an interaction in which speech is not monopolized by either the teacher or the students "but shared, and in which those involved are engaged in the class activity" (p. 1044). *Dialogue as discussion* is the third interpretation. In it, the word discussion is understood in terms of debate and dialogue is interpreted as an interaction in which questions posed can give rise to various answers so as to generate discussion among those involved. The fourth interpretation is *dialogue as uncertainty* which highlights dialogue as a form of interaction that depends heavily on the intentions of the teacher and the students and is therefore unpredictable. The intentions are linked "with the students' acceptance to engage with the proposed activity and with what the teacher wants and can do by asking and problematizing the situations" (p. 1049). Finally, *dialogue as movement* interprets dialogue as an interaction in which teacher and students consider the perspectives of the other and practice active listening, estrangement, and decentering.

#### *Research that focusses on experienced teachers*

##### Analysis of the communication throughout a whole classroom activity

Based on a qualitative approach, Ferruzzi and Almeida (2012) investigated what were the characteristics of a Mathematical Modeling activity to opportunize dialogical interactions and, thus, potentiate the students' learning in the classroom. The authors analyzed transcripts of interactions that occurred during the implementation of the whole classroom task that had been implemented in a 2nd year class of the Environmental Engineering course in a Federal



Technological University of Paraná. In their analysis, the authors sought to identify the teacher's actions during the task implementation and classified them into two categories. The first considers the difference between *dialogical and authority discourses*. Dialogical discourses are those in which the teacher considers the students' arguments in order to construct knowledge, while in authority discourse, the ideas presented by the student are not valued by the teacher. The second category aimed to distinguish between *interactive and non-interactive discourses* being interactive those in which there is exchange of ideas between two or more people and non-interactive those in which only one person is speaking.

The authors pointed out that the type of activity developed, besides allowing the students to participate safely, contributing with relevant arguments to the situation in question, provided the opportunity to establish an interactive communication rich in dialogic discourses. Moreover, they conclude that the teacher's actions were fundamental for dialogic interactions to be established in the classroom, because she was able to interact by promoting open questions ("How so?"; "Tell me what you know"; "Why?") in order to welcome the different ideas presented by the students.

Serrazina and Ribeiro (2012) relied on a teacher and her 4th grade students in Portugal<sup>8</sup> to investigate students' ability to communicate with each other and with the teacher. The researchers sought to understand how open-ended classroom tasks developed, in the students, the ability to communicate with each other. For this, the authors present a qualitative analysis from audio and video recordings of two different classes, but with the same students. Included in the analysis were the students' productions and interviews with the teacher and the students. The data collected referred to three moments of the work done: "1) Presentation and introduction of the task, by the teacher, to the whole class; 2) Solving the problem in groups of four students and 3) Communication of the strategies found by each group in class plenary" (Serrazinha & Ribeiro, 2012, p. 1373). Then, the data were grouped into three categories: learning, interactions, and communication. The analysis took place in light of three fundamental modes of communication: exposition, questioning (focus questions, confirmation, and inquiry), and discussion.

This research underlined that the classroom task created opportunities for students to communicate with each other and with the teacher in class. In addition to students being able to orally explain their reasoning, they represented mathematical ideas in writing. The authors also pointed out that the research opened the opportunity for the teacher to reflect on her actions and learn how to interact with her students. In this way, she increased her agility in provoking the students with questions of inquiry, for example, "*What is this? Could you explain it better?*", providing moments of reflection and opportunities for student participation. Finally, they concluded that there is a need for the teacher to participate in in-

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<sup>8</sup> In Portugal, 4th grade students are 9 years old.

service professional development initiatives. Such initiatives should promote opportunities for reflective thinking and help the teacher to better understand the quality of communicative interactions within her classroom and how they influence the mathematical learning of her students.

Martinho (2013) took as object of study a collaborative group conducted with three teachers who taught mathematics in the same school in Portugal. They taught 2nd and 3rd cycles of basic education. In her article, the author highlights the perspectives on classroom communication of one of the teachers, identifying her communicative practice from transcripts of episodes and their rereading both individually and in the collaborative group. The researcher took a qualitative approach and used four characteristics of communication as tools of analysis. First, *the patterns of interaction*, in which "students' mathematical knowledge is constituted in a social context that depends on the ability of both the students themselves and the teacher to understand, reflect, and make connections" (p. 90). Second, *information, questioning, and language*, which refers to the moments when "students engage in the process of explaining their ideas to others and with the goal of being understood, they themselves experience an evolution in their understandings" (p. 94). Third, *the influence and negotiation of meanings*, a situation in which the student constructs meanings from interactions with other classmates and the teacher. This negotiation of meanings happens when the student expresses his or her opinions and listens and reflects on other's opinions. Finally, *the teacher's practice*, turns its attention to how "the teacher stimulates students' interest and contributes to enriching the established interactions" (p. 97) including how he appropriates horizontal communication and how he provides opportunities for group work.

