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Knowledge of teaching practice of early childhood teachers developed in lesson study

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ABSTRACT

Background: Early childhood education is an important stage in the development of children. The early childhood teacher's knowledge of teaching practices is a fundamental aspect of didactic knowledge. Lesson study is a formative and collaborative process with the potential for developing knowledge of teaching practice. **Objectives**: To identify early childhood teachers' learning on their participation in a lesson study with regards to the construction of tasks, preparation of a lesson plan and teaching the children as fundamental aspects of knowledge of teaching practice, a central aspect of didactic knowledge. **Design**: Qualitative and interpretative methodology, with participant observation. **Setting and participants**: The research results from a lesson study carried out in the mathematics field in three Portuguese infant schools that receive children between three and six years old. Three early childhood teachers and a facilitator voluntarily participated in the study. **Data collection and analysis**: Data collection was done through participant observation with audio recordings of each session and the creation of a logbook. **Results**: This study shows the potential of lesson study for developing early childhood teachers' knowledge of teaching practice, a scarcely researched area.

Keywords: lesson study; early childhood education; professional development; teaching practice; patterns.

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Conhecimento da prática letiva de educadoras de infância desenvolvido num estudo de aula

RESUMO

Contexto: A educação de infância corresponde a uma fase importante do desenvolvimento das crianças. O conhecimento do educador de infância relativo à prática letiva é um dos aspetos fundamentais do conhecimento didático. O estudo de aula é um processo formativo e colaborativo com potencial para o desenvolvimento do conhecimento da prática letiva. **Objetivos**: Identificar que aprendizagens são desenvolvidas pelas educadoras com a sua participação num estudo de aula relativamente à construção da tarefa, elaboração do plano de aula e lecionação da aula, aspetos fundamentais do conhecimento da prática letiva, entendidos como aspetos centrais do conhecimento didático. **Design**: Segue uma metodologia de natureza qualitativa e interpretativa, com observação participante. **Ambiente e participantes**: A investigação resulta de um estudo de aula realizado, no domínio da matemática, em três jardins-de-infância portugueses que acolhem crianças entre os três e os seis anos de idade. Integraram o estudo, voluntariamente, três educadoras e a facilitadora. **Coleta e análise de dados**: A recolha de dados foi feita por observação participante com a gravação áudio das sessões e a elaboração de um diário de bordo. **Resultados**: Os resultados mostram que as educadoras de infância desenvolveram de forma significativa o seu conhecimento sobre aspetos da prática letiva quando planificaram, realizaram e refletiram sobre situações de aprendizagem, e sobre os documentos curriculares para a educação de infância. **Conclusões**: O estudo mostra o potencial do estudo de aula para o desenvolvimento do conhecimento da prática letiva dos educadores de infância, uma área pouco investigada.

Palavras-chave: estudo de aula; educação infantil; desenvolvimento profissional; prática letiva; padrões.

INTRODUCTION

Early childhood education corresponds to a critical phase in children's development, where "cognitive, social, cultural, physical, and emotional dimensions are interconnected and act together" (Silva et al., 2016, p. 10). In addition to general development, some specific areas, such as mathematics, have been aimed at. In Portugal, these areas s are expressed in the document Curricular Guidelines for Preschool Education (*Orientações*

Curriculares para a Educação Pré-Escolar - OCEP) (Silva et al., 2016), which includes the content areas of Personal and Social Development, Knowledge of the World, and Expression and Communication. Within this last area is mathematics, in which the domains of Numbers and Operations, Organisation and Data Processing, Geometry and Measurement, and Interest and Curiosity in Mathematics are considered. This document recognises that mathematical concepts "acquired in the early years will positively influence later learning and it is at these ages that mathematics education can impact more" (Silva et al., 2016, p. 74). Therefore, early childhood teachers must make intentional and progressively more complex lessons that help children carry out these learnings based on mobilising contexts, giving them meaning. It is a relatively recent document, which many early childhood teachers do not always mind much in their practices. Therefore, these teachers must be offered an education that can assist them in putting these guidelines into practice, particularly in mathematics.

Lesson study is a formative process of a collaborative nature centred on a teaching practice, which is part of the perspective of practice-based education (Ball & Cohen, 1999). In a lesson study, a group of teachers identifies a learning problem their students face, studies curriculum documents and other materials relevant to the identified problem, and prepares a lesson in detail to promote student learning regarding the issue in question. A teacher from the group teaches the lesson while being observed by the others, after which they have a post-lesson reflection based on the evidence collected about the students' learning (Fujii, 2018; Murata, 2011). This professional development process has been widely explored with primary and secondary school teachers (e.g., Gomes et al., 2022; Fonseca & Ponte, 2022a, 2022b, 2024; Lewis, 2016; Quaresma & Ponte, 2021; Schlichting et al., 2023; Suh & Seshaiver, 2015) but is still little explored by early childhood teachers (Fonseca & Ponte, 2023).

Knowledge aimed at conducting teaching practice is crucial to how teachers and early childhood teachers plan and carry out their teaching activities (Carrillo-Yañez et al., 2018; Ponte, 2012). In an exploratory approach (Ponte, 2005) particularly adapted to early childhood education, issues relating to constructing the task, defining the lesson plan, and actual lesson teaching stand out. Thus, this article aims to identify early childhood teachers' learning when participating in a lesson study regarding these fundamental aspects of knowledge of teaching practice.

