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Lesson study in initial teacher education: Key aspects that promote the development of prospective teachers' knowledge

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Based on the analysis of three lesson studies, carried out in different initial teacher education programs, we aim to identify key aspects that promoted the development of the prospective teachers' knowledge during the planning phase. We followed a qualitative approach and data collection includes fieldnotes, audio recordings and documental collection. The results show that the detailed preparation of the lesson, based on collaborative work on solving and adapting the tasks, anticipating students' work, and preparing the lesson leading, promoted the development of the prospective teachers' knowledge, enhanced by analysing different papers and by the facilitators' interventions.

Keywords: Lesson study, initial teacher education, teacher's knowledge, mathematics teaching.

Introduction

Several investigations point to lesson study as a professional development process where teachers and prospective teachers have the opportunity to develop their knowledge through collaborative work in a reflective environment (Gomes et al., 2022). Whether in the domain of mathematical for teaching or in specific aspects related to teaching practice (Leavy & Hourigan, 2016; Martins et al., 2023), the potential of this formative process is undeniable in the development of prospective teachers' knowledge. However, carrying out lesson studies in initial teacher education implies adapting this process. It is necessary to take some options, namely related to the role of the prospective teachers in each phase, to create opportunities for them to develop their knowledge. Among the different decisions that can be taken (Ponte, 2017), how to carry out lesson studies without taking the risk of oversimplifying the process and losing its essence? Willems and Bossche (2019) state that, in addition to understanding how lesson study is carried out, it is important that research identifies "circumstances and conditions for collective and individual learning among teachers, teacher candidates and students" (p. 267). Thus, we aim to identify key aspects that promoted the development of the prospective teachers' knowledge, particularly in the lesson planning phase.

Theoretical framework

Preparing teachers raises several challenges related to the evolution of society and students' new ways of learning. Thus, it is important that prospective teachers develop knowledge to learn how to teach through teaching approaches that promote the students' learning. One of these approaches is the *exploratory approach* (Ponte, 2005), similar to the *inquiry-based approach* (Stein et al., 2008). It allows students to explore concepts, procedures, and mathematical ideas, and emphasizes the importance of creating discussions among students. However, preparing and leading an *exploratory lesson* is a challenge for prospective teachers (Stein et al., 2008). This challenge is usually related to the gap between the theory that they learn during the initial teacher education program and the teaching practice in a classroom (Bergsten et al., 2009), but also with the knowledge they are still developing (Stein et al., 2008). Thus, finding situations that promote the development of prospective teachers' knowledge, during the period of their teacher training, continues to be an object of research.

Since the seminal work of Shulman (1986), several authors strived to understand how teachers' knowledge may be characterized. In the work of Ball et al. (2008) and of Ponte (2012), there are four dimensions that stand out: *knowledge of mathematics for teaching*, which involves understanding concepts, procedures, representations and their relations; *knowledge about students' learning*, which includes their habits, cultural values, difficulties and ways of learning; *knowledge of the curriculum*, which concerns the appropriation of the learning goals of Mathematics teaching, topics and contents, and its organization; and *knowledge about teaching practice*, which holds task design, lesson planning, organization of students' work, as well as the creation of learning environments.

Several investigations (Bergsten et al., 2009; Potari & Ponte, 2017) point out some privileged ways to promote the development of prospective teachers' knowledge during initial teacher education. One of the most powerful activities is a detailed lesson planning (Chen & Zhang, 2019). By looking closer to the different moments of the lesson, the prospective teachers can analyse the knowledge that students already have, as well as the knowledge they should have after that lesson. This analysis gives the prospective teachers opportunity to be more familiar with the curricular documents as well as the students' learning processes. It is also from this analysis, in parallel with the study of curricular guidelines, that they select and analyse tasks, considering their potential and limitations, concluding what characteristics can promote learning environments. Based on this work, it is hoped that prospective teachers be able to adapt the task and anticipate the students' work, seeking to define strategies to support them in the difficulties that may arise (Gomes et al., 2022). By doing this work, focused on students' learning, the prospective teachers can prepare their interventions and the way the communication should be established (Martins et al., 2023). Preparing the questions to pose and in what moment, as well as the strategies to support students, gives them tools to feel more comfortable and prepared to teach the lesson (Stein et al., 2008). Having classroom experiences, to put into practice what they planned, is also a productive way to promote the prospective teachers' knowledge (Bergsten et al., 2009). By teaching the lesson they planned, they can conclude on the effectiveness of the strategies they have defined for students' learning. In particular, analysing specific classroom events is essential for prospective teachers to understand how students learn and, consequently, being able to develop strategies to improve their practice (Martins et al., 2023).

