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Fostering prospective teachers' knowledge development within lesson study: What are the facilitator's moves?

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This paper presents a case study focusing on how lesson study (LS) provides tools to teacher educators to foster prospective teachers' reflections on teaching and learning. The research draws upon the concepts of the Theory of Didactical Situations to analyse the actions of a teacher educator on the LS milieu and the didactical contract. Through this theoretical lens, some moves of the teacher educator are put forward. Preliminary findings suggested that the educator mainly acted on the different roles taken by the participants to change the didactical contract or reinforce the milieu. Moreover, the impact of these moves on the prospective teachers' reflection within LS is discussed.

Keywords: Lesson study, initial teacher education, milieu, didactical contract, facilitator.

Introduction

According to recent international studies (Borko & Potari, 2020), the topic of teachers' professional development in collaborative contexts has received increasing attention in the field of mathematics education over the past two decades. One such context is lesson study (LS). This collaborative model of teacher professional development originated in Japan at the end of the 19th century. However, it gained popularity outside the Asiatic continent only after the 1995 TIMSS comparative study (Stigler & Hiebert, 1999). Since then, LS has seen a great deal of research focusing on its application with in-service and, lately, pre-service teachers.

Concerning initial teacher education (ITE), research shows a variety of promising results. Among others, Ni Shuilleabhain and Bjuland (2019) suggested that LS can provide prospective teachers with an effective environment to acquire knowledge in and for teaching. At the same time, some authors pointed out that LS is subject to additional challenges and constraints when practised in this context. Ponte (2017), for instance, underlined the imbalance of power and experience between the prospective teachers and the educators, which can cause difficulties in establishing truly collaborative relationships within the group. The educators' task is hence particularly delicate when facilitating LS in ITE, and they must maintain the balance between several different roles (mentor, expert, convenor, researcher, practitioner). Nevertheless, this combination of roles and its consequences have yet to be widely explored in LS research about ITE.

The case study presented in this paper is part of a broader doctoral research conducted within the framework of the ITE program held at the Lausanne University of Teacher Education, Switzerland, for prospective teachers in mathematics. The research aims, on the one hand, to investigate the potential relevance of the implementation of LS in this context and the possible learning outcomes of prospective teachers. On the other hand, it seeks to explore the specific conditions and adaptations that characterize LS essential features in this setting.

This case study, in particular, focuses on how a teacher educator can draw on LS characteristics to foster pre-service teachers' reflection about teaching and learning mathematics.

Theoretical background

Lesson Study and the Theory of Didactical Situations

Lesson study is the English translation of the Japanese expression *jugyou kenkyuu*, where *jugyou* means live instruction (one or more lessons), and *kenkyuu* refers to both study and research (Lewis, 2016). It is a form of professional development where a group of teachers works collaboratively to solve a teaching or learning problem. To do so, they undertake a research activity by analysing the curriculum, planning a research lesson, and observing it. The outcomes of the lesson are discussed, and the group can decide to re-engage in the process (giving it a cyclical structure) or disseminate the results to the professional community. LS is usually led by a facilitator that promotes the dialogue, involves all the participants, and allows the process to flow (Lewis & Hurd, 2011). In some cases, an external expert, or knowledgeable other, is invited to provide insight into the group reflection. It is important to observe that in countries where LS is well established, the role of the facilitator and the external expert are clearly defined, while elsewhere, the boundary between the two roles is more permeable (Clivaz & Takahashi, 2018). Clivaz and Clerc-Georgy (2020) reported their work as facilitators by identifying four roles: convenor, teacher trainer, researcher, and group member.

Speaking in terms of Brousseau's Theory of Didactical Situations (2014), LS can be modeled as a form of a didactical situation for teachers' learning (Clivaz, 2018). Indeed, when teachers engage in LS, their goal is to acquire new knowledge, but their attention is drawn to the task of designing and observing the research lesson. In this sense, the research lesson and the lesson plan constitute the *milieu* of the situation, i.e. "what the students¹ exercise their actions on and what gives them objective responses" (Brousseau & Warfield, 2014, p. 166) regarding the desired knowledge.

Didactical contract

Another key concept of the Theory of Didactical Situations is the notion of *didactical contract*. It consists of a set of norms, mostly implicit, that regulate the mutual expectations of the teacher and the students concerning the mathematical knowledge at stake (Hersant & Perrin-Glorian, 2005). Consequently, it is considered a means for the teacher to manage and maintain the didactic relationship (Hersant, 2014).

