Implementing the Japanese Problem-Solving Lesson Structure

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While there has been worldwide interest in Japanese Lesson Study as a model for teacher professional learning, there has been less research into authentic implementation of the problem-solving lesson structure that underpins mathematics research lessons in Japan. Findings from a Lesson Study project[1] involving teachers from three Victorian primary schools indicate that the focus on planning for sustained discussion of student solutions resonated with teachers' previous professional learning on questioning techniques and led to changes in their regular classroom practice.

Lewis (2002) describes the Japanese Lesson Study Cycle as having four phases: goal-setting and planning – including developing the Lesson Plan; teaching the "research lesson" – with its associated lesson observation; the post-lesson discussion; and the resulting consolidation of learning. While there has been worldwide interest in Japanese Lesson Study as a model for teacher professional learning, there has been less research into authentic implementation of the problem-solving lesson structure underpinning research lessons in Japan, in particular the ways that teachers can conduct in-depth, orchestrated discussions of student solutions that lead to mathematical learning (Innoue, 2011).

The Japanese problem-solving lesson structure for mathematics has evolved over four decades, originating in a desire to introduce open-ended problems in order not only to enhance students' higher-order thinking, but also to enable students to use their previous knowledge and skills to learn something new through the process of solving a problem (Becker, Silver, Kantowski, & Wilson, 1990). Major characteristics of these problem-solving lessons include: the hatsumon – the (single) thought-provoking question or problem that students engage with and that is the key to students' mathematical development and mathematical connections; kikan-shido – sometimes referred to as the "purposeful scanning" that takes place while students are working individually or in groups, which allows teachers not only to monitor students' strategies but also to orchestrate their reports on their solutions in the neriage phase of the lesson; neriage – the "kneading" stage of a lesson that allows students to compare, polish and refine solutions through the teacher's orchestration and probing of student solutions; and matome — the summing up and careful review of students' discussion in order to guide them to higher levels of mathematical sophistication (Shimizu, 1999). The neriage phase of a lesson – the "heart" of the lesson – begins after students struggle with the problem and come up with their own solutions. "During the process, a teacher highlights important mathematical ideas and concepts for students to reach the goals of the lesson" (Takahashi, 2008, p. 5). Typically, this stage takes upwards of half the time of a lesson. Such a lesson structure contrasts sharply with typical Australian lessons.

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This paper focuses on changes in teachers' beliefs and practice regarding the Japanese problem-solving lesson structure, based on findings from a Lesson Study project that involved six Years 3 and 4 teachers from three Melbourne schools and four numeracy coaches and curriculum leaders during 2012. Following a professional learning day late in Term 2, where participants were introduced to Japanese Lesson Study and taken through a "mock" research lesson and subsequent post-lesson discussion, teachers worked with four university researchers in two cross-school, collaborative research teams, with each team planning and teaching a research lesson in each of Terms 3 and 4 – four research lessons in total. Teachers were encouraged to develop their own research goals to guide their participation in the project. This paper is based on data from field notes and recordings of one of the two teams' Term 3 planning sessions, together with similar data and student work from their research lesson, a post-research lesson interview with the teacher who taught the research lesson, and conference presentations by participating teachers.

Neriage and *Matome* – the Heart of Japanese Problem-Solving Lessons

During Term 3, each of the two research teams spent four 2-hour sessions planning a lesson based on the Matchstick Problem (Figure 1). The Diamonds team consisted of two of the university researchers; three teachers – Lyn (who eventually taught the research lesson to her Year 4 class), Henry, and Keith; and two numeracy coaches – Paula, from the school network, and Megan from Lyn's school.

The Matchstick Problem was presented to all participating teachers in the first of the four Term 3 planning sessions, with teachers being asked to illustrate the way they counted the number of matchsticks required for 5 "squares" and find how many matchsticks would be required for 8 and 100 squares. They were not given a written statement of the problem as the researchers were interested in how they would formulate the *hatsumon* for the two research lesson classes.

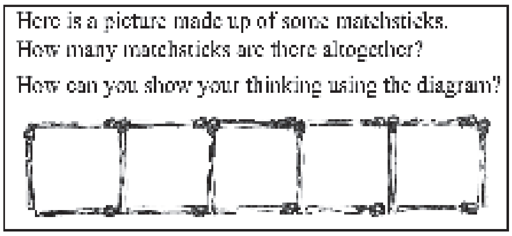

Figure 1. The Matchstick Problem as presented in the Year 4 research lesson

The problem was selected by the university researchers due to: i) the wide range of possible solutions; ii) the fact that it could be tackled by both Year 3 and 4 students (at this stage the classes participating in the research lessons had not been determined) with the problem lending itself to what in Japan would be called a "jump-in lesson", indicating that it could take place at many different points in the curriculum sequence; iii) the focus on algebraic thinking – an area of mathematics that has not been emphasised in primary school mathematics prior to the introduction of the Australian Curriculum: Mathematics (F–10)(Australian Curriculum Assessment and Reporting Authority, n.d) and iv) the opportunities for provoking students to justify their thinking and connect the patterns they found to the original situation. As this was the teachers' first experience of lesson study and there is no tradition of teaching using the Japanese problem-solving structure, it seemed too problematic for teachers to be required to find their own tasks.

