

TEACHER EDUCATION AROUND THE WORLD

ASPECTS OF MATHEMATICS TEACHER EDUCATION IN JAPAN: FOCUSING ON TEACHERS' ROLES¹

Yoshinori Shimizu

INTRODUCTION

One of the characteristics of mathematics lessons in Japanese elementary and lower secondary schools relates to the frequent exposure of students to alternative solution methods for a problem (e.g. Becker, Silver, Kantowski, Travers & Wilson, 1990; Stevenson & Stigler, 1992; Lee, Graham & Stevenson, 1996). Japanese mathematics teachers, particularly in elementary schools, often plan to organize an entire lesson around the multiple solutions to a single problem in a whole class instructional mode (Nagasaki & Becker, 1993; Shimizu, 1996; Stigler, Fernandez & Yoshida, 1996). Alternative solution methods for the problem are usually presented by several of the 30 to 40 students in a class.

In this setting, a teacher has to pose the problem and anticipate students' responses to it. In other words, the teacher has to consider, both in planning and during the lesson, the diversity of experience and knowledge students bring into the classroom. How do Japanese mathematics teachers select the problems for their lessons? Do they have certain techniques for dealing with the diversity of their students? If there are such techniques, how do prospective and beginning teachers learn and develop them?

In this article aspects of mathematics teacher education in Japan are discussed. Rather than presenting an outline of the entire education of Japanese teachers, I will focus on the teachers' key roles during the lessons, roles that prospective and beginning teachers are supposed to learn either in a teacher preparation program or through the interaction with their colleagues. In an effort to provide a context for this aspect of mathematics teacher education, a sample lesson and the typical organization of a mathematics lesson shared by Japanese teachers are described first. Next, I introduce several Japanese pedagogical terms that refer to teachers' key roles during the lessons. The importance of these roles for educating



teachers is discussed. Also, the importance of workshops as a means of promoting these roles is emphasized. The lesson on division by two-digit numbers is used for reference throughout the article.

LOOKING INTO A JAPANESE MATHEMATICS LESSON

Consider a fourth grade classroom in Tokyo in which the teacher, Mr. Matsumaru, introduces division by two-digit numbers. This is the first time that his students are faced with a problem that requires division by a two-digit number, although they have previously learned to solve problems that require division by single-digit numbers.

At the beginning of the lesson, Mr. Matsumaru refers to an earlier activity in which students had planted bulbs on the school grounds. The teacher uses this activity as context and poses the following problem to the students:

We are going to plant 128 bulbs of tulips into 16 planters. The same number of bulbs are to be planted in each planter. How many bulbs will be planted in each planter?

After he has presented the problem with a picture and a model that represent the setting, Mr. Matsumaru asks his students to think about how they could express the situation in mathematical terms. Based on the meaning of division as *dividing into equal parts*, students share the expression $128 \div 16$ as a mathematical expression for the setting. Consequently, the task at hand is to find the answer to $128 \div 16$. Mr. Matsumaru encourages his students to explore many different ways of finding the answer. After the students have worked on the problem individually, several solution processes and solutions are shared and discussed.

Typical Organization of Mathematics Lessons

A mathematics lesson in Japan lasts 45 minutes in elementary schools and 50 minutes in secondary schools and is typically divided into several segments (Becker et al., 1990; Stigler et al., 1996). A common lesson organization consists of segments that often serve as the steps or stages both in teachers' planning and in the teaching-learning processes (Shimizu, 1996):

- Presentation of a problem;
- Individual problem solving by students;
- Whole-class discussion about the methods for solving the problem;
and
- Summing up by the teacher (Exercises/Extensions).

As in the Mr. Matsumaru's introductory lesson on division by two-digit divisors, mathematics lessons usually begin with a practical problem or a word problem written on the chalkboard or taken from the textbook. After the problem is presented and read by students, the teacher confirms that the problem is understood by the students. If not, the teacher may ask the students to read again or, in some cases, she or he may ask a few students to show their initial ideas about the methods to solve the problem. Then, about 10–15 minutes are assigned for the students to solve the problem on their own.