REVIEW OF LITERATURE

Didactic knowledge

Teacher knowledge of teaching practice is an aspect of didactic knowledge (Ponte, 2012) or pedagogical content knowledge (Ball et al., 2008; Carrillo-Yañez et al., 2018; Shulman, 1986). Ball et al. (2008) call it content and teaching knowledge, including how the teacher sequences content for teaching, the examples he/she chooses to begin and to lead students to deepen the content, his/her assessment of the advantages and disadvantages of the representations used to teach a specific idea, and which methods are most productive. Carrillo-Yañez et al. (2018) refer to it as knowledge of mathematics teaching. They consider it knowledge of the "potential of activities, strategies, and techniques for teaching specific mathematical content, along with any potential limitations and obstacles which might arise. Also included is knowledge of resources and teaching materials, such as textbooks, manipulatives, technological resources, interactive whiteboards, and so on" (p. 247). Finally, Ponte et al. (2024) refer to this knowledge as knowledge of teaching practice and cite three main dimensions: (i) Design and implementation of the lesson and teaching units with emphasis on exploratory lessons in which students construct new knowledge based on a task; (ii) Tasks with emphasis on the representations and materials used; and (iii) The communication during the lesson, from the presentation of the task to the whole-class discussion.

In an exploratory lesson (Canavarro, 2011; Ponte, 2005; Ponte et al., 2016), the teacher begins by proposing to students a task that must be within their reach, through which they can build new knowledge of concepts, procedures, representations, or new mathematical ideas. Based on the task, students carry out autonomous resolution work, which can be done individually, in pairs, or small groups. Based on this work, the teacher leads a moment of whole-class discussion in which he/she asks a student or a group to present and justify their solution. Then, he/she asks another student or group to present a different solution. If a solution contains errors or inaccuracies, it provides good opportunities for intervention and argumentation by the rest of the students in the class. Different solutions can be compared, and students can evaluate the most efficient way to solve the task at stake, relating the strategies presented to students' prior knowledge. If possible, the lesson ends with a final summary prepared in collaboration between teacher and students.

Lesson studies with early childhood teachers

We briefly analyse the previous studies we could locate on the use of lesson studies with early childhood teachers. In a research study, Peña Trapero (2013) sought to analyse how lesson study can allow early childhood teachers to reconstruct their practical thinking, which consists of declarative thinking or theories and tacit or Gestalt thinking. The participants are a group of fifteen early childhood teachers (fourteen female and one male). The analysis of the evolution of the group of teachers showed that lesson study encouraged "reflection and critical questioning of personal values, beliefs, and assumptions about teaching whilst also enabling the reconstruction of teachers' practical knowledge, in particular their hidden beliefs, habits, and emotions" (p. 115).

In another work, Peña Trapero and Pérez Gómez (2017) studied the relationship between lesson study and the reconstruction of teaching dispositions (practical knowledge or knowledge in action). The study focuses on the practical knowledge of an early childhood teacher before and after her participation in a lesson study. The authors indicate that the teacher's resistance to change was overcome through the lesson study, helping to build a reflective and shared professional culture with pedagogical capital.

Estrella et al. (2022) sought to discover how an early childhood teacher developed her pedagogical content knowledge when designing and carrying out learning activities prepared in a lesson study focused on student statistics learning (the playful task of tossing two coins – informal inferential reasoning). The results show that after two completed lessons, "while the educator (why not teacher?) demonstrated knowledge and skills relevant to the curriculum and conceptual teaching strategies, the understanding of the content by the students ... still presented a challenge" (p. 1).

Following a case study methodology, Fonseca and Ponte (2023) aimed to understand the didactic knowledge learning of an early childhood teacher who participated in a lesson study with two other teachers on the topic of patterns, as well as her perspective on lesson study as a formative process. The results showed that the teacher became aware of the importance of working on mathematical ideas with great enthusiasm. It also showed that the teacher developed her didactic knowledge in several dimensions, such as school mathematics, curriculum, children and their learning, and knowledge of teaching practice, coming to appreciate the lesson study as a valuable process of professional development. The research shows the potential of lesson study for the professional development of early childhood teachers,

particularly regarding their practical knowledge and didactic knowledge in their general aspects. However, it remains to be seen how this development occurs concerning central aspects of teaching practice, namely planning, enactment, and reflection on learning situations, which is a contribution of this article.

METHODOLOGY

Participants and context

The research follows a qualitative and interpretative methodology and results from conducting a lesson study in mathematics with three early childhood teachers: Sara, Eva, and Sofia (the names of the teachers and students are pseudonyms). The teachers had never participated in a lesson study and were unaware of its dynamics. The first author conducted the lesson study playing the role of a facilitator. Sara[1] and Eva have over 30 years of teaching experience, and Sofia has less than five. They all worked at different schools. The study involved 59 children aged between three and six years old.

The lesson study began in December and was developed in twelve sessions (Sn), mostly fortnightly, lasting around 2 hours per session. Three of these sessions corresponded to research lessons, and two were moments of in-depth reflection after teaching the research lessons (Table 1).

