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Teacher support for children's base-10 understanding in Japanese kindergarten

Early understanding of base-10 concept has been shown to be associated with superior mathematical achievement among East Asian children. In addition to their base-10 structured number system, teacher support in kindergarten is also crucial to children's development of this complex mathematical concept. Therefore, this study examined how Japanese kindergarten teachers support children's base-10 understanding through informal learning activities. One class of 35 four-year-old children in a private Japanese kindergarten was observed. Our findings reveal that teacher support in their informal learning activities shared two common aspects, namely, 'children as the manipulatives' and 'every child's contribution is essential'. The former aspect suggests that using children as the manipulatives can also be effective in promoting children's base-10 understanding. Interestingly, the latter reflects that Japanese kindergarten teachers place great emphasis in nurturing children's social skills while supporting children in learning base-10 concept unconsciously. This study also provides new directions for future research on how free-choice/child-led play and activities, as well as music and body movement related activities can promote children's mathematical knowledge.

Keywords: base-10 concept; kindergarten; teacher support; informal learning activities; manipulatives

Introduction

There is consistent evidence that East Asian children have a higher achievement level in mathematics than their western counterparts. This difference becomes apparent as early as when they begin learning to count, representing numbers, and doing addition (Cheng and Chan 2005). Moreover, such achievement gap persists from kindergarten through high school, and remains relatively stable over time (Leung 2006). Numerous factors, including cultural beliefs, parental beliefs, education systems, teaching methods, and language differences have been suggested as contributing to East Asian children's superiority in mathematics. Among them, linguistic factor (e.g., differences in number system) appears to have a greater impact on East Asian children's achievement. For instance, East Asian number system (e.g., Chinese, Japanese and Korean) tend to be simpler, more straightforward, and have a higher transparency of base-10 system, in comparison to the English number system. Such linguistic characteristic confers an advantage to East Asian children's early mathematical development. Therefore, they tend to perform better at understanding number concepts and place-value, counting, and computation than their English-speaking peers (e.g., Miller et al. 1995).

Although it is true that East Asian number systems benefit children in acquiring number concepts, particularly base-10, but this is not the full picture. For example, Ho and Fuson (1998) found that 4-year-old Chinese children fail to demonstrate a clear understanding of base-10 concept even though they use number words that clearly reflect a base-10 pattern. This suggests that merely encountering East Asian number system seems insufficient to help young children develop a solid grasp of base-10 concept. Considering the arbitrary nature of this concept and its complexity, cultural transmission could be the only way through which children can acquire it (Kerbs, Squire, and Bryant 2003). Schools are often believed to be the best place for such cultural transmission because teachers provide different forms of support to help children develop their mathematical knowledge (Naito and Miura 2001; Weiland and Yoshikawa 2013). Therefore, it is imperative to go beyond merely investigating the linguistic benefits of East Asian number systems on East Asian children's base-10 understanding and examine how teachers support the development of this concept in kindergarten settings, which is an area that remains largely understudied.

Base-10 concept and number systems

Base-10 understanding has been widely believed as a crucial aspect of early mathematics (Geary 2006; NCTM 2000), which promotes children's mathematical achievement (Fuson 1990; Ong et al. 2022). To understand this concept, one needs to have a good

grasp of the two fundamental mathematical principles that underlie it: place-value notation and additive composition of numbers. For place-value notation, it is essential to understand that numbers can be expressed in different units, such as ones, tens, hundreds, and a digit's value depends on its position in the number. For example, the place value of 5 in 152 is 5 tens or 50, while the place value of 5 in 538 is 5 hundreds or 500. Even though the digits in both numbers are similar, their place value changes according to their positions. Next, as for additive composition of numbers, one must know that all positive integer 'n' can be composed and decomposed into two or more other integers whose numeric magnitude are smaller than 'n', and these others add up exactly to 'n'. For example, 8 can be decomposed into $5+3$, $2+6$, $1+7$ or $0+8$.