The author concludes that the development of a fertile environment capable of transforming communication in the classroom depends not only on the teacher's preparation and willingness, but also on the type of activity that is offered to the student. Activities that invite students to work in groups arouse questioning, leading students to structure meanings and to concretize their learning. She also points out that critical reflective capacity is expanded when it is under the lens of a collaborative group.

Analyses about communication in a specific part of the classroom task

Planas and Iranzo (2009) sought to highlight the importance of working with real classroom situations to understand the mathematics lesson from two perspectives: as mathematical content development and as social interaction. To do so, the authors adopted a qualitative approach and focused their analysis on a specific part of an open-ended classroom task: the moment in which students try to solve it in small groups. The task was implemented in a public secondary school located in the city of Barcelona in a class with 14- and 15-year-old students. The authors constructed a table with four criteria for analysis: *identification of mathematical practice*; *identification of socio mathematical norms*; *identification of meaning conflicts*; and *exploration of the relationships between practices, norms, and conflicts*. They then associated each sentence of the dialog with its respective criterion.

From this categorization, Planas and Iranzo (2009) highlighted the existence of conflicts that happened within the same group of students when solving the task. For example, some students used the task's real context to make decisions while others chose to use data from school mathematics itself to make decisions. The authors then noticed that within the same group different questioning occurred regarding what mathematical information was relevant to solving the task.

Another paper that looks at the communication that takes place as students attempt to solve a task in small groups is that of Ferruzzi and Almeida (2015). This paper also stems from the same research already described in the previous subsection (Ferruzzi & Almeida, 2012). In this opportunity, the authors, adopting a qualitative approach, sought to understand the interactions established in the classroom - between the teacher and a group of students and, they among themselves - during the implementation of a landscape of investigation. They analyzed episodes from transcripts of audio and video recordings and then compared the transcripts with field notes in order to complement the information. The researchers used the Inquiry Co-operation Model, proposed by Alrø and Skovsmose (2010), to analyze the quality of the interactions that took place during the landscape of investigation. The model proposes to describe the type of communication that is established during a landscape of investigation from the following dialogical acts: *getting in contact, locating, identifying, advocating, thinking aloud, reformulating, challenging, and evaluating*.

Ferruzzi and Almeida (2015) concluded that students were interested in performing the proposed activity, possibly because the task brought a situation with reference to the student's daily life that, moreover, was linked to their professional future. The authors mention another potentiality of landscapes of investigation, which is to provide an opportunity for the student to express his ideas aloud. During a group work, when a student explains what he is doing to a colleague, he is able to reorganize his thinking and build new understandings. Many times, when explaining his ideas, the student may realize a mistaken thought and, in that moment, she reconstructs her own learning. Besides, they emphasized that, during the course, the students made evaluations in pairs, thus exercising the ability to cooperate and were able to discover and appropriate underlying mathematical concepts. We emphasize that this work differs from the others included in the *corpus* because it is the only one that presents results focused only on the communication among students in the context of group work.

Ribeiro, Carrillo, and Monteiro (2012) focused their work on the analysis of communication during another specific moment of the mathematics lesson: the moment in which the teacher explains a new content to the students. To do so, they employed a qualitative approach to analyze a cut from a transcript of an audio and video recorded lesson taught by a 1st cycle elementary school<sup>9</sup> teacher in Portugal. As a main analytical tool, they used the MKT (Mathematical knowledge for teaching) Model, which aims to describe the

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<sup>9</sup> Children between the ages of 6 and 9.

teacher's professional knowledge and includes the teacher's goals, beliefs, and several domains and subdomains of knowledge. They also considered several types of mathematical communication promoted: *one-way communication* in which the teacher explains and the student listens and tries to take ownership of the explanation without arguing; *contributive communication* characterized by interactions in which the teacher asks the student to participate, but the student collaborates with very short answers; *reflective communication* in which the teacher poses questions that give students the opportunity to reflect and then values their arguments, and *instructive communication* associated with "interactive dialogues [. ..] whose direction is given by the students and in which the teacher considers useful and necessary a clarification, content construction, or negotiation of meanings" (p. 101).