While students are working on the problem, the teacher moves about to observe students' work. During this time period, the teacher gives suggestions or helps individually those who are having difficulties. The teacher also watches for students who have good ideas, with the intention of calling on those students – in a certain order – in the subsequent discussion.

During the discussion, students spend the majority of their time listening to the solutions being proposed by their classmates, as well as presenting their own ideas. When discussing solutions to the problem, the teacher asks students to present alternative methods to solve the same problem. Presenting an idea, even a wrong one, is strongly encouraged and praised. In some cases, the teacher may select an incorrect solution for presentation in order to make a point. Finally, the teacher reviews and summarizes the lesson, and, if necessary, presents an exercise which will apply what students have learned.

Teachers' Roles During the Lessons

The following pedagogical terms are commonly used to describe the teachers' key roles within a lesson: *Hatsumon*, *Kikan-shido*, *Neriage*, and *Matome*.

Hatsumon. *Hatsumon* means *asking a key question* that provokes students' thinking at a particular point in the lesson. At the beginning of the lesson, the teacher may ask a question to probe or promote students' understanding of the problem. During the whole-class discussion, on the other hand, he or she may ask, for example, about the connections among the proposed approaches to solving the problem or the efficiency and applicability of each approach.

Mr. Matsumaru, after students had shared the expression $128 \div 16$ as a mathematical expression for the problem setting, asked the following question: "With which number as a divisor, instead of 16, could you find the answer?" With this question, he was trying to emphasize the difference

between what the students had learned in the previous grade and what they were faced with now.

Kikan-shido. Kikan-shido means *instruction at students' desk* and includes a purposeful scanning by the teacher of the students' individual problem-solving processes. While the teacher moves about the classroom, silently monitoring students' activities, he performs two important activities that are closely tied to the whole-class discussion that will follow the individual work. First, the teacher assesses students' problem-solving progress. In some cases, the teacher suggests a direction for students to follow or gives hints for approaching the problem. Second, the teacher makes mental notes as to which students used the expected approaches and which students used different approaches to the problem. These students will be asked to present their solutions later. Thus, in the period of the purposeful scanning, the teacher considers questions like, "Which solution methods should I have students present first?" or "How can I direct the discussion towards an integration of students' ideas?" Some of the answers to such questions might have been prepared in the planning phase, but some are not.

Neriage. The term Neriage describes the dynamic and collaborative nature of the whole-class discussion during the lesson. In Japanese, the term Neriage means *kneading up* or *polishing up*. In the context of teaching, the term works as a metaphor for the process of polishing students' ideas and of developing an integrated mathematical idea through the whole-class discussion. Japanese teachers regard Neriage as critical for the success or failure of the lesson.

Based on the teacher's observations during Kikan-shido, he or she carefully calls on students to present their solution methods on the chalkboard, selecting the students in a particular order. The order is quite important both for encouraging those students who found naive methods and for showing students' ideas in relation to the mathematical connections among them. In some cases, even an incorrect method or error may be presented if the teacher thinks this would be beneficial to the class. Once students' ideas are presented on the chalkboard, they are compared and contrasted orally. The teacher's role is not to point out the best solution but to guide the discussion toward an integrated idea.

In the case of Mr. Matsumaru, he selected several students' solutions for the presentation and focused on the relationships among those solutions. He used the figure of the planters in various arrays as representations. He spent, in particular, a fair amount of the time discussing the idea that

“We can divide both the dividend and divisor by 2 without changing the result.” This idea had been proposed by a student and was then explained by another student as he used the figure of planters. The idea was expanded by other students who used the numbers 4 and 8 as common divisors of 128 (the dividend) and 16 (the divisor). The idea that “one can divide both the dividend and divisor by the same number without changing the result” was a main target of the whole-class discussion.

Matome. The Japanese term *Matome* means *summing up*. Japanese teachers think that this stage is indispensable for a successful lesson. The *Matome* stage is identified as a critical difference between the U.S. and Japanese classroom activities (Fujii, Kumagi, Shimizu & Sugiyama, 1998). According to the U.S.-Japan comparative analysis, the *Matome* stage Japanese teachers tend to make a final and careful comment on students’ work in terms of mathematical sophistication.

