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THE DEVELOPMENT OF NUMERICAL COMPETENCE AMONG JAPANESE YOUNG CHILDREN

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This paper first describes typical early math education offered by a majority of Japanese educators and recommended by the Ministry of Education. It takes forms of naive "child development" programs. Then, it illustrates how early math education works in Japanese preschools—more specifically, how quantitative activities spontaneously occur, and when they occur, how teachers take up these activities and try to develop them.

It is now well known that the mathematics achievement of older children in East Asian countries including Japan is much more advanced than that of their counterparts in the United States and many other countries. This East Asian superiority is usually attributed to good teaching in mathematics at school (e.g., Stevenson & Stigler, 1992; Stigler & Hiebert, 1999). However, a plausible alternative interpretation is that Asian children may be better-prepared for mathematics learning when they enter the school.

In fact, a similar superiority has been observed for younger children in Japan, that is, those in grades 1, K, and below (Hatano & Inagaki, 1999). For example, Stevenson, Lee, and Stigler (1986) showed that both kindergartners and 1st-graders in Sendai performed considerably better than those in Minneapolis, using tests carefully constructed to represent the curricula in both countries. Furthermore, to exclude the possibility that this superiority was primarily due to enhanced calculation skills, Stigler, Lee, and Stevenson (1990) constructed a battery of tests assessing competence both in the curriculum and indirectly related to it. The battery thus included not only word problems, number concepts and equations, and calculations, but also visualization, mental folding, and oral problems including tricky ones that did not require computation. Their study showed that 1st-graders in Sendai performed much better than those in Chicago on all these tests which were administered separately.

Japanese children seem to have a good start at earlier ages. Ginsburg, Choy, Lopez, Netley, and Chao-Yuan (1997) cross-nationally compared 4-year-olds' informal mathematical thinking, using ten tasks in the context of a make-believe birthday party. Although the American children could count higher than the Japanese children, the Japanese children could solve many more informal calculation problems, especially those involving subtraction. Overall, Japanese children performed considerably better than their American counterparts.

What factors can explain the superior performance in mathematics of Japanese young children? Although cognitive explanations, in terms of the systematicity of number words, the orderly verbal expression of numerical operations, and so on, are often offered, they do not seem plausible (Hatano & Inagaki, 1999). It is true that Japanese number words, derived from the Chinese system, are regular both in the order of reference (always beginning with the largest, say, hundreds, tens, and units) and in the indication of the base-ten system (ten-one, ten-two, instead of eleven, twelve), and this may have some facilitative effect (e.g., Miller, Smith, Zhu, & Ahang, 1995). However, this advantage must be discounted, because Japanese children have to learn two counting systems and numerical classifiers, both of which increase the complexity of the number word system. Japanese young children learn, often before the Chinese-derived system of number words used in school mathematics is learned, another enumeration

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system of original Japanese words up to ten. There are no similarities between the corresponding number words in the two systems. In addition, they learn to count objects with numerical classifiers which vary depending on the category and dimensionality of objects and may change euphonically. For example, whereas candies are counted as *hitotsu, futatsu, mittsu,* fish are counted as *ippiki, nihiki, sambiki* and plates, *ichimai, nimai, sanmai.* The orderly verbal expression of numerical operations would be advantageous especially for symbolic problems, but such problems do not occupy a very significant place for kindergartners and preschoolers. Therefore, socio-cultural explanations, especially those in terms of educational practices in preschool and at home, seem more tenable.

In this paper, we will first describe typical early math education offered by a majority of Japanese educators and recommended by the Ministry of Education. It takes forms of naive "child development" programs. Then, we will illustrate how early math education works in Japanese preschools—more specifically, how quantitative activities spontaneously occur, and when they occur, how teachers take up these activities and try to develop them.

Math in the traditional early education in Japan

If math is taught formally, it is not surprising that even young children know much about it. However, survey reports as well as our informal observations strongly suggest that Japanese early educators are rather reluctant to teach numbers systematically. Most Japanese day care centers, as well as kindergartens that usually constitute independent institutions, want not to be elementary school-like, if they do not adopt a kind of "child-centered" or "child development" program. No systematic teaching of addition and subtraction skills, nor of the conception of number, is usually given before children enter an elementary school that covers from Grade 1 to 6.

A survey by the National League of Institutes for Educational Research (1971) revealed that most kindergarten and day-care center teachers believed the "learning of socially approved behavior patterns" and the "extending and deepening of experience" to be the most important objectives of early education. Almost none of the teachers replied that the teaching of letters and numbers was important. Needless to say, it is likely that some of the teachers are teaching number skills as a result of parental pressure, in spite of these opinions stated publicly. However, teaching school-like subjects is not considered to be desirable.