As a matter of fact, these two mathematical principles can be relatively complex for young children to comprehend and acquire, which, in turn, may hinder their understanding of base-10 concept. East Asian children, however, may have a different experience due to the way their number system is structured, making it easier for them to grasp base-10 concept. Specifically, the East Asian number system (e.g., Chinese, Korean, and Japanese) is well-organized according to the base-10 system. In this system, the value of any digit in a multi-digit number is determined by both its face value (0-9) and position in that number. Furthermore, each position's value in the number also increases by powers of 10 (十) as it moves from right to left. For example, the number (11) in Japanese is (十一) which can be translated as 'ten-one' in English, and likewise for the rest, 12 (十二) and 13 (十三) as 'ten-two' and 'ten-three' respectively. Therefore, East Asian children can remember number-words as tens and ones without much of a hassle. However, in English, there is no such clue, and many inconsistencies exist. Number names such as 'eleven' and 'twelve', for example, remain arbitrary without any clue to how the number is composed. Likewise, for 13, the 'ten' becomes 'teen', and 'three' becomes 'thir-', and for 15, 'ten' becomes 'teen', and 'five' becomes 'fif-'. Aside from these complexities, in English, 13 to 19 are reversed, but not in Japanese. For example, '16' is read as 'sixteen' instead of 'one-ten-six' or 'teen-six'. Due to this, English-speaking children often have trouble understanding numbers in the first ten because smaller numbers are named before large numbers.

Despite the fact that the East Asian number word system does have a beneficial effect on East Asian children's learning of number concepts, especially base-10, this does not fully explain the whole story. For example, 4-year-old Chinese children do not understand base-10 concept despite the high transparency of base-10 system in their number system (Ho and Fuson 1998). These children could correctly say the number 12 as 'ten-two', but they could not add 10 items and 2 items together to make 12 without

counting. In light of these findings, it is clear that merely exposing young children to East Asian number system is not sufficient in helping them develop base-10 understanding.

The Sociocultural Approach to base-10 understanding

Cultural and social context are crucial contributors to child development. In particular, the sociocultural approach views children's learning and cognitive development as socially mediated processes in which they interact with other individuals collaboratively to construct and modify their knowledge, using both symbolic (e.g., words and number symbols) and material tools (Gauvain and Munroe 2012; Vygotsky 1987) while transforming their participation and contributing to their cultural endeavours (Rogoff 1998, 2003). Often, young children experience such social psychological processes when they acquire mathematical concepts (Rogoff 2003). In accordance with the sociocultural approach, we therefore hold that base-10 understanding stems from cultural transmission through which learning occurs as children collaborate with adults (e.g., parents and teachers) to co-construct knowledge by participating in and contributing to their own activities.

Over the years, many researchers contend that such cultural transmission should occur in schools in the form of formal education (Geary 1995; Naito and Miura 2001). In addition, other researchers believe that children generally take several years to understand base-10 concept (Carpenter et al 1998; Varelas and Becker 1997), and prior to formal schooling, they tend to represent numbers larger than ten as collections of ones rather than groups of tens and ones (Mix et al 2014). For this reason, studies to date primarily focus on how formal math instructions and their learning materials affect older children's base-10 understanding at the elementary school level (Fuson and Li 2009; Murata 2004). On the other hand, little attention has been paid to the development of base-10 understanding among younger children through informal learning which is known to be “nondidactic, is embedded in meaningful activity, builds on the learner's initiative or interest or choice (rather than resulting from external demands or requirements), and does not involve assessment external to the activity” (Rogoff, Callanan and Gutierrez 2016, 356). However, this form of learning is often incorporated into Japanese kindergarten curriculum (Sakakibara 2014) and may also facilitate Japanese children's understanding of base-10 concept.

Interestingly, recent study has demonstrated that Japanese kindergarteners could solve not only complex addition containing two-digit addends (e.g., $21+17$), but also used advanced arithmetic strategies, such as decomposition strategy, to solve these problems (Ong et al. 2022). This strategy involves splitting both addends into tens and units, adding them separately, and then combining them together (e.g., $21 + 17$: $20 + 10 = 30$, $1 + 7 = 8$,

$30 + 8 = 38$). The result suggested that they have already acquired a solid understanding of base-10 concept prior to elementary school and were much more competent than what many researchers have previously reported. In addition, the same study also revealed that Singaporean kindergarteners, despite having formal mathematics education in kindergarten, demonstrated a weaker grasp of base-10 concept than their Japanese counterparts. Considering these findings, we are left to wonder whether young children's base-10 understanding can only be developed through formal education and direct instruction. To address this question, exploring the play-based kindergarten curriculum in Japan could be a good starting point.