During the remainder of the first planning session, the two planning teams were asked to try to identify overarching, unit, and lesson goals. This proved to be very difficult, with participants expressing some frustration and confusion. Nevertheless, even at this very early stage, at the end of the session teachers at the school wanted to show the university researchers the classrooms that might be used for the research lesson. They were already discussing how they could display a full range of student solutions and what changes in furniture would be needed – for example, seating arrangements and extra whiteboards.

During the second planning session, the team addressed the statement of the problem; possible student solutions; and how to orchestrate sharing solutions. Teachers questioned whether they should follow the Japanese lesson structure. Keith thought it would be difficult for children to sit on the floor for 20 minutes. Megan suggested that students work in groups for 10 minutes, while the teacher would walk around to observe students' solutions, then ask students to come to the board and explain their solutions for another 10 minutes. Lyn predicted her students would solve it by counting for 5 squares, might continue counting for 8, and would not know what to do for 100. She added that while some of her students might observe patterns, the majority would just count. The group decided to trial a similar problem, collect student work and report in the next session.

As a result of trialling one or in some cases two similar problems, participants changed their minds about many aspects of the proposed research lesson. Lyn was very excited by her experience between sessions 2 and 3 when she both taught a problem-solving lesson and observed Trevor from the other group – Megan, Lyn and Trevor were present at both lessons and "debriefed" together. Lyn said she had "completely changed her mind" about what strategies and explanations her class was capable of producing. She brought along many samples of student work and volunteered to teach the research lesson. When Henry reminded the group that their school region's instructional model for mathematics required them to come up with learning intentions, Lyn said that based on the trial experience there was no need to state learning intentions at the beginning. Instead, students would come to understand these at the end of the lesson. This is in line with Japanese practice, where the learning intentions are expected to become clear in the matome stage of the lesson, after which students are expected to write their own reflections on the lesson.

Between sessions 3 and 4, teachers trialled the Matchstick Problem in classes that were not going to participate in the two research lessons. When asked in session 4 how long they had spent on the neriage stage in their trial lessons, Lyn said about 20 minutes, while the other two teachers said 5 minutes and 10 to 15 minutes. In the final lesson plan, 5 minutes were allocated to the introduction of the problem, 20–25 minutes for individual problem solving, 20–25 minutes for sharing solutions, 5 minutes for the summary, and 5 minutes for students to write their reflections. In the actual research lesson, individual problem solving took about 30 minutes, while sharing solutions took about 15 minutes. Nevertheless substantial time was spent sharing solutions. Lyn orchestrated the order of solutions, based on evidence from her observations and her ability to quickly identify strategies, most of which had been anticipated during the planning sessions. However, there were some surprises such as Emily's solutions (see Figure 2).

Five minutes were spent in the summary (matome) stage. The lesson plan had identified possible student responses for this stage as understanding: i) the importance of proving that their strategy and solution is correct; and that ii) a pattern may help them to solve multiple problems. Lyn asked "What is the important thing we learnt from sharing our strategies and working on this lesson today?" Jordan responded immediately "To double check and prove that your answer is right". After about two minutes of discussion about how to prove that Emily's answer is right, Lyn asked if anyone had anything else to add. Arki said "Instead of just trying to find the answer, a quicker way is to find a pattern". Figure 3 shows Lyn's summary of the students' responses, and the request for students to respond in writing to "How has your thinking changed after completing this lesson?"

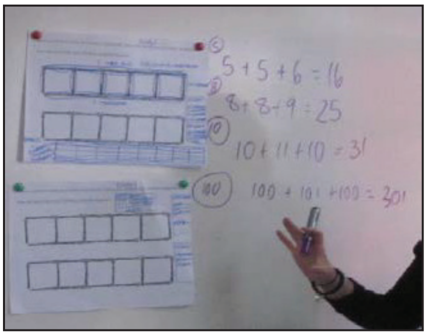

Figure 2. Emily's solution

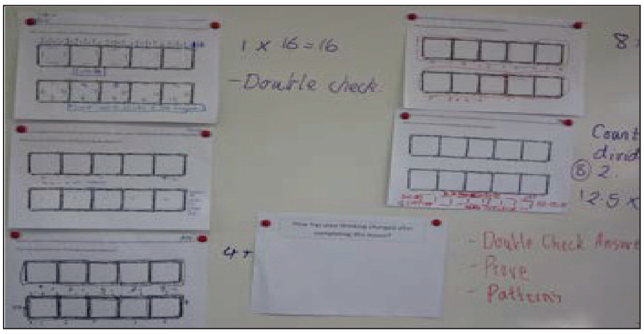

Figure 3. Part of the whiteboard at the end of the lesson

Conclusion

Numerous sources of data, including several participants' accounts at the Mathematical Association of Victoria's annual December conference, confirm that participants i) recognised the difference between *neriage* and the traditional 5- to 10-minute "show and tell" mandated in their school region's instructional model; ii) realised the importance of anticipating students' solutions to help them orchestrate the sharing of solutions and plan how to meet the "significant pedagogical demands that are involved in orchestrating discussions that build on student thinking" (Stein, Engle, Smith, & Hughes, 2008, p. 320); iii) spent considerable time planning the probing questions to use to elicit student responses; iv) saw the Japanese problem-solving lesson structure and its focus on sharing student solutions as a natural extension of the focus of their previous professional learning programs on questioning techniques to develop students' higher order thinking. Perhaps most significantly, all three schools involved in this project are planning to continue at least some aspects of Japanese Lesson Study in 2013, thus confirming its potential to provide a sustainable model for professional learning in the Australian context.

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