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How the situation seeds used in adapted lesson studies support the collaborative work of facilitators and future facilitators

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Our ongoing research investigates the role of situation seeds in the collaborative work and professional development of facilitators and future facilitators involved in LSa, an adaptation of Lesson Studies. More precisely, in this paper, we study the emergence and circulation of mathematical and didactic knowledge in the collaborative work carried out during the development of a particular situation seed by facilitators and its use in LSa designed to train new facilitators. To this end, we rely on the Three-Tetrahedron Model (3T-Model) proposed by Prediger et al. (2019) and the MTSK model of teachers' knowledge (Carillo et al., 2018). This paper presents and discusses the first results obtained.

Keywords: Adapted lesson study, facilitator(individuals), professional development, collaboratives (education), knowledge acquisition.

Introduction

Inspired by Japanese Lesson Study (LS) (Lewis et al., 2009), adapted Lessons Studies (Masselin, 2020), noted LSa, are a complex device involving several communities of practice (Wenger, 1998). LSa were created on the initiative of the Activities Group (hereafter AG) of the IREM of Rouen with the collaboration of researchers from the André Revuz Didactics Laboratory (LDAR), including Author 2. They are aimed at the professional development of mathematics teachers, from primary to high school. Their characteristics and three-loop structure (Masselin et al., 2022) allow LSa to be considered as a Collaborative Setting in Mathematics Teacher Education.

A peculiarity of the LSa is that they are based on situation seeds developed beforehand during one or more LS carried out between the members of AG piloting the device. A situation seed (Masselin et al., 2022) is the text of an open problem; much work needs to be done to develop it into a teaching situation, and the text of the problem itself can be adapted according to the context; hence the name of situation seed. Given the important role played by these situation seeds in LSa, our research aims to investigate how they support and condition the collaborative work and professional development (PD) of the various actors involved, from teachers to facilitators. The study presented here is specifically concerned with facilitators and future facilitators. Indeed, in 2020-2021, to support the dissemination of LSa, AG created a group of future facilitators, called LSa referents (hereafter RLSa), and organised their PD as facilitators (Masselin et al., 2022). The study also focuses on a particular situation seed. In line with the TWG28 *problématique*, we examine how this seed participates in the creation and co-construction of knowledge in relation to the PD of the facilitators and future facilitators involved. More precisely, our research questions are: How does collaborative work within a group of facilitators initiate and develop during the emergence, formulation and

deepening of knowledge related to a situation seed? How does the seed influence the collaborative work of facilitators and future facilitators and their PD as facilitators?

In the next section, we explain the motivation for introducing situation seeds in the LSa and the type of collaborative work involved in preparing a seed. We then specify the theoretical framework of this study and its methodology, before presenting the first results obtained, discussing them and concluding.

Situation seeds

The AG, composed of five members including Author 1 (marked B), carried out the first LSa with middle school mathematics teachers in the Academy of Normandy in 2016. The aim was to work with teachers on modelling, a competence emphasised in the recent curricular reform for compulsory education. This reform had led to the publication of a curricular resource by the Ministry of Education, of which AG was co-author. The constraints of a three-day PD course and the desire to help teachers make use of this resource led AG to introduce situation seeds inspired by examples from the resource in the LSa device. LSa were then given the additional objective of working on institutional transitions (primary school–middle school and middle school–high school), and brought together teachers from different school levels, from 2018.

The origin of a situation seed is the text of an open problem proposed to the AG members by one of them, the solution of which requires some modelling activity. The group analyses it, and if it finds it appropriate for creating a situation seed, an internal LS is organised. The group collectively draws up a roadmap (problem text, scenario, teacher intervention grid). The lesson is carried out by a member of the group, in a class, not necessarily his/her class, the others being observers and filming moments they consider interesting with their smartphones. The group collects the observation notes, the students' productions and the video clips, and then analyses them. This analysis leads to resources for facilitators, in particular the video library. It contains selected and encoded video clips and a facilitator's intervention grid. These tools are intended to support the work of the facilitators who will use the seed in LSa, to encourage the emergence of knowledge related to the seed, such as unexpected solving procedures or difficulties, or more general knowledge related to the management of students' group work and/or modelling activities. These resources are progressively refined and enriched through the implementation of LSa based on the seed, and the associated interactions between the different communities involved. “The bathing area” situation seed considered in this study (see Figure 1) was developed for the PD of future facilitators, and initially designed for grade 9 or 10 students.