Mathematics-related curriculum and activities in Japanese kindergartens

Formal schooling in Japan begins at the age of six when children enter elementary school. Prior to this, almost all children in Japan receive some form of early childhood education (Monbukagakushō 2017). Kindergartens in Japan are governed by the Ministry of Education, Culture, Sports, Science, and Technology (MEXT), and accept children between the ages of three and five (Sakakihara et al. 2015). Japanese teachers often adhere to the National Curriculum Standard for Kindergartens to design curriculum that provides appropriate, effective, and well-rounded learning experiences for children. Part of this National Curriculum Standard's section on 'environment' provides information and guidance on developing children's mathematical understanding, aiming 'to enrich children's understanding of the nature of things, the concepts of quantities, written words, et al. through observing, thinking about and dealing with the things and experiences surrounding them' (Ministry of Education, Culture, Sports, Science and Technology 2017, 16). In addition, the guidance also stated that 'children should be encouraged to place importance on their experiences based on the necessities of their own lives, so that interest, curiosity, and an understanding of the concepts of quantities and the written word can be fostered' (Ministry of Education, Culture, Sports, Science and Technology 2017, 17). However, MEXT does not advocate kindergartens to use more intentional or directed manner to teach mathematics. For this reason, Japanese kindergartens typically do not conduct systematic teaching/formal lessons and teachers rarely intentionally support children's mathematical learning (Cave 2022).

Despite this, mathematical concepts are frequently embedded into activities such as taking attendance, cleaning up, singing, art and crafts, playing games, etc., as well as teachers and children expressing and manipulating numbers orally rather than in writing (Sakakibara 2014). In addition, it is interesting to note that, Japanese kindergarteners often count using natural manipulatives, such as fruits, leaves, seeds, fingers, and even themselves, rather than artificial manipulatives, like Chips, Unifix cubes, blocks, that are

commonly used in formal education. Using manipulatives as a means of learning mathematics makes it easier, more engaging and effective for young children. Therefore, those natural manipulatives may play a crucial role in helping Japanese kindergarteners develop from concrete to abstract mathematical reasoning in a more meaningful way.

Apart from the frequent use of natural manipulatives, the incorporation of base-10 into games and children play, is also another interesting characteristic of the Japanese kindergarten curriculum. For example, teachers count out loud by tens during the skipping games, children and items are grouped into tens, and tasks/games have 10 varying levels of difficulty to complete (Ong 2018). Miura et al. (1994) suggested that these informal learning in kindergartens can enhance Japanese first graders' abilities to construct numbers in canonical base-10 form and to comprehend place value. Moreover, past studies have also shown that informal learning, such as playing games, can positively impact young children's mathematical development (Cohrssen and Niklas 2019). In view of the above findings, in combination with the fact that Japanese kindergarteners rarely acquire mathematical knowledge in non-preschool educational institutions (e.g., Kumon and Benesse) (Cave 2022), Japanese kindergartens may become a crucial learning platform where teachers support children in understanding base-10 concept through free play, games and everyday activities. However, despite the importance of teacher support in promoting young children's base-10 understanding, studies to date have not provided a complete picture of it, especially in the Japanese kindergarten context.

Research aim

The study aimed to identify and examine base-10 related activities in Japanese kindergartens that could promote young children's base-10 understanding, by analysing how Japanese kindergarten teachers support young children's base-10 understanding during those activities?

Method

Participants

This observation study was conducted in one private Japanese kindergarten located in Sapporo city, Hokkaido. One class of 35 four-year-old children was randomly chosen for the study. Two teachers were present in the classroom.

This kindergarten was carefully chosen on the basis of specific criteria, including adhering to the mainstream curriculum programs, meeting local regulations, and charging a tuition fee that is affordable for most families. This is to ensure that it represented the majority of the kindergartens within the Japanese cultural contexts. In addition, this kindergarten's daily routines mainly centred around play and classroom activities (either teacher-directed or child-initiated). Besides incorporating learning into children's play,

teachers often adjust their activities to meet the interests and needs of the children. Therefore, by conducting observation study in this kindergarten, it is more likely to capture a fuller picture of how Japanese teachers support children's base-10 understanding through play and other informal learning activities.

Observation study

The four-year-old class was observed twice per week for a period of five months, totalling 38 observations. Each observation lasted for an hour. The children attended the kindergarten from 930am to 130pm on weekdays. In order to capture as many types of activities as possible throughout the children's daily routines, all observation sessions were conducted sequentially according to the order of three different time slots, (1)930am-1030am, (2)1030am-1130am, and (3)1230pm-130pm. In accordance with kindergarten policy, no observation was conducted during the lunchtime (1130am-1230pm). Video recording and concurrent field notes were used to collect data on the interactions between the teachers and children during their activities.

Collected data were analysed as follows. Individual activities were first identified according to their respective starting points and ending points. For instance, during the morning assembly, the teacher asked the class to count the number of children present, and then she wrote that number on the white board. Following that, she informed the children that they would have a skipping practice in the hall before asking them to gather in the hall with their individual skipping ropes. If we consider the above example, the teacher's request for the class to count the number of children present became the starting point, and writing that number became the endpoint of that activity. Following that, another activity began when the teacher announced skipping practice to the class. Hence, from the above example, it is possible to identify two different activities based on their respective starting points and endpoints.

