HOW DOES A JAPANESE PRIMARY SCHOOL TEACHER MANAGE THE WHOLE-CLASS DISCUSSION NAMED NERIAGE?

Valérie Batteau
HEP Lausanne, Switzerland

This research aims at analyzing teacher practices in a Japanese context with a focus on the collective teaching during structured problem solving lessons, the whole-class discussion named neriage. We analyze teacher practices with the specific tools of the double didactic and ergonomic approach: the cognitive component of practices that concerns the choice and organization of the tasks for the students and the mediative component of practices that concerns the interactions of the teacher with the students. Video data gather a research lesson during a Japanese Lesson Study about the logical thinking and collective meetings before and after the research lesson. This research highlights a key element in the teacher's practices that can explain both the choice of tasks and how the teacher manages the neriage: the variation of the values of the didactic variables of the problem.

BACKGROUND

This research is motivated by a comparison of two educational systems: the French-speaking part of Switzerland and the Japan. On the one hand, a case study of three Swiss primary school teachers highlighted the difficulty for teachers to manage whole-class discussions by comparing the students' strategies, by hierarchizing the strategies, and by emphasizing the knowledge or the method at stake in the problem (Batteau, 2018). This difficulty is well known in the French context as well (for example, Charles-Pézard, Butlen & Masselot, 2012). On the other hand, the ordinary mathematics lessons are often carried out in the form of structured problem solving lessons in the Japanese primary school (for example, Stigler & Hiebert, 1999; Takahashi, 2008). The structured problem solving lesson consists of several phases. We focus on the collective teaching after students solve the problem: the whole-class discussion called *neriage*, followed by the summing up by the teacher, phase called *matome*. This term comes from the verb *neru* that means to mix or to polish something, and *ageru* means to raise something. In the context of mathematics teaching, this term refers to a whole-class discussion with two ideas: the first one is the presentation, comparison and, discussion of ideas, solutions, and procedures for solving the problem. The second one is the development of the *mathematical thinking* from this discussion.

The *mathematical thinking* is a central concept in the Japanese mathematics teaching: as a main objective in the Course of Study (Japanese national curriculum) and as a mean objective in the problem solving approach (Hino, 2007; Isoda, 2012; Isoda & Katagiri, 2012; Katagiri, 2017). Japanese researchers and teachers do not use a shared definition of *mathematical thinking*. For this paper, we adopt the *mathematical thinking* in reference to Katagiri (2017) that include method (kind of reasoning as deductive thinking, analogical thinking, inductive thinking…), mathematical content and, thinking on the content. This research aims at understanding the Japanese teacher's practices during the collective teaching: how teachers manage the *neriage* in order to develop the mathematical thinking of students?

THEORETICAL FRAMEWORK AND RESEARCH QUESTION

This research adopts the double didactic and ergonomical approach (Robert & Rogalski, 2005): a framework based on a double viewpoint, one in the French didactic of mathematics and another in ergonomics with the activity theory (Leontiev, 1975; Leplat, 1997). In this framework, teacher's practices are defined by what the teacher says, does, writes or not before, during or after class. Activities are moments of these practices, such as classroom activity or lesson preparation. Students' activities are considered as an intermediary with the learning. This framework is based on the assumption that students' activities are influenced partly by the teacher's activity. Indeed, this framework aims at analyzing the relation between teachers' and students' activity in class, but also the constraints on teachers in the context of their profession. Teacher practices are analyzed with two specific components of practices in the class: the organization of the tasks for students, the *cognitive* component, and teachers' interactions with students, the *mediative* component (Robert & Hache, 2013; Robert & Rogalski, 2005).

> The cognitive component corresponds to a teacher's choices regarding content and tasks, including their organization, their quantity, their order, their inclusion within a curriculum beyond the class period, and plans for managing the class period. (Robert & Hache, 2013, p.51)

The *mediative* component concerns the teachers' interactions with students, the teacher's choices that

> may include improvisations, speech, student investment and participation, instructions, assistance to students in completing the tasks, identification of their work and the work of the teacher, validations, explanations of knowledge, etc. (Robert & Hache, 2013, p.51)

This paper focuses on some aspects of the *cognitive* component of practices (the choice of tasks, their organization and, the progress of the lesson) and some aspects of the *mediative* component of practices: the teacher interventions during the collective teaching in *neriage* that participate in the development of *mathematical thinking*. The research question we investigated in this paper is therefore: how does a primary school teacher manage the tasks (*cognitive* component) and his-her interventions (*mediative* component) during the *neriage* phase of a problem solving lesson in order to develop *mathematical thinking*?