The bathing area

The monitors of a holiday camp want to take 120 children swimming together in a lake. They have a 25m long water line to demarcate a bathing zone. Can they comply with legislation?

Article D1332-10 Transferred from decree n°2008-990 of 18 September 2008-art. 1
The maximum number of bathers present in the establishment must not exceed three persons per two square metres for open-air bathing areas and 1 person per square metre for covered bathing areas.

Figure 1: Text for the seed “The bathing area” (our translation)

Theoretical framework

As mentioned in the introduction, in this study we are interested in the role of collaborative work in the professional development of LSa facilitators and future facilitators. This collaborative work takes place in different contexts and involves different actors and communities, during the development of the seed, its evolution, and its use in LSa. In this perspective, we find it interesting to refer to the Three-Tetrahedron Model (3T-Model) proposed by Prediger et al. (2019), which distinguishes three interacting levels: the classroom level, the teacher PD level (TPD) and the facilitator PD level (FPD), and four dimensions for each level: Content-specific learning support, Structuring the content and realisation in resources, Content-specific learning pathways, Content-independent pedagogy. To study the role of seeds in collaborative work and their PD potential, we furthermore focus on the emergence, development and circulation of knowledge around a situation-seed. To support this approach, we adopt the Mathematics Teacher's Specialised Knowledge (MTSK) model (Carillo et al., 2018). This model, represented as a regular hexagon (Figure 2), distinguishes three categories of Mathematical Knowledge and Pedagogical Content Knowledge and two categories of beliefs (detailed in Figure 2). This model helps us to delineate the forms of knowledge that underly the activities and interactions of the facilitators and future facilitators on the bathing area seed.

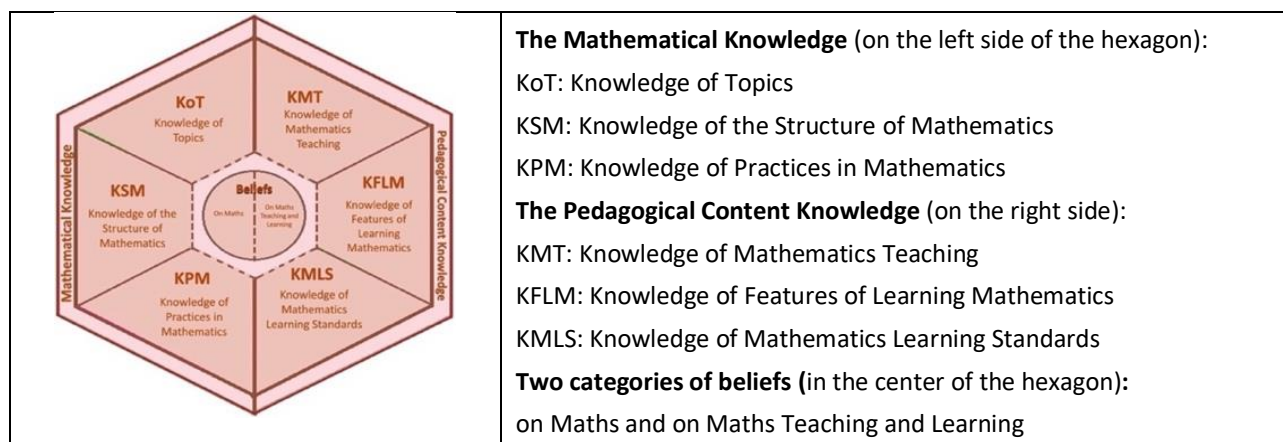


Figure 2: MTSK Model (Carillo et al., 2018)

The LSa organised so far have focused on the teaching and learning of modelling. This topic can be linked to several components of the MTSK model, but we find it useful to complement our theoretical framework with more specific resources, in particular the resources on modelling cycles (Blum & Leiss, 2007; Yvain-Prébiski, 2021) which are part of the AG's modelling culture.