Japanese early educators seem to contrast their institutions as enhancing children's social and personality development with elementary schools serving for teaching academic knowledge and skills. A recent survey by Yamauchi (1994) confirmed this tendency. He and his associates, in contract research by the Ministry of Education, conducted a questionnaire survey of kindergarten teachers on teaching for the development of quantitative thinking abilities, along with a detailed observation of children's quantitative activities in the kindergartens. In line with the guidelines for early education by the Ministry of Education, none of the kindergarten teachers taught numbers systematically. Instead, these teachers reported, they prepared materials that were likely to induce quantitative activities (e.g., a variety of card games, skipping ropes, score boards to write numerals on, etc.). The teachers enhanced such quantitative activities further by questioning the children or by participating in the children's activities. They also invited children who revealed more advanced understanding to express their ideas to stimulate other children. Let us give some exemplary responses by teachers below, which they seemed to endorse as highly appropriate for early educators (Hatano & Inagaki, 1999).

Seeing that children are collecting acorns or colored leaves, a teacher asks how many acorns or leaves they have, or suggests that the children compare their collections with one another by numbers. A teacher proposes to count up to 20 to children who are waiting for their turn at the swing, and counts together with them. When forming teams for a dodge ball game or relay race, a teacher asks children whether the two teams have the same number of children. When the numbers of the two teams are different, she encourages them to figure out how to

make both teams in the same number. She shares a good idea offered by a child who reveals more advanced understanding of math. When snacks or supplies are being distributed, a teacher asks each group, usually consisting of 5 or 6 children, to equally distribute pieces of food or objects to their own group of children, and, when a member of the group is absent, asks how many children the group now has. A teacher and her children together compute the increasing score for each team in a game such as dodge ball or soccer. A teacher goes through daily schedule with her children, pointing to numerals on a clock that is on the wall. A teacher makes children aware of a special day by marking it on the calender in the classroom.

These attempts by teachers are harmonious with the guidelines for early education by the Ministry of Education. The Course of Study for Kindergarten by the Ministry of Education (1988) emphasizes the teacher's indirect "teaching," in other words, the importance of inducing children's spontaneous play and arranging environmental settings. In one of the five content areas of the Course of Study, "to become interested in quantity and shapes in everyday life" is aimed at, but a special note is given stating that teachers should cultivate children to become interested in quantity and wait for children's spontaneous interest produced from their needs and experiences in everyday life.

Likewise, parents do not report that they are teaching numbers to their young children, though they want their children to acquire some number skills before Grade 1. It is possible, or even likely, as suggested by Stevenson and Lee (1990), that Japanese parents take high achievement in mathematics to be an important goal for children, and thus are willing to help children to acquire numerical skills and understanding even before they enter the first grade of elementary school. However, Azuma, Kashiwagi, and Hess (1981) found that many more American mothers of 3-year-olds than their Japanese counterparts replied that they had taught counting regularly and systematically, bought toys and books designed to teach counting, and tried to teach the names of shapes. According to an earlier Japanese study by Fujinaga, Saiga, and Hosoya (1963), more than 80% of the middle-class mothers wanted their kindergarten children to master addition, and 70% of them, subtraction of numbers up to 10 before entering grade 1. These mothers added that they were teaching number skills whenever they found appropriate opportunities. Taking all these results into account, we must conclude that whereas Japanese parents may be eager to arrange the environment and help children when needed, they seem to teach less actively than American parents. Of course there are exceptions—some Japanese mothers, known as "education moms," intensively teach math to their children or send them to special preparatory schools for study. However, the proportion of such mothers of young children is not large.

These findings are somewhat puzzling, but we interpret them in the following ways (Hatano & Inagaki, 1999). We assume that Japanese culture places a high value on the acquisition of mathematical skills and understanding. Using Ginsburg et al.'s (1997) expression, it "favors quantitative activity" (p. 201). For some reason, counting, quantifying, measuring, calculating, etc. are considered to be legitimate activities to reveal one's intellectual competence in Japan. Early educators and other mature members of the society are thus willing to help less mature members to acquire such competence. As a result, quantitative activities occur fairly often in kindergartens, and when they occur, they attract children's attention. Kindergarten teachers, who have been trained in the traditional "child-centered" or "child development" program, tend to take up some of these activities and try to develop them, though they are not particularly interested in nor try to deliberately pursue children's mathematics learning—at least, it is not a major educational goal for them. Children's mathematical achievement is a product of their teachers' unconscious efforts to engage them actively in group activities, which often involve quantitative components.