METHODOLOGY

The data of Japanese teacher practices were collected in a primary school designated by the Ministry of Education as a research school in Joetsu. A group of teachers was working on the *logical thinking* as an annual school research theme in the context of *lesson study*. This group of teachers defines the *logical thinking* in mathematics as the ability to explain with arguments. The *lesson study* is a format of teachers' professional development based on the collaborative works (for example, Miyakawa & Winsløw, 2009). The teacher called Noriko had four years of teaching experience at that time, and the research lesson was taken place in a *lesson study* meeting at the prefectural level, with her class of grade 3, students of 8-9 years old.

The data includes the videos of the research lesson, two collective pre-lesson and one collective post-lesson meetings. Video data were transcribed in Japanese, and translated into English or French. We gather written data: blackboard of the research lesson, posters in the classroom that refers to the previous lessons of the sequence, teacher report of the research lesson, and lesson plan. The lesson plan concerns the mathematical analysis about the sequence of nine lessons, the choice of tasks, the learning objectives and, details the progress of the research lesson with the specific learning objectives.

For the research lesson, we carried out an *a priori* analysis of the problem identifying the didactic variables, possible strategies and mathematical knowledge at stake. This study consists of a qualitative research of teacher's practices in considering aspects of *cognitive* component of practices (the progress of the observed lesson, the choice of tasks for the observed lesson and also for the whole sequence of lessons, the teacher's activity and the activities proposed to the students by the teacher) and *mediative* component: teacher interventions during *neriage*. Written and video data let us characterize *cognitive* and *mediative* components of teacher's practices. To understand teacher choices during the lesson, we supplemented these analyzes with the written preparation documents (lesson plan) and the *lesson study* meetings. These analyzes then allow us to identify common elements in the *cognitive* and *meditative* components of the practices for the teacher.

ANALYSIS OF NORIKO'S PRACTICES

Cognitive component: choice of tasks, their organization and the progress of the lesson

The research lesson is the eighth lesson of a sequence of nine lessons named « hint of shadow. » The learning objectives of the sequence are in geometry to name the solid, the faces and the positions of the faces, to build a solid, to describe a solid with his faces and the relationships between the faces. Noriko analyzes the mathematical content, the Course of Study and, the textbooks. She decides to focus the sequence on the faces, their positions on the solid and their relationships in order to describe the solid. She explains her mathematical analysis during a meeting pre-lesson.

> Noriko: As expected, I think the important elements are the faces. When I looked at the 2nd and 4th year textbooks before and after [grade 3], as expected, I found that we spend time on the tops and sides of the solids rather than on the faces. We will assemble the shapes of the faces. Children understand little by little that they can name and make the solid. Because in reality we are gathering the parts of the solid, I would like to do a solid building activity. At that time, I would like students to keep in mind that when we use this kind of solid, we used this kind of face, for example.

According to her analysis, Noriko plans the tasks of the sequence during the meeting pre-lesson.

> Noriko: After handling a lot of solids [during the lessons 1, 2 and, 3], I would like to avoid assembling the faces for example in the quiz whose goal is to find a solid [lessons 5, 6, 7 and, 8].

In the lessons 1, 2 and, 3 the tasks are to build different solids and to describe them, their faces, and the positions of the faces. In the lessons 4 to 8, the tasks are quizzes toward few manipulations of faces of the solid, the tasks aim to describe and to communicate the mystery solid from the relationships between the faces in order to develop *logical thinking*. In the Course of Study (Isoda, 2010), the *logical thinking* method includes analogical, deductive and, inductive thinking methods "since students need to justify each step of their reasoning” (p.41). Furthermore, it needs steps to resolve a problem and, each step should be explained in a logical way in order to reach the result. The *logical thinking* in the Course of Study is also connected to the ability to express and communicate the procedure and the ability to deal with “Phenomena in their daily lives” (p.41). According to the Course of Study, Noriko writes in the lesson plan.

> In this unit, we use “shadows” to pick up solids and their constituent faces. There are other three-dimensional components, sides and top of a solid, but the important elements for children to grasp a solid are the shape of the surface and its positional relationship. […] In order to convey your solid to other students, you can express it by comparing it to things around you and explaining the positional relationship between the faces. It can be regarded as a logical thinking ability.

The task of the research lesson (8) is a quiz in which Noriko shows with shadows three faces of a mystery solid (two triangles and one square), and gives three directions (front, below, side) without specifying to which face it corresponds. The problem is to find the mystery solid: the unique solution is a pyramid with a square base (Figure 1).