Methodological choices

To answer our research questions, various data were collected between January 2021 and June 2022. They concern both the initial development of the seed by the AG and its use for the coaching of the future facilitators of the RLSa group, which at the time consisted of six secondary and two primary teachers. In line with its FPD objectives, this part of the coaching is structured in four steps, the first two constituting an internal LS for the RLSa group, and the next two being aimed more specifically at preparing them for the role of facilitator:

1. Collective study of the situation seed by the RLSa group (resolution, a priori analysis and development of a roadmap).
2. Realisation of the scenario in a classroom by one of the members of the RLSa group, observed by the others who collect video clips.
3. Collective creation of a video library including the description, analysis, re-editing, encoding of selected video clips from step 2.
4. Co-construction of didactic contributions, partly related to the seed, partly more general, for the realisation of future LSa.

These four steps were planned to be held face-to-face and AG organised a platform to share internal LS's data with RLSa group. The pandemic context prevented step 2 from being held in a single classroom with all RLSa present.

The data collected are very diverse: minutes of working meetings of the AG and RLSa groups, notes of classroom implementations, email exchanges, video libraries, roadmaps, scripts of work sessions and shared files produced by group members. The coding of the data takes into account several actions that support the emergence and capitalisation of knowledge: data collection, data presentation and sharing, revision of data after reflection, and data dissemination, which corresponds to a transfer from one group to another. The knowledge identified is then coded using the MTSK model and situated with respect to the 3T-Model.

For the data analysis, we distinguish three phases in the process, depending on the collectives involved. Phase 1 corresponds to the collaborative work of the AG group leading to the initial seed. Phase 2 corresponds to the collaborative work of the RLSa group on this seed under the guidance of two members of AG (B and F). Phase 3 corresponds to the collaborative work of a subgroup of AG and RLSa members aiming at the exploitation of the seed for the PD of primary teachers. In the following section, we present a synthetic overview of the first results obtained by triangulating the different analyses. Due to limit constraints, we limit ourselves to the first two phases.

Results

Phase 1: Collaboration and development of knowledge in the creation of the seed by AG

“The bathing area” problem was introduced to AG by B, in early 2021. She shared with the group elements of a thesis using this problem that she had co-authored in 2014-2015 as part of the professional master's degree in didactics at Paris Diderot University, (Kerboul et al., 2015): the formulation chosen for the problem and the productions of groups of students from her 9th and 10th grade classes. AG members decided to create at seed from it, but considered that the photo in the text, which suggested a rectangular shape, oversimplified the students' mathematical task (KSM). The group also analysed the students' productions, which helped to extend the geometric shapes envisaged to the case of semicircular and polygonal areas (triangular, hexagonal, trapezoidal). These geometric shapes were then examined in terms of the feasibility of their mathematical treatment by grade 9 and 10 students. For example, the group imagined students' procedures for an arbitrary trapezoidal shape (KMT) and linked them to its knowledge of the curriculum. According to them, this shape required complex algebraic treatment (KMLS) and the students would be stuck with an equation of the type $x+y+z=25$, x , y and z representing the lengths of the three sides of the trapezoid delimiting the bathing

area. AG members also analysed two procedures not considered in the thesis: the entry by a function related to the length of the water line and the use of trigonometry for a regular hexagon. The hexagon raised a new question: how to prove that the surface maximising the area is a semi-disc? In the search for a proof, a member of the group made the connection with Didon's problem, and enriched the group with epistemological knowledge related to geometric properties (KoT and KMLS). A file was created for the memory of the group and a possible use in LSa.