In the moments of reflection that followed the research lessons, the discussion developed based on the field notes collected by the observers, focused on the reflection on children's work, the constraints, and the construction of proposals for improvement of the next lesson to be taught with another group of children, constituting important moments for sharing and building collective knowledge of teaching practice.

Table 1

Lesson study sessions and stages

Sessions (Sn)	Stages
S1	▪ Presentation of the LS concept and aims ▪ Schedule of the subsequent sessions
S2, S3, S4, S5, S6	▪ Analysis of the Curriculum Guidelines for Childhood Education and other documents

[1] This teacher is also a participant in Fonseca and Ponte's (2023) lesson study group.

	▪ Selection of the topic to work on (which turned out to be the repetition patterns) and definition of the question to investigate. ▪ Planning the research lesson and the observation work
S7	▪ Research lesson 1 (taught by Sara)
S8	▪ Reflection after lesson 1
S9	▪ Research lesson 2 (taught by Eva)
S10	▪ Research lesson 3 (taught by Sofia)
S11	▪ Reflection on lessons 2 and 3
S12	▪ Semi-structured collective interview

Data collection and analysis

Data was collected through participant observation with audio recording of all sessions (Sn). All recordings were transcribed, and we conducted inductive analysis following Amado's (2013) procedures to identify particularly relevant learning in the field of knowledge of teaching practice that the participants highlighted. With this aim, and taking as reference Ponte et al.'s (2024) framework, we analysed episodes of the planning and post-lesson reflection sessions to identify teachers' knowledge of the design of the task and choice of materials, the definition of the lesson plan and teaching the research lesson, paying attention to the analysis of students' strategies and difficulties, and conducting the lesson at different moments.

RESULTS

In this section, we present significant episodes as emerging evidence of the participants' learning regarding knowledge of teaching practice that occurred during the planning and reflection process after the research lessons.

Knowledge of teaching practice: planning

Task construction and choice of materials

Task

In the second session, the planning included selecting and recognising the topic in the OCEP (Silva et al., 2016). However, without the facilitator foreseeing it, Sara brought a task proposal to share that was included in the topic of patterns. In her opinion, the task would "have to be individual because [children] always tend to be pulling materials towards themselves" (S2).

> Sara: I bring a proposal about patterns. I was thinking… because we will be working on the winter theme, I thought about something with clothing. I thought of the story "What if animals dressed like people" as motivation. The story will be told, and then we will talk about clothing items. I thought of a pattern with the same clothing for everyone. [S2]

In the initial proposal to which the group adhered, the children would have little active and limited participation in the construction and exploration of the concept since they would have to reproduce the pattern that had been previously given:

> Sara: We had enough pieces for each child to continue the pattern we wanted them to reproduce. We gave them a string and a little box with all the clothes mixed. The goal is for them [children] to reproduce the pattern on the string. Then, we would reflect on how many reds there were, what came next, and what the order was. Therefore, this type of reflection. [S2]

In the following session, after reading an article about the emergence of algebraic thinking in a group of four-year-old children using pattern tasks shared by the facilitator, Sara began by mentioning that the previously defined aim of the lesson would have to be changed because the reading gave her some other views: "in fact, when I read that article you sent, it made me think that they [children] should be the ones to create their own pattern because they experience another type of learning instead of simply reproducing one [pattern]" (Sara, S3). A debate followed on the nature of the typology of tasks in mathematics to clarify the importance of exploratory tasks and their role in promoting the development of different mathematical skills in students, namely communication and reasoning. Still regarding the preparatory readings and their importance in the construction of mathematical knowledge, and specifically knowledge about the content to be taught, the following dialogue took place:

> Sara: For me it is important to read these things [referring to OCEP] to make me reflect and think about my practice. I thought: What do we want with the task? I think it's about children getting a sense of what a pattern is and identifying the unit!
>
> Eva: When you say identify the unit, it means...?

Sara: It's that little bit that repeats itself.

Eva: Ah!" [S3]

The discussion and sharing of notes taken from the preparatory and framing readings of the selected topic in different documents were essential to identify the *state of the art* on the topic, to raise awareness of the importance of designing an integrated task in an exploratory approach, and the subsequent structure and dynamics of the research lesson. An open task would then be developed with the potential to lead students to construct new knowledge. Reading and analysing the OCEP (Silva et al., 2016) and other documents also helped participants to understand the topic of patterns, recognising the need to "…master the content so that we can teach it safely to children" (Eva, S10). Sara further stated:

> Sara: This has been very productive [to read documents]. Knowing what I'm doing, knowing what this is for... it's another world of knowing. For example, this content [patterns], I just called it sequences, and for me it was just about developing children's visual memory, attention, and concentration. That was the goal. I have been researching the bibliography you sent [referring to the facilitator] and I realised: hold on Sara, this is not a sequence! Let's call things by their names. Do you understand what was learned?! [S3]

Except for Sara, the initial preparatory readings were not always well received by the participants because they did not have reading habits. However, sharing key ideas during the sessions allowed them to acquire formal language when approaching specific concepts with the children when they said: "I already did this, but I didn't know what it was called in scientific language" (Eva, S8).