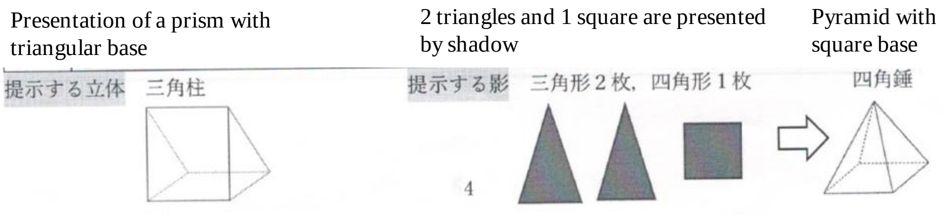

Figure 1: Extract of a temporary lesson plan

If the triangle comes in the front, a square underside and, a triangle in a side, the solid is a pyramid. Noriko anticipated a wrong answer (Figure 1), a right prism with triangular base, called “shape of cake” in a previous lesson. This prism should be obtained with a square in the front, a triangle on a side and a square underside. In this case, the three faces are two squares and one triangle with keeping the directions. This prism should also be obtained with a square in the front and two triangles on the side. In this case, the directions change: front and two sides.

Noriko chooses for the lessons 5, 6, 7 and 8 similar tasks with the same pedagogical material and by varying the values of the didactic variables: the mystery solid (cube, truncated pyramid, prism), the position of the faces (front, below, sides, back), the forms of the faces (triangles, squares, rectangles…), the number of given conditions (positions and forms of faces) and associated or not, the given material to students. For the progress of the research lesson, Noriko structures the lesson in the problem solving approach in which different phases are present (introduction of the problem called *hatsumon*, group and individual work, *neriage*, *matome* the summing up by the teacher). The particularity of the progress is the back and forth between the collective, the group and the individual work. She adds several subtasks during the *neriage* and students dispose of individual or group work to realize the additional subtasks. At the same time, she varies the pedagogical supports (projectors, blackboard, previous displayed *matome*, learning material - triangles and squares) and varies orally and written work.

To conclude, Noriko chooses the tasks and their organization according to the individual and collective work during the meetings of *lesson study* and the key element of her cognitive component is the variations of the values of the didactic variables from a same task, a quiz with shadows, in order to let students the possibility of observing, arguing according to these variations of values of didactic variables and so, to develop the *logical thinking*. The progress of the lesson (table 1) is characterized by the variation of pedagogical supports, the variation of students' work (oral, written and, manipulation of materials) and the variation of forms of work (collective, individual and, group) in an effective way in order to involve all students, even when a single student explains his-her strategy and, to aim the learning objectives.

Mediative component: teacher's interventions

Noriko realizes different kinds of interventions during the *neriage* with reference to the first idea of *neriage* (Table 1). Indeed, she asks students to present, to explain, to compare, to justify, to validate their strategies and answers. She also validates their strategies and answers, reformulates the students' interventions, repeats their interventions, involves other students when a single student presents and explains his-her strategy.

Work/Time	Noriko's activity	Students' activity
Collective *Hatsumon* 4:35	Introduction of the problem: what is the solid shown by shadow and which direction of solid is it? (7:18)	Students choose 3 directions of the faces of the mystery solid (front, underside, side)
Indiv. 11:59 Group 21:15	Noriko moves inside students' desks She asks students to discuss by 2 about the mystery solid	Students manipulate triangles and squares to find the mystery solid
Collective *Neriage* 22:11	Noriko asks what the solid is realized by students with the material. (22:11) She writes 2 answers shape of pyramid and shape of cake.	Students answer shape of pyramid and shape of cake
Discussions about the shape of cake	Noriko asks students when a student gives an explanation to imagine the solid and to move their figures (24:18, 27:48 and 27:59). She asks details of a student's strategy and the position of faces (24 :35). She writes under the name of solid the students' explanations to build the shape of cake. Noriko and students look and read the *matome* of previous lessons displayed in the classroom Subtasks: if the square is the underside, can we form a shape of cake and what are the front face and the face opposite to the front? (27:31) How must students do to obtain a shape of cake? (28:12) What figures used to build the shape of cake? (28:58)	Four students explain how they find a shape of cake and show how they built the solid (22:11 and 26:40-28:12 and 28:35) Students answer orally to Noriko's questions and written by drawing When a student explains his-her strategy, students manipulate the figures in order to follow the strategy and to build the solid