By searching for problems close to the seed in grade 9 and 10 textbooks, AG members then noted the omnipresence of the rectangular model to treat this problem of optimisation (activated knowledge of the KMT type). This observation activated the creation of a file integrating solutions with different geometric shapes, where the case of the rectangle itself was treated with two different functions. The individual phase of data collection followed by the presentation to the group thus led to a deepening of the pedagogical content knowledge mainly (PCK). The didactic knowledge of AG was gradually enriched by the further collection of statements, evidence, and the production of documents for future LSa. The critical analysis and collective revision of the seed thus made the collaborative work evolve and generated new knowledge. However, the group work focused on vertical mathematisation and the mathematical concepts mobilised to solve the task in grades 9 and 10 classes, once a geometric model had been selected. At this stage, there was a lack of modelling hypotheses in relation to fragments of reality (the lake, the water line, the monitors). The reflection on the text of the law was reduced to the need to identify a proportional model and the group perceived the seed in the light of the algebraic and functional content of the grade 9 and 10 curricula.

However, the modelling cycle of Blum & Leiss (2007) was known to AG. F and B shared an excerpt from the LS “Garage” booklet¹ with other AG members to help them identify the modelling steps associated with “the bathing area” problem. This stimulated an updating of knowledge (didactic conceptual knowledge, KMT, linked to the specificity of modelling work in mathematics, KPM), and allowed AG members to identify what a real situation linked to the seed would correspond to, to understand that the seed is already a model situation and to list modelling hypotheses linked to horizontal mathematisation (on the shape of the lake, the water line, the law).

AG members collectively modified B's initial formulation, influenced by their knowledge of the practices of mathematical activity related to modelling (KPM), and their work on this problem. The pictures of the lake were removed because they led to a rectangular shape. The new statement (Figure 1) would be used as a basis for the coaching of the facilitators of the RLSa group (see phase 2). At the end of phase 1, AG initiated the preparation of resources to structure the collaborative work in phase 2 and collect data from the RLSa group. Here, we identify the dimension (content-specific learning support) of FPD. It leaves the future facilitators a lot of autonomy in terms of scenario design and teacher intervention grid. AG, through the seed provided to the RLSa group, suggested a certain openness in terms of geometric modelling (content-specific learning pathways) linked to the content. By organising an internal LS in this way, AG wanted to make the RLSa group aware of an important

¹ <https://irem.univ-rouen.fr/sites/irem.univ-rouen.fr/files/groupes/Activites/CahierLSGarageIREMSite.pdf>

dimension of TPD in LSa: the flexibility of the seed whose problem text and scenario are not fixed in advance (structuring of the content and realisation in resources).

Phase 2: Collaboration and knowledge development in the LS internal to the RLSa group

The pandemic situation of March 2021 constrained the planned organisation of the collaborative work. If they collectively enriched the roadmap initiated by AG, the RLSa group could not carry out the internal LS planned together. The experiments were implemented at three different teaching levels with two teachers or even a single teacher filming moments of the lesson. The analysis of the reports (with student group productions, comments, lesson reports) and the video clips from the experiments were shared (among the members of the RLSa group and AG). It enriched the knowledge related to the students' interactions with the content (KFLM). In grades 9 and 10 classes, several sources of blockage were identified: the lack of information on the dimensions of the lake, the positioning of a water line dividing a patatoidal lake into two parts, the covariation between a dimension of the rectangle and its area, the testing of only integer lengths in the case of the rectangle and the attempts to convert m into m^2 . These were shared on the platform as shown by the extract of report produced in Table 1, and then collectively discussed.

Table 1: Extract of report of one RLSa member shared on the platform (our translation)

Many students model the lake as a potato, and as a consequence, propose a rope stretched in the middle of the lake. It is not easy for them to imagine themselves at the edge of the lake. Would the beach be different? I think so. Or you'd have to have images of a lake in your mind. I found that I wasted a lot of time having to explain this part of the statement.

The experiment carried out in a primary school made it possible to identify a new procedure consisting of placing three children every two linear meters and showed the importance, at this level, of having a grid for estimating areas without using formulas. They also showed the potential of the seed for working on the product of decimals (KMLS) as shown in the report of one AG member.

The data from the primary school experiment, which was not originally planned, thus led to new perspectives of exploitation of this situation seed for use in cycle 3 (grades 4 to 6). This resulted in a reorientation of the collaborative work, including a re-evaluation of the seed, towards the domain of magnitudes, measures and numbers in cycle 3 and the transition from primary to secondary education on these topics, which would be systematised in phase 3.