Lesson study is a professional development process that has shown benefits in promoting the development of prospective teachers' knowledge (Leavy & Hourigan, 2016; Ponte, 2017). In this formative process, prospective teachers have the opportunity to plan, lead and reflect on classroom events, leading them to put into practice the theory they have learned. One of the particularities of lesson study is the detailed planning of the research lesson, carried out in a collaborative environment (Fujii, 2018). The work begins with the curricular study of the mathematical topic or a student's capacity to be developed, leading to the selection of the task to be proposed. As stated by Fujii (2018), "choosing the right task is crucial, and it is partly the reason why planning a lesson is so important in lesson study" (p. 10). Thus, prospective teachers analyse the task's potential and limitations from the point of view of mathematical learning within the curriculum documents. Based on this analysis, they can adapt, for instance, the numbers presented in the statement, the context to interpret, or the order of the questions, to meet the learning goal (Fujii, 2018; Gomes et al., 2022). During lesson planning, prospective teachers also anticipate the students' work, which requires a lot of time to discuss the different solving strategies that they may present, as well as the possible difficulties they may have.

To anticipate students' responses, Fujii (2018) highlights the importance of using curriculum documents to consider students' prior knowledge which would be used to solve the task. In addition to anticipating the students' work, prospective teachers can also prepare the *flow of the lesson* (Fujii, 2018). In other words, prepare the interventions or questions they will pose, when they will pose, how they will support students in their difficulties, and how they will lead the whole-class discussion.

Methods

This investigation follows a qualitative approach (Bogdan & Biklen, 2007), considering the sessions of three lesson studies carried out in three higher education institutions located in different areas of Portugal as data source. The lesson studies were prepared and facilitated by the first author in two cases (LS2, LS3) and by the second author in the other (LS1), together with the supervisor of the corresponding higher education institution, which both assumed the facilitator role. All the work was developed considering *exploratory lessons* as the teaching approach for research lessons, and the lesson studies followed the cycle proposed by Fujii (2018).

The prospective teachers were in the last year of their initial teacher education, in the curricular internship. Thus, they were supervised by a teacher from the institution they attended and accompanied by a cooperating teacher from the school where they were carrying out their internship. One of the lesson studies (LS1) involved two middle prospective teachers (grades 5-6), Adriana and Margarida. After analysing the school's curricular planning, the cooperating teacher defined that the research lessons should address the exploration of non-negative rational numbers, in grade 5. Each prospective teacher taught a research lesson in the same class, on this mathematical topic but, proposing different tasks. Another lesson study (LS2) involved two secondary prospective teachers (grades 7-12), Mónica and Olívia. According to the school's planning, the cooperating teacher defined the review of direct proportion as the learning goal, in grade 7. Both prospective teachers taught the lesson, on the same day, but in different classes. The third lesson study (LS3) involved three secondary prospective teachers, Lila, Maria and Sílvia. By the supervisor's suggestion, each prospective teacher prepared, taught and reflected on three lessons. They all chose to work with functions, in grade 10, but with different learning goals in different classes. Adriana and Margarida (LS1) had a few courses on mathematics (32 ECTS), whereas the other prospective teachers (LS2, LS3) had three years or more of specialized qualification in mathematics (198 ECTS). Prior the lesson studies, all prospective teachers had several courses in different areas as sociology and psychology of education, didactics of mathematics, or school organization. All of them observed several lessons taught by experienced teachers before the lesson studies so they were familiar with the students' dynamics in the classroom.

Data were collected by the first two authors, who assumed the dual role of participant observers and researchers (Bogdan & Biklen, 2007). Data collection includes fieldnotes, audio recordings of the lesson studies' sessions and the interviews carried out with the prospective teachers, before and after each lesson study, as well as document collection. To identify the data source in the data analysis, it was considered five phases: *goal setting*, *lesson planning*, *research lesson*, *post-lesson discussion*, and *reflection* (Fujii, 2018). For data analysis, we considered the literature review on how to promote the development of prospective teachers' knowledge during their initial teacher education (Potari & Ponte, 2017), as well as the particular characteristics of lesson study (Fujii, 2018; Ponte, 2017),

focusing on the lesson planning phase. We selected the most significant episodes of the lesson studies planning phase, paying particular attention to the situations that promoted the development of the prospective teachers' knowledge. By a thematic analysis strategy, based on the theoretical framework, we identified three key activities: *selecting and designing tasks*, *anticipating the students' work*, and *preparing the lesson leading*. The first two authors started by separately coding the episodes in these activities and identified the dimension of knowledge developed by the prospective teachers. Then, all the authors met to discuss this work and to reach a consensus, assuring the quality of data analysis. All names are pseudonyms to ensure the participants' anonymity.