Hersant and Perrin-Glorian developed the concept of the didactical contract by characterizing its action at different scales. At the macro level, the contract depends on the teaching object. The meso-contract acts at the level of the realization of an activity (e.g., the resolution of a problem) and is influenced mainly by the existence of a milieu and its didactical potential. The micro-contract is situated at an episode-level (corresponding to the interactions on a unit of knowledge) and is influenced mainly by the distribution of responsibility between the teacher and the students (Hersant & Perrin-Glorian, 2005). Furthermore, two dimensions of the contract can be pointed out at every

¹In this case, teachers.

scale: the *epistemological dimension*, directly related to the knowledge at stake, and the *social dimension*, characterized by the respective expectations of the teacher and the pupils for the production of knowledge (Hersant, 2014). According to Hersant and Perrin-Glorian (2005), the analysis of the teacher's game on the didactical contract and the milieu provides a dynamic look at the teaching-learning processes in regular classes.

Although the notions of adidactical situation, milieu and didactical contract were not developed in the context of professional development, they can provide a suitable theoretical lens to analyse the construction of knowledge during LS, especially in the ITE case. Indeed, in this context, the role of the educator is complex, due to his/her learning agenda (that may differ from the LS learning goal) and his/her different roles in the LS process. Moreover, other constraints like strict schedules, partially established content, and evaluation entail a stronger didactical contract. At the same time, LS structure itself, as well as the role of the research lesson and the collective conception of the lesson plan, can create a convenient milieu for the reflection of prospective teachers.

Considering these theoretical tools, the research question can be framed as follows: *To what extent does the teacher educator act on the milieu and the didactical contract provided by LS to foster prospective teachers' reflection on teaching and learning?*

Data and method

This research is a case study of a training class based on LS during the Autumn semester of 2021 at the Lausanne University of Teacher Education. The project involved five prospective lower-secondary school mathematics teachers, while a university educator with experience in LS served as the facilitator. The educator was also in charge of grading the prospective teachers at the end of the course. Two experienced schoolteachers supported the group's work during one planning session, the lesson observation, and the post-lesson discussion. The LS included 12 meetings of around 1.5 hours each, plus a research lesson that was held in the class of one of the schoolteachers. As a researcher, I collaborated with the teacher educator to prepare the LS meetings and observed them without participating.

The LS was organised around the teaching of integers in grade 7. This topic was chosen before the beginning of the LS, for two reasons. First, from a mathematical point of view, integers are a crucial point in the development of an abstract conception of mathematics. The reason behind their structure relies only on internal mathematical arguments, such as Henkel's permanence principle². Besides, despite its mathematical importance, this topic doesn't take up much space in the mathematics curriculum of the Swiss state of Vaud. In grade 7, it should be taught for two or three weeks. The second reason was the need for the facilitator and the researcher to prepare documents, articles, and other material in advance to enrich the students' milieu.

Within the theme of integers, the prospective teachers chose to focus on the teaching and learning of multiplication, with particular attention to the sign rule. From the teacher educator's standpoint, one

²i.e., the idea that algebraic operations must behave consistently in all numerical systems, especially when developing extensions to these systems.

of the learning goals of the ITE program was for the prospective teachers to understand the mathematical reasons underpinning the sign rule (i.e., the permanence principle). The second goal was for the prospective teachers to be able to make and justify their didactical choices when operating the didactical transposition of this piece of knowledge to the class.

All the meetings were filmed and summarized in a synopsis. Other data collected consist of the audio recordings of each preparation meeting, the collective lesson plan, the documents shared within the group, and the course final assessment. Qualitative data analysis was based on Hersant and Perrin-Glorian (2005) method and comprised three main steps. First, according to the synopsis of each session and the preparatory documents, a number of tasks proposed to the prospective teachers were identified. Those training tasks constituted the meso-level of the analysis. Each task was then divided into separate episodes based on the interactions among the participants. Particularly relevant episodes were integrally transcribed. Second, for each task involving the permanence principle and its didactical transposition, *a priori* analysis was performed to highlight the learning goals and the elements of the milieu. These two elements were used to establish if the milieu was robust enough to ensure retroactions and bring out the desired knowledge. Step three consisted of the *a posteriori* analysis. For each episode (at the micro-level), the following aspects were identified:

- the role taken by the prospective teachers, namely pupil, student-teacher, teacher, researcher-practitioner (according to Guille-Biel Winder et al., 2018);
- the role taken by the facilitator, namely coordinator, expert, teacher trainer, practitioner, researcher (adapted from Clivaz & Clerc-Georgy, 2020);
- the kind of micro-didactical contract (according to the sharing of responsibility for the production and validation of knowledge).

Some examples of the simplified version of this analysis are given in the next section. All analyses were conducted in French; the translation was only for presentation purposes.

Preliminary results

As a first result of the data analysis, some recurrent moves in the game of the educator with the milieu and the didactical contract could be identified. In this section, these moves are presented, together with some examples to illustrate them.