Materials

Once a story that would frame the exploratory task was selected based on the intended curriculum aim, a discussion of suggestions took place, leading to collective decisions being made about the manipulative material that would accompany the task and how it would be made available to the children. Sara suggested "using felt sweaters [a semi-rigid material similar to fabric] because it is a good material to manipulate, with attractive colours, which they [children] are not used to handle. Then, I would add the pegs and string as a surprise factor" (S3). Once the type of material was

decided, the colours and number of pieces to give to each child were discussed depending on their age and level of development.

For Eva, it did not make "sense for three-year-old children to use the same material to build a pattern since they would have a hard time opening the pegs to hang the sweater on the string" (S3). A climate of empathy and trust helped the participants to consider different learning scenarios, leading them to think about the dynamics of the lesson in terms of the intended learning and the level of maturity of the children in terms of expected performance:

> Sara: I definitely think it is the children aged four, five, and six who have knowledge that we are interested in knowing and deeper undestanding! three-year-olds are still very much in the discovery phase and their fine motor skills are not sufficiently developed. We can start a pattern by pasting it onto a sheet of paper for them to continue.
>
> Sofia: We work with everyone, but the thee-year-olds do a more simplified task. They only wear red and yellow shirts. [S4]

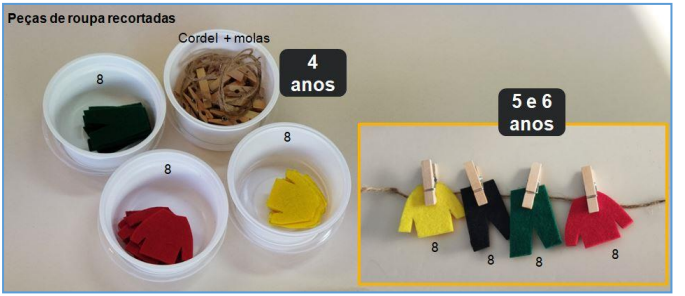
Once the issue of defining the colours to be used in the clothing items (black and green for the pants and yellow and red for the shirts) had been solved, the number of items that would be distributed to the children according to their age group was discussed, as well as how they would be made available. In Sara's opinion, four-year-olds should not have the same number of sets of pieces as five- and six-year-olds "because we would complicate the task. The four-year-olds will have eight red shirts, eight yellow shirts, and eight green pants placed in three bowls. The five and six-year-olds have another [set of] eight black pants" (S4). The decision to make the clothing items available separately in yoghurt bowls was based on an assumption the participants anticipated:

> Eva: By placing the clothes on the table or all together in a bowl, children may have difficulty using and identifying all the colours to create unity, besides wasting more time looking for them [of the pieces]. Our goal is not to know if you can identify and remove the four colours from the pile but to know if you can build the unit using all the available colours. [S4]

After this dialogue, it was collectively decided that five and six-year-old children would have sets of eight black pants, eight green pants, eight red shirts, eight yellow shirts, a string and pegs provided in different yoghurt cups. The four-year-old group would have the same materials except for the set of eight green pants (Figure 1). In turn, three-year-old children would have a white A3 sheet, white glue, paintbrushes and two yoghurt bowls with eight red and eight yellow shirts.

Figure 1

Manipulative material distributed to each child by age group



The string size should be according to the number of elements each child could use to create their unit and the number of times they could repeat it. Each string should be one metre long to ensure that the unit could be repeated more than twice. The following excerpt is an example of a decision made based on anticipating situations:

> Sara: They [children] also won't be able to make very large patterns...
>
> Eva: But if you use all the pieces, you won't be able to repeat the unit many times. We'd better give the string more length.
>
> Sara: Let's try putting the pieces on the string. [Try it on a 70 cm string]. Maybe it's not enough...
>
> Sofia: Maybe 1 m is ideal. [S4]

These moments of dialogue and experimentation as students were particularly important because they provided the teachers an awareness of the importance of selecting materials. Living the experience in the role of a student when trying to solve the task and reporting the children expected difficulties while solving it allowed for the creation of conditions to develop

and prepare the didactic sequence, mobilising and developing knowledge of the teaching and learning process, making them more attentive and aware, similar to other lesson studies (Fonseca & Ponte, 2022b).

Given that the aim was to better understand the children's learning process by observing their strategies for creating the unit, constructing the repetition pattern, and justifying or describing their pattern to the group, we decided to observe the performance of children aged four, five, and six, although three-year-old children also participated in the first part of the lesson (Table 2).

In short, in these initial sessions, the collaborative work involved much decision-making: a) whether the task would be the same for all the children or whether it would be applied with different levels of complexity according to the age group; b) whether the observers would consider the whole group, or whether they would observe groups of children from the age of four onwards; c) how the material to give to the children would be made available: the pieces of clothing would be together on the tabletop or in yoghurt bowls separated by colour; the number of pieces to be made available per set would be the same or different depending on the age group; what would be the string size , how many pegs would be given and its size. The decisions taken were always reflected in the information shared in the sessions about the results achieved by the children in solving the previous tasks, in the anticipation of the performance expected by the children and the defined learning aim. This work contributed to expand knowledge of teaching practice through the reflection generated regarding the design of tasks and organisation of the students' work (Fonseca & Ponte, 2022a, 2022b, 2023).