Results

Selecting and designing tasks

By analysing a paper on curriculum management, Adriana and Margarida (LS1) showed some discomfort with the nature of the tasks, explaining that “objectively, we never had to distinguish an exercise from a problem” (Margarida, goal setting). When analysing the tasks, they selected, they realized that they had to make a more careful selection:

Supervisor: [Do you think the tasks] have the necessary characteristics to be exploratory tasks?
Cooperating teacher: ... If we want interesting [whole-class] discussions...
Margarida: ... We'll make a new selection... We will bring other tasks, is that OK? (lesson planning)

So, they selected tasks to promote “as many different strategies as possible to later use in the [whole-class] discussion” (Margarida, lesson planning), showing a greater concern with the characteristics of the tasks. To better understand the potential of those tasks, the supervisor suggested them to solve the tasks with all the strategies they recall, focusing on the representations students could use:

Adriana: Here we have fractions where they [students] can use different representations. Regarding point six [0.6], they can say it's sixty percent [60%].
Supervisor: Or even they can say it's one sixths [$1/6$]. (lesson planning)

Discussing about the representations students could use led the prospective teachers to reconsider the ones that were more important for that lesson, and how they could be related.

In LS2, Mónica and Olívia considered that “we have to diversify and increase the degree of challenge [of the questions]” (Olívia, initial interview). However, they selected tasks with a low degree of challenge, that only asked to identify situations that could be represented by a direct proportion. The facilitators then suggested reading a research paper about teacher's learning about communication, tasks and reasoning. After discussing the main aspects of that paper, namely the characteristics of the tasks, the prospective teachers adapted the tasks they had selected. For instance, they changed the word “reasoning” in some questions since “[it] already lead them [the students] towards proportion” (Mónica, lesson planning) which could limit the strategies they could follow. They also reordered the task's questions to have “the graph and the table as the starting point to the algebraic expression ... to lead to the generalization” (Mónica, lesson planning), encouraging the use of different representations and promoting students' reasoning processes.

During LS3, this challenge was not visible. The prospective teachers proposed tasks to students to work with different solving strategies, which may have resulted from the work they did before the lesson study. They planned and observed several exploratory lessons before engaging in lesson study,

leading them to become more familiar with this teaching approach. However, during the lesson planning, and by anticipating and discussing the solving strategies the students could use, they felt the need to change some questions so that the students could work with different representations.

Anticipating the students' work

Considering the knowledge of mathematics for teaching Adriana and Margarida (LS1) already had, they explained that, for them, the tasks were very simple. Thus, the biggest challenge was “putting myself into the student's shoes” (Adriana, lesson planning) to anticipate the difficulties they might have. The supervisor then suggested solving the tasks step by step, using different strategies and based on that work, rethinking the difficulties that could arise. So, the prospective teachers could overcome this challenge and focus on the work the students could carry out and how they could support them:

Margarida: I doubt they can apply the algorithm using [values with] commas!
Adriana: ...How are we going to explain the algorithm with [values with] commas? We can't be the decimal positions and then get the result like this. (lesson planning)

In LS2, Mónica and Olívia soon showed concern in anticipating the solving strategies that students could use and the difficulties they could have, as well as trying to prepare their strategies to support them in those difficulties. The starting point for this anticipation and preparation work was a research paper that was read and discussed during the lesson planning, and it not only referred to the importance of drawing lesson plans, but also exemplified one on direct proportionality, which was the topic to explore with the students. However, by collaboratively analysing the anticipation work they did, the supervisor signed that they did not consider one possible solving strategy, simplest than the ones they contemplated. So, Mónica and Olívia rethought the work students could do, adding strategies with more straightforward procedures and representations to the anticipation work they already had done.

The anticipation of students' solving strategies and difficulties made by Maria and Lila (LS3) was, at first, quite general, just referring to the “difficulties in interpreting the task's context” (Maria's lesson plan). However, the prospective teachers did a more detailed work after being involved in each other's lesson planning discussions, enhanced by the collaborative work:

Maria: As I already had all the solving strategies, and we also prepared the lesson very well considering these strategies, there was nothing, ... [nor] any moment that surprised me. (first post-lesson discussion)

This work of anticipating the students' solving strategies and difficulties was, for Sílvia, “a fundamental component” (first lesson reflection), and allowed prospective teachers to feel “better prepared, and to help the student more easily” (Lila, first lesson reflection) during the lesson.

Preparing the lesson leading

The lesson leading preparation started from the students' difficulties the prospective teachers anticipated based in the learning goals each group had defined for each research lesson. Following the facilitators suggestions, Adriana and Margarida (LS1) prepared how they would establish communication in the classroom, something that they were not used to do when they planned lessons, paying particular attention to the teacher's actions leading the whole-class discussion:

Margarida: To start the whole-class discussion, we need to make an invitation.
Adriana: ... If I ask a group to start [the whole-class discussion], isn't that already an invitation?