Changing the didactical contract by taking an expert perspective and stepping out of the situation.

With this move, the educator (E) passes from the role of coordinator to the role of expert, and steps out of the LS didactical situation to convey some specific message about teaching or learning in actual classes. Thus, the prospective teachers are still in charge of formulating hypotheses, but their validation is taken into charge by the educator. In this case, the educator acts on the epistemological dimension of the didactical contract.

An illustration of this move can be observed in meeting 6 at 1:20:29 (table 1, bold). The aim of this meeting was to refine the lesson plan; task 4 involved teaching the demonstration of the sign rule using the distributive property of multiplication. In this case, the change in the educator's role led to a change in that of the prospective teachers (from researchers-practitioners to student-teachers).

Time	Summary or transcript ³	Role of the educator (RE), Role of the prospective teachers (RPT)	Micro-didactic contract
1:17:20	E looks at the demonstration and proposes to do it with -2 and -3 instead of -3 and -5. The group agrees.	RE: Coordinator RPT: Researchers-practitioners	The responsibility of the production and validation of knowledge is collective (albeit guided by the facilitator's questions)
1:18:30	E asks if the teacher at the board shows it or the pupils do the demonstration on their own. [Silence]. PT1 replies that it depends on the distributive property, but the pupils have not yet seen it. PT5 asks if the illustration with the rectangles should be used for distributive property, E observes that pupils can't do it with negatives. PT5 replies that in this case he doesn't think pupils could do it alone. E summarises: hence the teacher will show it.	RE: Coordinator RPT: Researchers-practitioners	
1:19:47	<i>PT5: If you have any better ideas, but since pupils haven't seen distributive property...</i> <i>PT3: Normally they did.</i> <i>E: Yes, actually they've seen some examples in 5th-6th grade, with the algorithm of multiplication, when doing mind calculation...</i>	RE: Coordinator RPT: Researchers-practitioners	
1:20:06	<i>PT3: Maybe it's better to remind them of the distributive property before [the demonstration] ...</i> <i>E: should we remind them of the distributive property?</i> <i>PT1 and PT5: Yes</i> <i>E: So, what could be a good example? [Silence].</i>	RE: Coordinator RPT: Researchers-practitioners	
1:20:29	<i>E: it is essential, when we teach, to have good examples. Examples that [snaps his fingers]</i>	RE: Expert RPT: Student-teachers	
1:20:41	<i>PT3: 7(25+75)?</i> <i>E: No, it's the opposite</i> <i>PT5: Ah, yes</i> <i>E: when doing 7(25+75), you would prefer doing 7·100</i>	RE: Expert RPT: Student-teachers	E takes an expert viewpoint as well as the responsibility of validating prospective teachers' answers. Moreover, he refers directly to teaching "in real life"

Table 1: Extract of meeting 6, task 4: planning of the demonstration of the sign rule

Changing the didactical contract by taking a participant's perspective

The educator purposely passes from the coordination of the discussion (or the role of teacher trainer) to the role of a participant by explicitly admitting that he doesn't have the answer to a particular question. In this case, the change in the didactical contract is marked by affirmations like "it's a true question". Participants are thus more engaged in elaborating together hypotheses regarding pupils' learning. The milieu given by the research lesson is strengthened as it becomes the only way to validate the participant's hypothesis. In this case, the educator acts on the epistemological dimension of the didactical contract and on the milieu.

An example of this move could be observed again in meeting 6 at 1:00:32 (table 2, bold). In task 3, the participants chose to use a GeoGebra animation⁴ to test the multiplication with integers. The group reflected on the choice of numbers to use in the animation. In this case, the prospective teachers' role

³For space reasons, some utterances are only summarised. Fully transcribed utterances are reported in italic.

⁴<https://www.geogebra.org/m/sgs3faxy>.

didn't change, but the fact that the educator didn't know the answer to their questions and took their perspective encouraged them to formulate hypothesis to test during the research lesson.