According to the authors, the analysis revealed a teacher-centered explanation in which the teacher used mainly one-way communication as an explanation strategy. Thus, they concluded that it is "important and necessary for teachers to challenge their students constantly" (p. 118) and further emphasize that this challenge becomes possible when teachers mobilize their professional knowledge, recognize their beliefs, and estimate the implications of their actions when imposing their goals.

The moments in which the teacher conducts mathematical discussions were also specifically studied by Ponte, Pereira, and Quaresma (2017). The study was based on the observation of two lessons implemented in the 9th grade of elementary school in Portugal<sup>10</sup>. The authors adopted a qualitative approach and data analysis was based on *the Model of teacher actions in conducting mathematical discussions*. This model includes the following actions: *inviting* (the teacher encourages the initial involvement of students in a given segment of the discussion), *informing/suggesting* (the teacher introduces information or validates student responses), *supporting/guiding* (the teacher leads the student to continue participating in the discussions using questions), and *challenging* (the teacher encourages the student to construct his/her own reasoning).

The analysis developed by the authors highlighted the conflicts the teacher faced in the classroom, such as being able to identify the right moment to start a discussion or deciding how to welcome contributions (from students) that are not very appropriate for the moment. The analysis also revealed how the teacher encouraged her students to deepen and evaluate the mathematical discussions by having to constantly reformulate her interventions. In addition, the authors highlight "the importance of the teacher being able to deal with unexpected situations" (p. 189) a point similar to that raised by Milani (2020).

## **Establishing a dialogue between the literature review and the teacher-researcher**

In this section, we turn our attention to the second objective of this article, starting the

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<sup>10</sup> It contemplates students as young as 14 years old.

reflection about the meaning that the literature review acquires when it is developed in the framework of a research conducted by the teacher about his/her own practice. To this end, we establish a *dialogue between the articles* that make up the *corpus* and the research developed by Salgado, highlighting the suggestions and contributions of each work as well as the questions and concerns about the research that emerged from reading them.

Reflecting on the words of Ponte et al. (2007), especially those related to the fact that students need to learn to communicate, Salgado realized the challenge she had to face: besides becoming familiar with a task of a different nature than the one her students were used to solving, they should learn a new way to communicate and she, even being an experienced teacher, should accompany them in this process. In turn, reading the article allowed us to reflect on the dimensions of management and regulation of communication by the teacher. These dimensions refer to the way the teacher establishes ways of participation in the classroom; the way he or she welcomes and encourages the student who experiences difficulties and the way he or she stimulates the interaction between the students with more difficulty and the others, and the way the teacher rescues the purpose of the class.

The work of Milani (2020) revealed to us the richness and complexity of the notion of dialogue. By interpreting *dialogue as participation*, we realize that this type of interaction can be fruitful because in these moments communication is not monopolized by any of the participants which allows for a genuine exchange of ideas and negotiation of meanings. The interpretation of *dialogue as uncertainty* highlighted, especially for Salgado, the fact that this type of interaction puts teacher and students in a risk zone because it contemplates unpredictable questions and answers. The author also pointed out that we could not be absolutely sure whether the dialogue would actually take place in the classroom. The most, we could do was to plan a task that would be interesting and challenging for the students so that they would be more likely to accept the invitation to participate in the landscape of investigation and, consequently, to initiate the dialogues. Once the invitation was issued it would be the students who would have to accept. However, it was from this interpretation of the notion of dialogue that Salgado understood that this type of interaction expands the opportunity to strengthen affinities with her students and to develop active listening, seeking together an appropriate way to solve the situation. Such reflections led us to the interpretation of *dialog as a movement* in which the teacher manages to leave his place of speech, puts himself in the student's position, and tries to understand their perspectives.

We noticed identifications with the article by Martinho (2013) since this researcher was also concerned with bringing to the classroom a task with potential to engage the students and to analyze the challenges that the teacher faces during its implementation. In particular, this work brought to the forefront the fact that, beyond our motivations, it would be necessary to propose to Salgado's students a task of a different nature, one that escaped from the traditional exercises that so often occupy the central role in the mathematics classroom. A similar point was raised by Ferruzzi and Almeida (2012) who put emphasis on the importance of the type of task that would be presented to the students in order to promote

true dialogical interactions. Through these readings we understand how important it is to present students with a task that can transform the quality of communication in the classroom and that gives the teacher the opportunity to formulate questions that invite their students to expose their perspectives and, therefore, transforming the communicative classroom's patterns. Thus, we concluded that proposing a task with the potential to be a landscape of investigation that problematizes issues from the students' own life experience could be a fertile option to produce transformations in communication in Salgado's classroom.