Illustrative examples of informal math activities

In order to deepen understandings about how early math education works in the Japanese culture, one classroom activity of 3 to 4 year-old children in preschool is illustrated below. The

observed preschool was a private one in the Yokohama area with about 350 children, a majority of whom were from middle to upper-middle class families. On the day of the observation, there were thirteen children and two teachers, one teacher with the experience of 5 years and one assistant teacher with the experience of 3 years, in the classroom.

Creating objects with sheets of papers known as "Origami" is rather common activity even among young children in preschool. The observed activity was a similar kind but the children used a variety of newspapers and advertising papers instead of "Origami," sheets of square paper, colorful and smaller. Many quantitative as well as geometrical components were identified throughout the activity, and the children seemed to have been enjoying it. The observed activity got started during the free-play time when one child has got few sheets of newspaper from a shelf. The following protocol illustrates how the activity was originated spontaneously by the children.

(A fictitious name has been assigned to each child)

Koji: Let me have half! Half!

Nami: I'm not gonna give you half.

Ken: There are 3 sheets.

Koji: [Went to the teacher] She doesn't wanna give me half.

Teacher: [Looking at Nami] He wants you to give him half. [Sharing Nami's papers with Ken and Koji,] we have plenty. I'll give each one of you a sheet ("ikko" in Japanese). One sheet ("ichimai" in Japanese) each so... [The teacher brought a pile of newspaper and gave one sheet of paper to each child who wished to have one. At the same time, She provided two rolls of scotch tape on the combined tables of two.]

As the teacher set up the working tables and the tape, some children started to create the paper objects of their own. For example, a few children created and wore paper cloaks by folding two edges of the paper symmetrically into triangles and placed the scotch tape on them. One child just folded a sheet of newspaper into four saying, "Fold this into half. Fold this into half. Tap, tap, tap...". There also was the child who crumpled up a sheet of paper into a ball and treated it as if it had been a bean-paste ball of a cartoon character, Ampan-man.

The children's activity seemed to be expanded and activated, when the teachers had finished with their works and started to participate in the activity by providing slightly more advanced paper objects than those made by the children, "thin long stick" and "paper plane". The children who were playing with other toys or tools began to gather around the teachers and each of them asked the teachers to make one for him/her. When the child received the objects from the teachers, he/she played with the objects. When the teachers made paper objects for the children, many teacher-child interactions referring to quantity and/or geometry were observed. Such interaction often involved in (1) the order of the child who wanted the objects (e.g., "Please make the same one as Mai-chan's." "Wait. After making the one for Kou-chan, OK?"—the child and the assistant teacher. "Next to Hana-chan will be Ami-chan. She asked me first, so you have to wait for your turn. Wait. OK? I will make one for you, too." —the assistant teacher), (2) the quantity of the object (e.g., "Could you go and get me a scotch tape? One."—the teacher), and (3) the shape of the objects that the teachers were making (e.g., "I want you to make it slim."—the child).

By the time a majority of the children in the classroom received the objects from the teachers, several children had, again, started to create objects of their own. Some of them used the teacher-made objects to create more complicated paper objects. And others created the original objects using new sheets of paper. The teachers looked around the classroom so that they could check each child's activity. The teachers actively offered help when needed, and the children spontaneously asked the teachers for help as well. Many uses of quantitative as well as geometrical terms were observed when the teachers helped the children make objects. For example, when the teacher saw the child who was pulling scotch tape hard, she said, "Don't you think you are taking too much?

Don't you think it's too long?". Another example is that the teacher responded to the child, who showed a very long stick, by saying, "You put them together! Two of them!?". The interaction with the teachers seemed not only to provide the children with many opportunities to experience the quantitative and geometrical terms, but also to help the children develop their understandings in quantity or geometry. For example, when the child was struggling with a huge sheet of paper trying to make a shape of tied ribbon, the teacher told the child that her paper was far too big and handed a smaller one. Then, another child, who was watching and listening to the conversation, returned her paper back to the shelf and got a smaller sheet of paper, and asked the teacher, "My teacher, will the small one be fine? Like this one?".

Concluding comments

Through the above careful observation of the children's free-play in Japanese preschool, rather common preschool activities, such as paper activity, were found to provide the children with varieties of quantitative as well as geometrical experiences. The paper activity of the children became the major activity in the observed free-play time, as the teachers prepared the working environment by setting the tables and tapes in the classroom, and invited the children to join the activity by providing paper objects and also helping the children make the objects of their own. At the same time, through the interaction with the teachers, the children seemed to have many opportunities to encode/decode and develop understandings in quantity and geometry. The observed tendencies in the Japanese preschool seem to support the view that the teachers' appropriate responses supported by Japanese culture are positively influencing young children's learning of mathematics.

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