Time	Summary or transcript	Role of the educator (RE), Role of the prospective teachers (RPT)	Micro-didactic contract
0:56:37	E asks if it would be better to test $3 \cdot (-2)$. [instead of $-2 \cdot 3$]. PT1 says that the commutative property might still be an issue. PT5 agrees, as it would remove the constraints of the French interpretation [of the multiplication].	RE: Teacher trainer RPT: Researchers-practitioners	The responsibility of the production of knowledge is collective, the validation seems mostly guided by the facilitator
0:57:10	E replaces all the 2s in the lesson plan with 3s and asks if this solves the problem. PT1 answers that this is rather running away from the problem. PT3 instead agrees with E, as it would help focusing on the sign.	RE: Teacher trainer RPT: Researchers-practitioners	
0:58:14	E tests the animation by doing $3 \cdot (-3)$ and $(-3) \cdot 3$. He observes that it is not represented in the same way.	RE: Teacher trainer	
0:58:43	E adds that he agrees with PT1 when he says that it would hide the problem. PT1 adds that in the class some curious pupil might ask why they only use 3s. E asks him if he's more inclined to keep the 2s and 3s. PT1 replies that it's ok for him to use only 3s, but they must be careful not create traps [for the pupils].	RE: Coordinator RPT: Researchers-practitioners	
1:00:02	E asks the rest of the group's opinion. PT5 makes a stance: if they want to focus only on signs, maybe it's worth using only 3s. PT1 agrees.	RE: Coordinator RPT: Researchers-practitioners	
1:00:32	<i>E: I don't know. Like, that's really true, I really don't know</i>	RE: Participant	The responsibility of the production of knowledge and formulation of hypothesis is collective, the validation is left to the research lesson
1:00:41	PT1, laughing, proposes to vote. E adds that the risk is that pupils think it only works when the absolute value is the same. He asks for PT4's opinion, she replies that she preferred when the values were 2 and 3.	RE: Participant RPT: Researchers-practitioners	
1:01:08	E asks PT4 what multiplications to test. PT4 observes that if they ask the pupils to guess how $3 \cdot (-2)$ works, they will not notice that it is different from $(-2) \cdot 3$ and they will just put the -2 on the arrow.	RE: Participant RPT: Researchers-practitioners	

Table 2: Extract of session 6, task 3: testing the GeoGebra animation

Changing the didactical contract by explicitly mentioning participants' roles

With this move, the educator changes the didactical contract by explicitly mentioning the different roles of the participants or his own. In this case, he acts on the social dimension of the didactical contract. This can affect the LS situation differently according to the roles, as illustrated by the following two examples.

The first example occurred in meeting 7, during which a mock lesson was performed. Task 2 was about the preparation of the setting for this lesson. Two participants, PT2 and PT5, drew the number line on the blackboard. They omitted the odd numbers and put an arrow on the two sides of the line.

- E: As pupils, what do you see here?
 PT1: A number line.
 E: I don't see a number line.

In this case, the educator encouraged the prospective teachers to take the pupils' perspective and, therefore, to step into the didactical situation set by the LS.

The second example occurred in meeting 11 when the participants reflected on the research lesson and its outcomes. During this session, one of the schoolteachers, T2, was present. In task 3, the participants were invited to reflect on the aspects of the lesson that could be improved. T2 explained that when he had to teach the multiplication of integers, he made a different choice for his class and explained why, questioning at the same time the group's choices for the research lesson.

E: If I had to summarise, and here I am really wearing my “teacher trainer's hat”, it is the teacher's choice, but it is a conscious choice, and in my opinion, it must be a transparent choice.

In this case, some tension was created between T2 and the rest of the group, including the educator. As a result, the educator felt it appropriate to regain his expert role and to mediate between the positions. He thus acted on the social dimension of the didactical contract.

Discussion

This paper presented some examples of how the LS setting can provide teacher educators with tools that help them stimulate participants' reflection during this process. Among other things, the research lesson (either in an ordinary class or as a mock lesson), the collective elaboration of the lesson plan, and the roles taken by the participants contribute to establishing a milieu and a didactical contract on which the educator can act.

Specific moves of the educator were identified and analysed. He juggled the different roles available in the LS to reinforce the milieu, allowing the prospective teachers to change their own role in the research, take different perspectives, and deepen their reflection. In some cases, the educator acted on the didactical contract to take an expert perspective and convey a specific idea to the pre-service teachers. Nevertheless, the educator's game with these roles could also create tensions during the process, as his expert viewpoint was questioned and needed to be explicitly re-established.

However, it is important to stress that this research is a case study: the educator's moves also depend on his own experience, as well as his pedagogical choices and epistemology. At the same time, these moves were developed based on the LS characteristics. It might therefore be appropriate to expand research on the facilitator by enlightening games on the milieu and the didactical contract performed by other facilitators or educators, with in-service or pre-service teachers.

Lastly, this paper focused on analysis on a micro-level and on the changes in the micro-didactical contract. Another part of this doctoral research investigated the didactical potential of the milieu on the participants' outcomes at the meso-level. Moreover, the paper takes into consideration the viewpoint of the educator and his tools to foster prospective teachers' reflection. Another research question of this doctoral research focuses more on the prospective teachers' construction of knowledge and their standpoint. Further investigation is needed on how all these aspects can be integrated to provide a dynamic vision of the learning development of prospective teachers.

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