The next step was to separate all mathematical activities from those unrelated to mathematics. Based on Child Math Assessment (Starkey 2002), we considered an activity as mathematical if the teachers and children used numbers (e.g., counting) and/or arithmetic (e.g., addition and/or subtraction) at any point between the activity's starting and ending points. As a final step, we segregated mathematical activities with base-10 from the rest for further analysis.

Thematic analysis was used in this study. Using field notes and observation transcripts of those base-10 related mathematical activities, short analytic memos were created to tentatively identify themes and patterns. Next, codes were developed before they were categorized to generate themes. These results were later compared with the earlier short analytic memos to produce the final analysis. This approach ensures

systematic coding that minimizes fragmentation and decontextualization risks (Bryman 2016). The coding and generating of themes were conducted by two independent coders. Reliabilities based on coding 100% of the data which yielded 85% agreement. All disagreements were resolved by discussions and subsequent consensus.

In this study, the authors served as both observers and coders. They are PhD holders in education and psychology who have undergone rigorous training in research methodology during their undergraduate and graduate studies. Furthermore, they also have extensive experience conducting observational studies in kindergartens/schools and are specialized in qualitative research.

Ethical considerations

All participants were informed of the purpose and procedures of the research, as approved by the university ethics committee. Parental consent was obtained through the kindergarten principal prior to the observation study. During observation, the authors carefully ensured that the study does not cause any risks, damage or harm to both the teacher and the child participants. All data were used exclusively for research purposes.

Finding

A total of 15 activities related to base-10 were observed during the 38 observation sessions. Four activities out of 15 were selected for further analysis because the other 11, which included grouping of children or items into tens and singing songs or playing games related to base 10, were either the same or close in functional nature as the four selected activities. Therefore, the four activities represented the four main ways in which Japanese kindergarten teachers support children's understanding of base-10 concept in this study.

Interestingly, even though each of the four activities differed from the other, teacher support in these four activities shared two common aspects. The first one is 'Children as the manipulatives', and the second one is 'Every child's contribution is essential'. Activity 1 to 4 clearly illustrated how teacher support revolved around these two aspects.

Activity 1: Counting the number of children in the 'train'

Teacher Y suggested to the children that they will play the 'train' game after their daily morning assembly. The game begun as the children moved in clockwise direction to the piano music played by Teacher S. As part of the game's rules, all children were expected to stop moving and play rock paper scissors game with another child once Teacher S stopped playing the music. If the child lost the game, he/she was required to move behind the winner and place both of their hands on the winner's shoulders. The newly formed pairs started to move in the same clockwise direction when the music resumed and paused

for rock paper scissors game once the music ended. Likewise, those pairs that lost the game moved behind the winning pairs. The newly formed quartets started moving once Teacher S began to play the music again. Going through the same process, the 33 children who were present on that day, formed one long and curving line resembling a long train after they had completed five rounds of rock paper scissors game. Teacher Y then asked the children how many children were there in the line, but no one was able to answer. Upon seeing that, she moved closer to the first child in the 'train' and started to count out loud sequentially from the first child to the last child in the 'train' while touching each child's head when she reached their spots. Even though Teacher Y counted out loud for all the numbers, she paid particular attention to the 10th, 20th and 30th children by pausing at their spots and placing emphasis on their numbers. For example, Teacher Y stopped briefly at the 10th child and said the number ten in a very slow pace, while the other children looked on [Figure 1 near here]. Likewise, as Teacher Y approached the spot for the 20th child, she paused once again and pointed to the 1st child, then explained to the class that there were 20 children from 1st to the 20th [Figure 2 near here]. Meanwhile she raised her voice and said the number "twenty".

Considering the nature of this 'train' game, it did not require the children to use much mathematics since they only had to play rock paper scissors and then formed one long 'train'. Despite that, Teacher Y incorporated mathematics into the activity by asking the class how many children were in the 'train'. As soon as she realized that the children could not answer the question, she provided mathematical support to them by counting together with them while focusing specifically on the 10th, 20th and 30th numbers. Besides learning how to count to higher numbers, such as 33, the children also got to learn about groups of tens through this mathematical support. Interestingly, in this support, the 'train' itself had become both a teaching and learning tool, as Teacher Y used the 33 children as the manipulatives for counting, as well as to introduce base-10 concept. In addition, this game required all the 33 children in the class to participate and the presence of each of them contributed and influenced the contents of the mathematical support. For instance, Teacher Y would not be able to incorporate base-10 concept into the game in such interactive and playful way if only 8 children participated in the activity. Therefore, teachers' support in this game could not have been what it was if each of the 33 children did not play their roles and contribute.