Construction of the research lesson plan

Designing the dynamics of the lesson

Once the task and its respective materials had been defined, the following sessions were dedicated to constructing the research lesson plan with the sequence of the activity to carry out. Questions like "*What do you want the children to know at the end of the task?*" and "*What do you want to know about children's thinking and problem-solving strategies?*" were put forward by the facilitator as a way of provoking reflection on what would be truly significant and how teachers could plan their educational action intentionally. This structure and organisation of thought were important for identifying the challenges children faced in studying the selected topic and

for the detailed construction of the lesson plan. Given the awareness of the importance of learning progression and the need for its contextualisation, two tasks were planned to provide prerequisites for the full understanding of the concept to work in the research lessons and the lessons dates were set. As the first diagnostic task, a "Christmas sequence" would be worked on, the aim was for children to continue the predefined sequence by glueing together different shapes of pasta (stars, presents, Christmas trees). In a second task, based on a story, they had to draw stripes (green and blue) on the shirt of a frog, the main character in the story (Figure 2).

Sara's participation in decision-making about the dynamics of the lesson, namely the organisation and management of space and materials, the management of learning, and how the sequence of exploratory lesson moments would be enacted contributed to the awareness of the importance of anticipating children's difficulties, outlining solution strategies and preparing leading the whole-class discussion by preparing in advance the guiding questions, that should be written on the lesson plan, the teacher should ask when the children are explaining their thoughts. (Fonseca & Ponte, 2022b, 2023, 2024).

Figure 2

Task 2 - Frog's shirt stripes

For Eva, "visualisation and enactment are important at these ages, often functioning as a model" (S4), and it is necessary to pay particular attention to how the concept of pattern would be presented in the first moment of the research lesson. After exploring the story, the teacher would begin by creating her unit using materials other than pants or shirts, choosing to "use white socks with different patterns to ensure that children are not induced in their constructions during independent work. We can take the

centipede in the story and say that it needs to wear socks" (Sara, S5). The initial exploration of the concept in a large group at the time of motivation was aimed at ensuring that the children fully understood "what a unit is and what a repetition pattern is before doing the task by themselves because the aim of the lesson is to see if they can invent a pattern" (Sara, S4).

Thus, Sara presented a more elaborate proposal for the activity sequence. The following dialogue took place:

> Sara: Children at these ages need concrete things**.** I think we should begin with telling the story as motivation, and this corresponds to the first moment of the lesson. In interpretation, we link the story with the pieces of clothing that appear in the story. This would take 15 minutes. After that [introducing the topic of patterns], we continue: if the animals needed clothes, they would have to wash them and then hang them out to dry! I have the centipede socks here. I'll arrange them like this and build a unit on the string. Then, with my hands, I delimit the unit and say: 'Do you see this little bit? It's my unit'. Then, I ask a boy to come and repeat my unit as many times as he can. 'Is it the same? What do you [children] think? Look! Manuel made a pattern. Can everyone read my pattern? Can you help me?'
>
> Sofia: Will this still be with them [children] sitting on the cushions?
>
> Eva: For all children?
>
> Sara: Yes. I think that in this little time, we must work on the concept very well so that they understand the unity and the pattern. After that, I will launch the task: 'I have a challenge for you. On the table there are some small bowls with pieces of clothing, a string, and small pegs. They must invent a pattern with the pieces and hang them on the stringline. Think about your little bit and repeat it.' [S4]

As the way the activity sequence could be directed was simulated, the facilitator asked questions that the children could ask so that the teachers could anticipate strategies for overcoming possible difficulties encountered during the children's independent work:

> Sara: Think about your unit using all the pieces and repeat it.

> Facilitator: ‘Sara, can I put all the pieces? I no longer have any yellow ones, but can I still put them on the line?’,these are some of the questions children may ask. What do you say?
>
> Sara: ‘You can only do it if you can repeat it.’
>
> Eva: Imagine that some people don’t ask but put all the pieces together, even if they are missing a colour. Can we ask them?
>
> Facilitator: If you are leading the lesson, of course. This is to lead them to the discovery of errors. It is important to question them so that they can identify the error and correct it. One strategy could be to ask them to read the pattern they created out loud and isolate the unit, for example, or ask them to say how many times they repeated the unit...
>
> Eva: So (...) must we think in advance about how to get around that situation?
>
> Facilitator: Sure! [S4]

Another situation that caught the participants’ attention was how the tables were organised for autonomous work and for the presentation of work during whole-class discussion due to their influence on learning. Sara, who volunteered to teach the first research lesson, demonstrated this awareness:

> Sara: I thought about putting groups of four children at separate tables. But then I remembered: the best thing is to sit in the [child’s] seat and try to understand if they all have the same viewing angle. I saw that with the tables separated when some children are presenting, others won’t be able to see because they are facing the wrong way Only those facing to the front can see [the presentation]. I looked and said: this arrangement doesn’t work! But if we put all the tables together [making a horizontal line] and we sit the children around, when a child stands up, I help him/her stretch the string and everyone else can see. This arrangement of tables is easier for everyone to see. If we sat on the cushions there would be no space to stretch the string either. When it was their turn to present, they would no longer have any clothes or pegs on the string.