In general, in the *Matome* stage the teacher reviews what students have discussed in the whole-class discussion and summarizes what they have learned during the lesson. Mr. Matsumaru summarized the regularity of division students’ had found and discussed as follows: “The answer remains the same when we divide both the divisor and dividend by the same number.” Also, Mr. Matsumaru emphasized the usefulness of the idea for reducing the problem with division by a two digit number into ones involving only single-digit divisors.

ASPECTS OF MATHEMATICS TEACHER EDUCATION IN JAPAN

Mentoring Beginning Teachers

To become a teacher in the Japanese educational system, a student must obtain a teacher’s certificate by completing the subjects in a university course, in accordance with the provisions of the Educational Personnel Certification Law. Although the teaching certificate is valid throughout the country, each local government is responsible for hiring teachers. With the teacher’s certificate, prospective teachers take an examination offered by each local board of education. Successful prospective teachers are hired by the local board.

Beginning teachers who have been hired are considered to be novices who need the support of their experienced colleagues. All beginning teachers are required to participate in the induction training program for one year after their appointment. For each beginning teacher, a master teacher,

who might be a head teacher or another experienced teacher, is assigned to help the novice make a successful start of their educational service and to learn and practice the different roles the teacher assumes in the course of a lesson.

During the induction period, workshops are offered both at the national and at local levels. The induction program includes approximately 300 hours of closely supervised and monitored teaching, with some of the classroom lessons being observed. In addition, the novices attend at least 20–30 full or partial days of further training at educational centers run by the regional prefecture or the local boards.

There are other opportunities for beginning teachers to learn from their experienced colleagues. Workshops of a particular style, *Jugyo Kenkyu-kai* (lesson study meeting), are regularly held for both beginning and experienced teachers. The workshops include an actual lesson observed by the attending teachers as well as an extended discussion after the lesson. Teachers exchange ideas about the lesson with a focus on the content taught and on the teacher's roles assumed during the lesson. Experienced teachers or mathematics educators are sometimes invited to comment on the development of the observed lesson, on the interpretations of the topic taught, and on how the lesson could be improved. In addition, there are many informal circles of 10 to 20 practicing teachers. The teachers gather after school once a month to discuss, for example, how they were successful or not in their teaching of mathematics, to introduce interesting problems or topics, and to examine the proposed lesson plans from various viewpoints.

The physical arrangement of the school promotes the interaction among colleagues. All teachers share a large room, the teachers' room, where each teacher has a desk. In addition to classroom teaching, teachers spend a considerable time in the teachers' room. This situation allows them to share information about students, ideas about mathematical topics, and instructional materials. Also, teachers in public schools are required to move from one school to another several times in their careers, possibly every three to ten years, within their regional prefecture. In some prefectures, teachers even move from elementary schools to lower secondary schools, and vice versa. Teachers also move within a school from one grade to another each year. These moves may be beneficial for beginning teachers as they help them become familiar with the content taught in different grades.

Educating Beginning Teachers About Lesson Plans

Throughout the educational process, lesson plans are used as vehicles with which teachers can learn and communicate about the topic to be

taught, possible students' approaches to the problem presented, and the important teacher roles. Preservice teachers are intensively taught how to write lesson plans well. Inservice teachers also do have opportunities to write or examine lesson plans at workshops and the informal circles after school.

In general, lesson plans are written in detail. Writing lesson plans is a critical exercise for preservice teachers, although they can easily access sample lesson plans in a teachers' edition or in other books. For a particular topic, these lesson plans also include expected students' responses to the problems. During this period of education, prospective teachers are learning through intensive coaching to write and polish their lesson plans by using a particular format (Figure 1).

Steps	Main learning activities	Anticipated students' responses	Remarks on teaching
<ul style="list-style-type: none"> • Posing a problem • Students' individual problem solving • Whole-class discussion • Summing up (Exercise/Extension) 			

Figure 1. A Common Framework for Lesson Plans.