Margarida: I think so. Something as “read or explain what you did in that task”. (lesson planning)

In addition, they also thought about how they could challenge the students, which was also unusual in their previous lesson plans:

Margarida: You could ask “if we divided the apples into 4, how many quarters would we have?”
Adriana: Yes, it seems to be a challenging question. It seems that I challenge them to go beyond what is in the question. (lesson planning)

In the case of Mónica and Olívia (LS2), the preparation of strategies to support students in their difficulties and the lead of whole class discussion were not emphasized during the lesson planning, when compared to other aspects such as the anticipation of students’ work:

Mónica: I think we should have prepared better... the communication part ... For example, in this question, what will be the keyword to use? ... or a key question We had only described “the teacher should guide to”. (final interview)

For Mónica, it was a challenge to lead the whole-class discussion which, according to her, was due to the preparation of that moment, which was not detailed. She became with little confidence to interact with the students.

At the beginning of the LS3, the prospective teachers prepared interventions to support students that explicitly pointed out which procedure to use:

Lila: ... Okay, I got it. I am giving too much information...
Maria: ... What could we say ... If the student doesn’t understand?
Lila: What is understood by the initial instant?” ... If I ask that, they’ll immediately say “replace with zero because it’s the first instant” (first lesson planning)

Discussing the implications of teachers’ interventions on students’ learning led the prospective teachers to rethink how they could support students without reducing the degree of challenge of the task. In fact, when they planned Lila’s third lesson, the interventions they prepared encouraged students to represent the situation graphically. Therefore, they could understand what was required in the task, without an explicit intervention, which also promotes the use of different representations.

Discussion

Although with specific characteristics of each context, the analysis of these three lesson studies provides some indications about key aspects that promoted the development of the prospective teachers’ knowledge. One great challenge the prospective teachers faced was selecting tasks to enhance student learning. Reading different types of papers (LS1, LS2) led them to understand the importance of carefully selecting and designing the tasks to propose to students. By discussing how a task influences student learning, they felt the need to adapt the tasks they initially selected (LS2, LS3), developing their *knowledge about students’ learning* and *knowledge about teaching practice*, such as in Gomes et al. (2022). Anticipating the students’ work, especially the difficulties they might have, was another challenge for prospective teachers. To overcome it, Adriana and Margarida (LS1) followed the suggestion of the supervisor and solved the tasks through all the strategies they thought that the students could use, developing their *knowledge of mathematics for teaching*. Additionally, Adriana and Margarida (LS1) and Mónica and Olívia (LS2) rethought the representations that the students could use, developing their *knowledge about students’ learning*. In LS3, as Stein et al. (2008) pointed out, collaboratively anticipating the students’ solving strategies helped the prospective

teachers to anticipate students' difficulties, which also relates to *knowledge about students' learning*. This anticipation work also allowed the prospective teachers to prepare their interventions for the research lesson, which was important for leading this lesson. In particular, the fact that Mónica and Olívia (LS2) did not prepare their interventions in detail, led them to feel not well prepared. However, they recognized that the communication is an essential aspect of the mathematics lesson, so it is also important to pay attention in detail to this during the lesson planning.

We focused on lesson planning as an important way to develop prospective teachers' knowledge (Potari & Ponte, 2017). Reading different types of papers, focused on how to promote students' learning, led the prospective teachers to rethink some aspects of their teaching practice. In initial teacher education, prospective teachers are at an early stage of development of their knowledge and, usually, do not have teaching experience. So, discussing issues regarding the characteristics of tasks (LS1, LS2), students' possible solving strategies and the representations they could use (LS1, LS2, LS3), as well as teacher's actions (LS1) and interventions (LS3), were key aspects to support the development of their knowledge. The role of the facilitators was also a key aspect that promoted the development of the prospective teachers' knowledge. During the task analysis and task solving (LS1, LS2), the anticipation of students' work (LS2), or the lesson leading preparation (LS1, LS3), the facilitators' suggestions led the prospective teachers to rethink what they had planned and to develop their knowledge. So, the support of supervisors, teacher educators, and cooperating teachers play an important role in the development of prospective teachers' knowledge (Chen & Zhang, 2019).

Conclusion

In these lesson studies, collaborative work was a common denominator that distinguished lesson study from what is usually done in initial teacher education programs. By sharing ideas about the papers they read, collaboratively solving and analysing tasks, and anticipating the students' work to prepare the research lesson, the prospective teachers had the opportunity to contact other teaching perspectives. Usually, prospective teachers work with their supervisors and cooperating teachers but do not develop in-depth work in a collaborative basis with colleagues. However, in these lesson studies, this in-depth work supported by the supervisors in a collaborative environment led the prospective teachers to rethink their own former practices, highlighting the potential of lesson study in initial teacher education.

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