The RLSa group then initiated two separate video libraries: one for LSa in grades 9 and 10 classes, and one for LSa in grades 4 to 6 classes. The facilitator intervention grid created made it possible to share and review the didactic knowledge of the content with B and F. The collaborative work then continued in two directions. B and F helped the RLSa group to identify the phases of the Blum & Leiss' modelling cycle from the video clips and validated this work. Yvain-Prébiski, a researcher invited by B, also shared with the RLSa and AG groups her work on the concepts of horizontal and vertical mathematisation, and her extended modelling cycle (Yvain-Prébiski, 2021). The intervention of this knowledge (KFLM) was facilitated by B.

In phase 2, the internal LS involving primary, middle school and high school teachers thus provoked the PD of future facilitators. This was facilitated by a collaborative work of knowledge identification (at the first level, that of the classroom) according to the level of teaching. The collaborative work organised and supported by AG on the creation of video libraries and on modelling cycles activated several dimensions of PD for the RLSa group at the three levels of the 3T-Model. Table 2 below summarises the main results for this phase (similar tables are available for phases 1 and 3).

Table 2: Levels of PD and MTSK for the RLSa group in phase 2

Type of collaborative work	PD level and dimension	MTSK
Sharing of classroom scenario (internal LS), notes and selection of video clips	CL and TPD: Content-specific learning pathways FPD: Content-specific learning support, structuring of the content and realization in resources	KFLM
Initialisation of two video libraries	FPD: Structuring of the content and realization in resources, Content-specific learning support, Content-independent pedagogy. TPD: Content-specific learning pathways	KMLS
Seminar by an invited researcher	FPD: Content-independent pedagogy, Structuring of the content and realization in resources	KFLM
Identification of steps of modelling cycles	FPD: Content specific learning support, content specific learning pathways	KFLM

Discussion and perspectives

The results obtained confirm that "the bathing area" seed plays an important role on the collaborative work of the facilitators and future facilitators involved. The elaboration, the critical analysis, the exploitation of this seed to coach future facilitators with, in particular, the constitution of two video libraries, allow for the emergence, the clarification, the deepening and the circulation of knowledge that contributes to their TPD and FPD. Furthermore, the analyses show that the three levels of the 3T-Model intervene and work in synergy, due to the characteristics of both the LSa device and its adaptation to support future facilitators. The results also show that the knowledge that flows in collaborative work involves the six dimensions of the MTSK model to varying degrees in all phases (for example, in phase 2, the KFLM dominates). Even though it was not always easy to assign a specific dimension to each piece of knowledge identified, these results confirm the interest of the theoretical framework used in this study and leads us to seek to deepen the coordination of Carillo's and Prediger's models in future research on LSa.

The collection of data took place in the pandemic context, which forced us to adapt the device and slowed down the process, but as shown in the previous section, the experiment had interesting consequences. It revealed further potentialities of the seed and led to the development of a new collaborative work aimed at preparing new LSa for the PD of primary school teachers.

However, there are limitations to this research. Understandably, the knowledge involved is to a large extent situated, linked to this particular seed and its curricular environment. It might remain so unless efforts are made to decontextualize it. We observe such efforts in reports of collective discussions in all three phases. They lead to the emergence of more general knowledge on modelling issues and teaching practices, including group work and inquiry-based approaches, which are not very present in teaching practices, despite curricular injunctions. Moreover, the FPD of future facilitators is not limited to the device studied here. The co-organisation and management of LSa by pairs of facilitators and future facilitators plays an important role in it. AG also developed a facilitator's roadmap, which

is clearly valued. The role of the seed should also be examined without limiting it to the interactions of facilitators and future facilitators, but by considering the interactions of the latter with the teachers in LSa. The use of indicators to specify whether the PD is spontaneous or programmed, initiated by an individual or a group could also enrich our study. In addition, we focused on a specific seed but it would be interesting to consider whether other seeds have similar potential.

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