> Sofia: Staying at the tables is ideal.
>
> Sara: Yes, they have space to show so everyone can see. I will organise the tables with the children's names so they know where they have to sit and put the materials they will use. [S6]

In Eva's understanding, the cups with the pieces of clothing should not "be placed in a line [horizontal row], because we would be inducing an order (...) they [the children] may not even think about this order, but they follow it because the cups are already like that. They must be placed in a circle" (Eva, S6). The concern in anticipating the children's difficulties, the influence that the arrangement of the material can have on the understanding of the aim of the task, and the ability to think before acting were highlighted throughout the sessions, making the participants more attentive and knowledgeable about the children's needs and, based on them, plan their educational action better.

Preparation of lesson moments

Once the procedures for presenting the materials were defined, detailed planning of the structure of the research lesson was carried out, namely checking the lesson segments, the times allocated (Table 2), and how the lesson would be conducted.

Table 2

Expected segments and approximate duration

Segments / Moments of the research lesson	Time
1. Motivation and presentation of the task	25 minutes
2. Autonomous work	20 minutes
3. Whole-class discussion and final synthesis	30 minutes

Regarding the management of children's work during autonomous work, Eva questioned whether a limit on the number of pieces should be imposed:

> Eva: Shouldn't we impose a limit on the number of pieces that can be repeated? Imagine that some [child] put eight yellow pieces, eight green, eight black, that is, without connection, what do we do?

> Facilitator: If you see this happening, you have to guide them so they understand that they cannot use the pieces this way.
>
> Sara: Say: “But what is your little bit, after all?” “Isolate it with your hands so I can see which one it is.” “If you put all the pieces like this, you won’t be able to repeat it.” [S6]

The way the teacher acted in accordance with the anticipation of possible difficulties expressed by the children when solving the task was registered in the plan. Sara showed her concern about knowing how to act in the event of children finishing the task before the time:

> Sara: My biggest problem is if there are children who finish the task faster than the others. When they finish the task, they no longer want to be there, but others may need more time, what do I do? There should be a strategy: either make a drawing, or paint one...
>
> Facilitator: It’s only 20 minutes! They are not taking into account that the patterns may have errors and they can correct them when they are questioned and that this takes time. [S6]

How children should be asked to present their work was also the object of analysis and discussion:

> Eva: How do we know who to call first?
>
> Facilitator: In fact, where they will encounter more difficulties is in autonomous work because it is not easy to understand all the students and the difficulties they will have in building their patterns (...) They must find out which child has the pattern with the most mistakes or who could not do it, so they can be the first to call. Not as a way of exposing something as wrong, but rather to question it and make him/her identify the error (...) You must be aware that the first questions you ask the child will help others better understand or validate their knowledge. It also serves to systematise knowledge for the whole group. “Ah! Hers was missing a piece... maybe mine was missing too...” [S6]

Bearing in mind the aim of the task and the difficulty that children in this age have in expressing and justifying their thoughts, it was necessary to

anticipate the type of questions to ask when they were called to present their work to the whole group. This prior preparation of the questions to ask would help children to express their thoughts and identify errors, if any, also contributing to the whole group's consolidation of the concept. Thus, and following the anticipation of possible difficulties that children would experience in oral communication, we defined guiding questions the teacher should ask when the child presented his/her work: "Can you tell me what the unit, the "little bit", that you invented is? Show it, isolating with your hands. Can you read your unit? How many times did you manage to repeat it on the string ?..." During the whole-class discussion, the teacher should also be able to lead the children in identifying and correcting possible errors in the constructions and understanding the orientation of the pattern (left to right). The defined mode of action was also in line with that indicated in the OCEP (Silva et al., 2016) when they explain that the teacher must support children's reflection by "asking questions that allow them to construct mathematical notions (...) intentionally leading them to deepen and develop new knowledge" (p. 74) in whole-class.

In the session before to the research lesson, the teachers solved the task once again, agreeing on the presentation method, the way the lesson would be conducted, the instructions and warnings to give to the children at each moment of the lesson, defining how they could guide and support them in the anticipated difficulties. All the timely decisions and planning were important learning experiences that allowed the teachers to build and deepen their knowledge of students and teaching practice since, in everyday life, it is difficult to make such a detailed study and prediction in the planning and enactment of teaching activities. These changes were reflected in the lesson plan, with the group's agreement and a proactive attitude being evident from the participants, particularly from Sara, in presenting and clarifying questions. Such an example was what happened in the discussion of planning the leading of the whole-class discussion about how to act at the time of the final synthesis (generalisation) was questioned:

> Sara: I have a question you will have to teach me, because I was worried. Here in the plan... In the summary, where it says that the teacher must end by highlighting the importance of patterns in everyday life. How do I explain to children the importance of patterns in everyday life?! The only thing I remembered was that patterns help us keep things organised. Everyone can see that arrangement. But how do you explain this to children?!

> Sofia: Why don't we show photographs of some objects in the generalisation moment and ask if they can identify any patterns? For example, identifying patterns on a sweater or arranging the dishware in the "dolls house" to associate the theoretical concept with practice.
>
> Facilitator: Yes, we can go that way. Basically, it's about making them to realise that we find many patterns around us, highlighting their importance in the construction and organisation of things, making the connection with the images you're going to show. [S6]

The sequencing of the actions to develop at each moment of the lesson based on the anticipation of the children's difficulties contributed to transmitting greater security and confidence to the teachers, especially Sara, as she was the first to teach the lesson, making more evident the importance of anticipating and planning in detail the learning and conducting the activity at different moments of the research lesson, as evidenced in other lesson studies (Fonseca & Ponte, 2022a, 2022b, 2023).