On the other hand, the work of Ferruzi and Almeida (2012) as well as that of Serrazina and Ribeiro (2012) allowed us to reflect on the importance of the teacher's interventions for the creation of investigative environments in the classroom. According to the evidence presented in these articles, the development of reflections can lead the teacher to modify her interaction with the students to the point of being able to insert provocations that stimulate them to participate, for example, "And now what can we do?"; "And if it were different, how would it be?". In turn, the readings pointed out the need for the teacher to imagine alternative ways to improve their interventions in the classroom, for example, asking students to share different strategies to solve an activity and from them open a discussion about positive and negative points. It was from these authors that we began to consider the need to adopt theoretical tools that would allow us to analyze the different types of questions posed by Salgado during the classroom task and their impacts on the students' later work.

We also found another point of convergence with Serrazina and Ribeiro's (2012) article: just as the teacher involved in the authors' research had the opportunity to reflect on her actions and learn to interact with her students, Salgado would also have the opportunity to reflect on her communicative actions when she conducted the systematic analysis of the data collected from her research. From our experiences as teachers and teachers educators, we agree with the authors when they highlight the importance of in-service professional development opportunities that foster these reflective and investigative processes. Martinho (2013) complemented these ideas by highlighting the role of collaboration to expand the teacher's reflective capacity. In our case, we were taking advantage of participation in a Professional Master's Program to develop a research focused on a teacher own practice with a focus on communication in the classroom. Although we had a formal bond of student/supervisor, from the beginning of the work we set out to establish a collaborative relationship between both of us. We were, moreover, members of a collaborative group (GdS) that allowed us to share our reflections and analyses. These readings highlighted that we were working in a context that gathered all the conditions indicated by the research for the development of fruitful investigations about teaching practice.

The research of Planas and Iranzo (2009) and Ferruzzi and Almeida (2015) point out that students, when developing communication in the classroom, are learning to talk to and about mathematics, and to construct mathematical conjectures. With this, we as researchers understand another potentiality of working with landscape of investigation: they enable students to be the ones who determine, through dialogue, what information they will consider

relevant. We were able to make connections between this point and our past experiences when we invited our students to participate in investigative tasks. The possibility of being the ones to delimit the situation and choose the paths to be taken usually generates surprise and insecurity in students, especially those more accustomed to working within the exercise paradigm. Therefore, we concluded that it would be important for Salgado to be prepared to make communicative interventions that support her students in this process.

In turn, the article by Ferruzzi and Almeida (2015) revealed the potentialities of the Inquiry Co-operation Model proposed by Alrø and Skovsmose (2010) to analyze the quality of interactions that develop during a landscape of investigation. We were already considering adopting this model in our analyses and Ferruzzi and Almeida's work gave us the opportunity to contemplate how such a model could be put into action as well as its analytical potentiality.

In turn, the works of Ribeiro, Carrillo, and Monteiro (2012) and Ponte, Pereira, and Quaresma (2017) brought to the forefront the importance of considering a moment in class that is little addressed in research that analyzes landscapes of investigation: the opportunities for socialization and/or the moments in which the teacher needs to introduce or clarify some topic. Ribeiro, Carrillo, and Monteiro (2012) have highlighted the link between the teacher's knowledge and the communication he establishes in these specific moments. While we recognize the potential of studies focused on teacher knowledge, we decided to adopt a more holistic analytical approach that would allow us to capture the various dimensions of teaching practice and how they are evidenced in communication. Finally, the work of Ponte, Pereira, and Quaresma (2017) highlighted the importance, in terms of negotiating meanings and mathematical ideas, of moments of socialization. We understand that, on such occasions, teacher-student and student-student communication can open the door to argue about the paths taken, broaden the view of the situation addressed, and talk about mathematics. This is how Salgado prepared herself specially to manage these moments aiming to promote rich discussions that would enable moments of knowledge construction. In turn, when reading these works, we were clear that we should conduct systematic analyses of the different socializations that would happen during the implementation of the task. This would give us an opportunity to understand to what extent Salgado managed to make good interventions and lead her student to reflect and negotiate meanings about the subject in question, identifying evolutions in her interventions.

## **Conclusions and concluding remarks**

In this paper, we seek to achieve two goals, located on different planes. First, to conduct a systematic literature review of scientific articles focusing on communication in the mathematics classroom. Although the communicational nature of mathematics teaching and learning processes is highlighted by several authors (Alrø and Skovsmose, 2010; Guerreiro et al., 2015; Martinho, 2013, Serrazina and Ribeiro, 2012), the search conducted revealed a scarcity of works with this focus in our country. Moreover, of the nine articles selected, seven

reported research conducted in school years that, in Brazil, correspond to elementary education, while the other two were developed in higher education. Thus, we detected a gap linked to the lack of research, published in Portuguese or Spanish, which takes as an object of study the communication processes that take place in high-school mathematics classes and that explores their (possible) specificities.