An important part of planning for a lesson is *Kyozai-kenkyu*. *Kyozai-kenkyu* refers to the careful analysis of the topic in accordance with the objective(s) of the lesson. It includes analyses of the mathematical connections both among the current and previous topics (and forthcoming ones, in some cases) and within the topic. Also included are the anticipation of students' approaches to the problem and the planning of instructional activities based on the anticipated responses. For example, the current National Course of Study (Ministry of Education, 1989) emphasizes the importance of understanding and using regularities of four operations. In accordance with the Ministry's intentions, Mr. Matsumaru had planned to implement a lesson that focused on the importance of regularities of divisions, such as $a \div b = (a * c) \div (b * c)$ or $a \div b = (a \div c) \div (b \div c)$, based on his interpretation of the topic: These regularities of division would be useful for the students later when they would study division by decimal

fractions (in fifth grade) and by a common fraction (sixth grade): $0.8 \div 0.2 = (0.8 * 10) \div (0.2 * 10) = 8 \div 2$; $2/5 \div 3/4 = ((2/5) * 20) \div ((3/4) * 20) = 8 \div 15$.

It should also be noted that Mr. Matsumaru intentionally had selected both the particular numbers 128 and 16 and the problem which required a partitive division for introducing the topic. Consciously, he had chosen not to use numbers like $120 \div 20$ or a problem setting that required a quotitive division. He thought that if he would have used $120 \div 20$ for introducing division by a two-digit number, students' attention would be confined to dividing the two numbers each by ten. Also, if he had used a prime number like 17 for the divisor, no regularity of division would have been noticed by his students.

For any given problem, prospective teachers in a teacher preparation program will be expected to anticipate several student responses to the problem. For the division problem, possible strategies included:

1. Guessing.
2. Repeated subtraction: "How many "16s" are there in 128?" ($128 - 16 - 16 - 16 - \dots - 16 = 0$).
3. Repeatedly substituting numbers into the expression $\Delta * 16 = 128$ ($1 * 16 = 16, 2 * 16 = 32, 3 * 16 = 48, \dots 8 * 16 = 128$).
4. "Dividing by 16" means "dividing by 8 first and then by 2" ($128 \div 16 = 128 \div (8 * 2) = (128 \div 8) \div 2 = 16 \div 2 = 8$).
5. Dividing both the dividend and divisor by the same numbers, e.g., $128 \div 16 = (128 \div 2) \div (16 \div 2) = 64 \div 8 = 8$, or $128 \div 16 = (128 \div 4) \div (16 \div 4) = 32 \div 4 = 8$.
6. When multiplying the divisor by 2, the quotient is halved ($128 \div 4 = 32, 128 \div 2 = 64$) so the answer of $128 \div 16$ is half of $128 \div 8 = 16$.

The success of a lesson depends heavily on the interpretation of the topic. Thus, Kyozaikenkyu is a crucial part of the lesson planning for Japanese teachers. This kind of analysis is heavily emphasized in pre-service teacher training courses at the university. Kyozaikenkyu is also emphasized as student teachers are supervised by experienced teachers during their practice teaching. In summary, the educational value of a careful content analysis is considered very important.

FINAL REMARKS

In this article, several pedagogical ideas commonly shared by Japanese teachers were described. The discussion of multiple solutions to a problem

in a whole-class mode is a common style for teaching mathematics in Japanese schools. Teachers play several key roles for making this teaching style work well. These key roles are learned by prospective and beginning teachers through both formal and informal educational settings.

A mathematics teacher in the Japanese educational system must not only finish a teacher preparation course and pass an examination, but also learn from their colleagues the teachers' roles and the educational value of a careful subject-matter analysis. Beginning teachers in Japan are expected to continue learning teachers' roles through the informal interaction with their experienced colleagues as well as in a formal educational setting.

NOTE

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*Department of Mathematics and Informatics
Tokyo Gakugei University
Koganei, Tokyo, 184-8501 Japan
e-mail: shimizu@u-gakugei.ac.jp
Tel/Fax: +81-423-29-7471*