Knowledge of teaching practice: post-lesson reflection

After the first research lesson, discussion on the field notes and the hypotheses raised in the lesson plan, focused essentially on two dimensions: (i) the children's performance, particularly on the learnings observed, the followed solution strategies, the difficulties manifested, the ability demonstrated in the argumentation and justification of the hypotheses followed and the connections established and (ii) lesson management, specifically on the segments and duration, how the task was presented, and how the whole-class discussion carried out. The reflective moment that followed was particularly enriching because participants could, without fear, share discoveries, learning, and knowledge of the dimension of teaching practice and students while expressing the difficulties felt in teaching and managing some moments of the lesson.

Analysis of strategies and difficulties

Usually, the participants considered that children understood the aim of the task because they could create simple repetition patterns, mostly (like ABCD in terms of colour), but also some of a more complex nature, "which I wasn't expecting at all!" (Sara, S8). The greatest difficulty was "fine motor skills. In opening the pegs and understanding how they joined the string, the piece of clothing, and securing the two elements with the peg, but (...) they

overcame the difficulty" (Sara, S8). Despite recognising that handling the pegs was a challenge for some children, the participants considered "keeping using them in the following lessons" (Eva, S8) because the children had overcome it. Contrary to participants' initial expectations, "none of the children asked for validation of their work, nor did they request help from an adult. Nobody called me to help or ask if it was OK, because the normal thing was to call me every two minutes, which surprised me" (Sara, S8). For Eva, "the material was a facilitating element. The size of the pieces was ideal for children to handle. The colours were appealing, contributing to the success of the task" (S8). Sara was surprised at the fact that all the children, except for one, "demonstrated knowledge of writing orientation [in constructing the pattern from left to right]. Something that I use to put into question!" (S8).

Leading the lesson

Presentation of the task and leading autonomous work

Regarding the leading of the lesson, particularly when motivating and presenting the task, the assessment of Eva and Sofia was positive:

> Eva: The way you introduced the socks, built the unit, and explored the concept by calling Dinis to continue your 'little bit' in the stringline was very well connected. Maybe I would be struggling to hang the socks! It was good to see you, because now I'm going to imitate you in my lesson.
>
> Sofia: The fact that you delimited the unit with your hands was important for them [children] to understand which was the 'little bit' that they should repeat in the line." [S8]

In this regard, Sara made an unexpected statement regarding learning about the content taught:

> Sara: I have to say here that even though I have worked with patterns my entire life, I had not really realised what a pattern is and its importance. It was the question I asked yesterday about the importance of patterns in life, and from the explanation you gave me [referring to the facilitator], I managed to put myself in the children's shoes and tried to understand what they are useful for and why they are useful. It's the organisation. And now, I understand why the pattern

> is the principle of algebra. I had a wrong conception of a pattern. I only recently learned how to explain it and make children understand and generalise it. It's never too late. [S8]

Sofia suggested, as an improvement, "more socks in different patterns. At the time of exploration, if we had at least eight socks for example, we could repeat the unit more than once and, visually, this repetition would be more noticeable" (S8). The group accepted the suggestion, which was recorded in the plan for the next lesson, which Eva would teach.

Regarding the leading of the autonomous work moment, contrary to the initial expectations, no children "organised the cups in the order in which they built their unit. They removed their clothes, organised them on the table and immediately put them on the line. They didn't leave it on the table as a model" (Sara, S8). Eva added that the "strategy followed by most children shows the good visual memory they have, but also because most of the models were simple to build, except for João's, which made AABCDD, and David's, which made AAABCDDD" (S8).

Whole-class discussion

In the participants' opinion, the moment of whole-class discussion was "extremely important for the children to understand the intended aim: to know what a unit and a repetition pattern are. They realised that they could make different patterns with different [levels of] complexity" (Eva, S8). The following dialogue shows the recognition of the importance of whole-class discussion:

> Sofia: The discussion was important for Manuel because he started to build the pattern in the middle of the line... He repeated the unit twice, but left spaces between the elements and filled the spaces with other elements at a certain point...
>
> Facilitator: The fact that you explored Maria's pattern, which only had one element missing in the last unit, made Manuel understand why he hadn't built a pattern. [...] The fact that you asked Maria to read the pattern out loud made him to realise that he mixed up the pieces and he became aware of his mistake when he said: "Ah! I mixed everything up!" And then the discussion was extremely important, not only for Manuel but also for the whole group. [S8]

In a more in-depth analysis, the facilitator questioned Sara about "the relevance for all the children being called to present their pattern, which made the moment long and dispersed the attention of some children" (S8). The dialogue made the participants aware of the need to manage more efficiently when calling on children to describe their patterns; there was no need to call on all. As a suggestion for improvement, it was defined that, in the following lessons, the teacher should call on the children with more significant examples from the point of view of the construction of mathematical ideas in whole-class. The facilitator suggested they should start by calling "those [children] who have errors in the pattern or could not finish or continue. Then, call one or two who have a simple pattern and then one or two who have managed to make a more complex pattern" (S8).