The literature review performed evidence a diversity in the theoretical perspectives adopted by researchers when studying communication in the mathematics classroom. Some of them have roots in the field of Education while others were developed within the field of Mathematics Education. Moreover, the analysis indicates the need to choose categories and theoretical models that are adequate to study the communication established in the different moments of a mathematics class (presentation of tasks, group or whole-class discussions, explanations by the teacher, etc.).

Regarding the methodological perspectives employed, all articles adopt a qualitative approach and were developed considering a small number of teachers. We also highlight that although two articles were developed in the framework of collaborative processes between researchers and practicing teachers (Martinho, 2013; Milani, 2020), none of them can be characterized as teachers' research.

This literature review highlights the complexity involved in the processes of transforming communication in the mathematics classroom. They also show the importance of teacher reflective actions and the potential of collaboration to sustain and encourage these processes. Furthermore, the results point to the strong interconnection between the nature of the tasks proposed in the mathematics classroom and the communication that takes place there. Finally, they reveal that not only the teacher, but also the students need to engage in the process of learning new ways of communicating mathematical ideas within the classroom.

The second goal of the paper, located on a different plane from the first, aimed to analyze the meanings that literature review takes on when it is conducted within the framework of a teacher's research. The description and analysis of the works presented, show that the systematic literature review developed assumed the three senses posed by Becerra (2004). In this way, it allowed Salgado and Leticia to appropriate the knowledge already produced around communication in the mathematics classroom. It also enabled them to investigate their own investigative field, outlining theoretical and methodological perspectives and identifying gaps. Finally, it allowed them to mobilize this knowledge as a starting point for the unknown, directing the investigation that Salgado was initiating to little explored research objects.

This exercise allowed us to delineate the differential of Salgado's research and its potential contribution: it would be Brazilian research focused on communication in the mathematics classroom in high school, developed by a teacher about her own practice and with the collaboration of two communities that helped the teacher throughout the process (the Professional Master's and the GdS). In light of the literature review, research developed with



this focus and in this context was particularly fruitful and unprecedented.

In turn, the literature review helped to better delimit the theoretical tool that would be used in Salgado's research. Specifically, the work of Ferruzzi and Almeida (2015) pointed out the effectiveness of the Inquiry Co-operation Model to analyze dialogues established within landscapes of investigation. Thus, we decided to adopt this model to study the communicative actions established when Salgado invited his students to participate in a landscape of investigation with a focus on Financial Education. However, the articles by Ponte et al. (2007) and Ponte, Pereira, and Quaresma (2017) highlighted the importance and specificity of the communication that is established in moments of discussion with the whole class. This is how we decided to complement the theoretical tools of the research with the distinction between *focusing*, *confirming*, and *inquiring* questions, used mainly to interpret moments of socialization.

We can say, then, that in our experience, the systematic literature review has acquired all the meanings associated with this activity when it comes to academic research. In addition to them, it was possible to identify two other senses that the literature review takes on when it is conducted in the framework of a teacher's research. First, reading the articles was an opportunity for Salgado to reflect on her teaching practice, considering how certain actions she performed daily within her classroom impacted the communication that was established there. Thus, it was an opportunity for her to recognize herself in the voices of the teachers participating in the research and to delineate challenges that she also faced. The need to overcome teacher-centered explanation - highlighted by Martinho (2013) and Ribeiro, Carrillo, and Monteiro (2012) - and to develop students' communication skills - pointed out by Ponte et al. (2007) - are two examples of this.

Second, the completion of the literature review was an important moment to start planning the communicative actions that Salgado would develop in his classroom and that would become the object of the research. For example, we confirmed our interest in proposing a task of open nature from the works of Planas and Iranzo (2009) and Ferruzzi and Almeida (2012 and 2015), which show its potential to promote interaction among students. Moreover, the analysis of the articles made it possible to anticipate possible challenges that could arise in Salgado's classroom and to imagine possible ways to face them.

We conclude that, in the case of teachers' research, the literature review allows to situate the work in the field of investigation as well as to give important subsidies to the teaching practice that will be the object of research. In this way, our analysis contributes to unveil some of the multiple potentialities of teachers' research as a formative opportunity and as a way to construct valid knowledge in the educational field.

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