	and what is the build solid at the end? (29:06) What are the figures used to build the solid? (29:51) What solid do they build? Give the positions of faces (29:55) and students write and draw the positions and the figures of the faces	
About the pyramid	She asks the same kinds of subtasks in the case of the pyramid	Students realize subtasks with manipulation
Individual 35:50	She moves inside students' desks	Students write why the cake is a wrong answer
Collective *neriage* 37:25	Subtasks: why the shape of cake is a wrong answer and how many students find it (37:25) and she asks what the figures are according to the direction in the pyramid (39:45) to name the front of the pyramid, then the underside (40:15)	A student explains why the pyramid is a right answer and the cake a wrong answer (37:49)
Individual 40:29	Subtask: if the solid is a pyramid, what is a side to the front?	Students write and draw the answer
Group 41:03	Moves inside students' desks	Students discuss by 2
Collective 41:23	Subtask: draw the shape of cake and write/draw the figure side to the front	Students realize the subtask
Group 41:54	She asks if the solid is a shape of cake, what is the front? (42:43)	Students discuss by 2 about their answer
Collective *neriage* 43:46	She shows a right prism with triangular base and asks the names of figures on front, underside and side (44:17) Subtasks: look at the conditions of the problem (two triangles and one square drawn on the blackboard) (45:40). The solid should be different if you try to change the direction? What will it be? (45:52) And if the square is in front for the cake, what will be the underside? (45:59) Does somebody remark something for the quiz? (47:02) She concludes and compares the two solids: the projected figures were the same but the number of each projected figure was different (47:47)	A student gives the names of figures on front, underside and side (44:29) Students realize subtasks orally and by written
Group 48:07	She asks why the cake is an impossible answer	Students write explanations
Collective *neriage* 49:57	Discussion on the reasons why the shape of cake is a wrong answer and the difference between the two solids	Students find difference between the two solids. One student explains the cake is a wrong answer because the positions of shadows and the figures are different

Collective *Matome* 52:03	Noriko says and writes: because the positions of shadows and the figures are different

Table 1: Progress of the research lesson, Noriko and students' activity

We present here Noriko interventions that refers to the second idea of *neriage*: the development of *logical thinking*. First, she anticipated in the lesson plan that two answers will appear (Figure 1): the right answer, the regular pyramid with a square base (the two triangles are in front and side, the square bottom) and the wrong answer, called the "shape of cake", a right prism with triangular base (the two triangles are front and opposite to the front, the square bottom). She manages the *neriage* with additional subtasks based on the variation of the values of didactic variable of the problem (table 1). For example, a subtask relies on the solid and the faces: "if the square is the underside, can we form a shape of cake and what are the front face and the face opposite to the front?" Other subtasks rely on reflections on the directions of the faces for a solid: "The solid should be different if you try to change the direction? What will it be?" or "And if the square is in front for the cake, what will be the underside?" The subtask relies on the solutions of the problem: students have to justify why one solution is right and the other is wrong (37:25).

Noriko	I would like to ask you, how many people say that they were wrong and why? […]
Student:	For the shape of the cake, all the shapes appear with the three shadows, but because the face next to the front side will be a square, so if you want to show the shape of the cake, there must be a triangle and two squares. So, it's a pyramid shape.

Noriko varies the values of the didactic variables (the chosen faces, the positions of the faces and, the solid) in order to develop the *logical thinking* of students. Another example of task is: how the prism with a triangle base can become a right answer to the quiz in keeping the three faces (two triangles and one square) and the two positions (front and below). What will be the third position? (51:17)

Noriko:	[…] If you want to have the shape of the cake, here it's a triangle, here it's a triangle, which position would you like to see here? […] When considering the shape of the cake, where the front is a triangle and the bottom is a square, where is the triangle coming?
Student:	Opposite of the front face?
Noriko:	That's right. […] it's a "cake."

The discussions during the *neriage* lead to a *matome* contextualized to the problem "because the positions of shadows and the figures are different." It refers to the reasons why the shape of cake is not a correct answer. Noriko aims the development of *logical thinking* of students during this lesson, but not the decontextualization of knowledge, as the relationships between faces. Here, the *matome* does not meet the functions of decontextualization and institutionalization of knowledge. She criticizes her *matome* during the post-lesson meeting "It was bad. […] I regret." She anticipated a *matome* in which students have to point out that different solids should be obtained with the same shadows according to the relationships between the faces.

To conclude, the Noriko's interventions during the *neriage* can be explained by a key element, the variation of the values of the didactic variables. This variation of values of didactic variables involves subtasks based on two students' answers, the right and a wrong anticipated answer, in order to let students the possibility of observing and arguing and so, developing their *logical thinking*.

DISCUSSION AND CONCLUSION

This study highlights a key element in the *cognitive* and *mediative* components of practices: the variation of the values of the didactic variables with additional subtasks (and multiple variation problems during the sequence) organized around two students' answers: the right answer and a wrong answer, in order to reach the research objective of the *lesson study*, to develop the *logical thinking* of students. These variations involve the choice of tasks (*cognitive* component) and her interventions during the *neriage* with additional subtasks based on these variations. Furthermore, our results concerning the choice of problems in the lesson sequence proposed by Noriko should be linked with the main teaching approach in China. In this approach called teaching by variation problems, one of the possibilities is to propose a problem with multiple variations by varying the conditions and conclusions (Sun, 2011).

This research points out coherence in teacher's practices between the global level, choice of tasks and mathematical teacher's analysis in *lesson study* meetings and the local level, teacher's interventions during the collective teaching.

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