Regarding the moment of generalisation and the connections made, the following dialogue shows the participants' perception of its importance in the whole-class construction of mathematical knowledge by children:

> Sara: Many of the children raised generalisation hypotheses that made me believe they had made a bigger leap than I would have expected. The discussion was the 'click' moment [...] Jumping from images to everyday tasks, I wasn't expecting it!
>
> Facilitator: Were there connections between knowledges at the time of the discussion?
>
> Sara: Of course. They looked for patterns on their shirts, on their bibs (...) I never thought they would identify the pattern, for example, on the little boats, where the sequence of the months of the year is, or on the calendar of weekly attendances, because I thought they wouldn't be able to see that it was repeated because it is a longer pattern. They [children] could relate an everyday action with what they understood from the task, which surprised me." [S8]

In a critical self-analysis of the lesson taught, Sara recognised the importance of the whole-class discussion:

> Sara: What was different in this lesson? I have to say that I would not do the discussion part, presenting and justifying their work the large group. It is a mistake. In this lesson, the reflection was way more effective because it was with whole-class (...) They [the children] could analyse the error

> and correct it with the help of others, and that is what made the difference in acquiring new knowledge and rethinking our practices! [S8]
>
> She added:
>
> Sara: When I say that I was surprised by the generalisations, I must understand why that happened in this lesson and doesn't happen in other situations. Knowing the group,I did knowthey were going to make patternsSome were more complex than I would have expected, it's true, but I knew they were capable. From my analysis, it was that click you mentioned [referring to the facilitator] that occurred during the discussion. Seeing where the colleague went wrong and why that is not a pattern, how it can be corrected, because then they can reflect. This peer-to-peer support is an added value. [S8]

Sara's words reinforce the importance of communication and justification of work in consolidating learning when she says, "What I learned from my lesson today is that the best strategy for consolidation is whole-class discussion" (S8).

In short, in the dimension of knowledge of teaching practice, the teachers' discourse shows that they began to give greater importance to planning their actions based on the learning aims defined for the lesson, questioning themselves about the learning that children should develop at the end of the work as a way of structuring their educational action. It also allowed them to reflect and contextualise representations of their own practice.

They demonstrated a broader knowledge of the design of the lesson structure since, during planning, they made decisions about the content of the task to develop, the presentation method, the work modality and the material to use. These decision-making moments, based on shared knowledge of the children's learning process and in line with the intended learning aims, provided significant learning in the field of teaching practice. Sara's words are enlightening:

> Sara: The lesson planning differs from ours [lessons] because we don't plan in such detail and plan in the sense of what I want them [children] to learn, how they can learn, and

> whether they have learnedor not. It has been a real learning experience for me. I look at my actions very differently. [S8]

The moments dedicated to preparing the leading of the whole-class discussion also led the participants to reflect on action and deeper knowledge of practice, constituting a strong formative experience of professional development, similar to that evidenced in other studies (Fonseca & Ponte, 2022a, 2022b, 2024; Ni Shuilleabhain & Clivaz, 2017; Schlichting et al., 2023).

The teachers recognise that the fact that they previously planned how they would ask the children to present their work and the questions they would ask contributed not only to the effective management of learning situations but also as a structuring moment for learning in the way children appropriated the concept.

In Sara's understanding, "when the teacher asks the right questions during the discussion, he/she helps the children to structure their thinking, making them realise what they have learned and where the error is" (S12), demonstrating an awareness of the importance of whole-class discussion in children's appropriation of mathematical ideas.

CONCLUSION

This research illustrates the learning path towards central aspects of didactic knowledge in a group of early childhood teachers who participated in a lesson study. The results show that the participants showed a broader knowledge of the curriculum documents that support early childhood education, identifying repetitive patterns as an important theme for developing children's algebraic thinking. Selecting and analysing the topic contributed to raising awareness of the content and the importance of planning actions with clearly formulated learning aims. They proceeded to create a learning situation following the usual approach in early childhood education and centred on an original task for which they designed appropriate materials.

The participants say they are more willing to prepare for moments of whole-class discussion as they recognise that children of this age can reflect and justify the strategies used to solve a task when guided to express themselves orally. Significant learning emerges with the design of exploratory tasks aimed at children in this age group.

The study shows how the teachers developed relevant aspects of knowledge of teaching practice when they planned, enacted, and reflected on learning situations as they went through the process of problematising their own practice. It also highlights aspects of the development of didactic knowledge that are relevant to early childhood teachers, which go beyond what is documented by Estrela et al. (2022) and by Fonseca and Ponte (2023), providing indications on how to lead lesson studies with early childhood teachers, an area that has been little researched.

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AUTHORSHIP CONTRIBUTION STATEMENT

GF collected the data, did the first analysis and wrote the first version of the methodology and results. JPP wrote the first draft of the introduction and theoretical framework. GF and JPP actively participated in the discussion of the results, reviewing and approving the final version of the work.

DATA AVAILABILITY STATEMENT

The corresponding author, GF, will make the data supporting the results available upon adequately justified request.

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