Activity 2: Confirming class attendance with fingers

During the daily morning assembly, Teacher S and the children sat in a big circle. She began by asking how many children were present in the class. However, the children simply shouted out random number without any proper calculation. This led Teacher S to

decide to work out the answer together with the children. First, she displayed three right fingers to represent 30 and five left fingers to represent five (5), which equalled the total number of children in that class (35 children) [Figure 3 near here]. She then folded her three left fingers down one at a time while reading out the names of those three absent children. Following that, she displayed three right fingers to represent 30 again and two left fingers as two (2), and then waited for the children to answer [Figure 4 near here]. Many children were able to shout out 32 as the answer this time round.

In this activity, Teacher S did not provide the children with the answer right away, but rather she provided them with mathematical support by explaining the steps leading to the answer. Even though Teacher S did not physically count the children like Teacher Y did in Activity 1, she used all the 35 children from that class as the manipulatives for counting. Teacher S also used her fingers as supplementary manipulatives to help children to visualize the number of children. It is interesting to note that instead of folding her fingers one by one, she counted by groups of tens, using her right fingers to represent the tens and left fingers for the ones. This may be a good learning platform for the children to learn base-10 concept since many were paying full attention to the demonstration, while others were using their fingers to count just like Teacher S. Furthermore, it was evident from this activity that each child in the class has a crucial role to play in contributing to the content of the mathematical support, as their presence on that day would determine the numbers displayed by Teacher S. This means that, besides 'Children as the manipulatives', 'Every child's contribution is essential' is also another key aspect in this support provided by Teacher S.

Activity 3: 'Taking turn to make a pose'

Teacher Y and the children were rehearsing for their autumn concert in the hall. As part of the concert, the children performed based on the 'Ichijiku Ninjin counting song'. 'Ichijiku Ninjin' is a traditional Japanese counting song with lyrics comprises of ten types of vegetables names that sound like the numbers one through ten in Japanese. In the song, the names of the vegetables are arranged as if they are counting from one to ten. For example, the first vegetable (ichijiku, figs) resembles the Japanese pronunciation of number one (ichi), and the last vegetable (Togan, winter melon) sounds like the old Japanese counting word ten (Toh).

Teacher Y first lined the children up into three rows, with 10 children in each row. Every child in each row was required to stand up to make a pose when their turns came. Once all the ten children finished making their poses, all of them hop to the other end of the hall. As soon as everyone was ready, Teacher S began playing the piano and Teacher Y beat the drum to create a rhythm that guided the children while they sang. The first boy

(circled in blue) in the first row [Figure 5 near here], stood up and made a pose as the children sang the first vegetable (ichijiku). Following that, the second boy (circled in green) in the same row [Figure 5 near here], also stood up and made a pose while the second vegetable (ninjin) was mentioned in the singing. Similar to the first two boys, all the other eight children in the row, including the third boy circled in red in Figure 5, also made their poses when their turns came. After the tenth boy (circled in black) in the row made his pose [Figure 6 near here], Teacher Y stopped beating the drum and the children stopped singing. After a short pause, all the ten children in the first row started to hop to the other end of the hall one by one along with the singing of 'Ichijiku Ninjin counting song' by Teacher Y and the children. Following that, Teacher S and Y resumed playing the song on the piano and hitting the drum, respectively, while the children in the second row did the same performance as those in the first row. The rehearsal ended after all the children in third row finished making their respective poses and hopped across the hall to join children from the previous two rows.

Through this performance, the children got to experience and 'use' base-10 because they were segregated into groups of tens and the group size was reduced from ten to zero, one by one, as each child moved away from the group once their 'vegetables' names were mentioned in the song. In addition, all the children also sang the 'Ichijiku Ninjin counting song' with lyrics comprising of a group of ten types of vegetables names. Even though Teacher Y also used all the children in the class as manipulatives like the previous two activities, however, in this activity, all the children became the manipulatives for displaying each of the ten vegetables instead of being counted. Clearly, each of the children contributed to the mathematical support provided by Teacher Y since the learning experience of base-10 concept was "created" as a result of their participation.

Activity 4: 'How many squids are there in the class?'

Following the singing session, Teacher Y and S, along with the children gathered in a big circle and discussed about what they had done on that day. Teacher Y noticed a boy stretching his legs back and forth and not paying attention to the discussion. Suddenly, she started imitating the boy's actions and asked the class how many legs an octopus and a squid has. As an octopus has six arms and two legs and a squid has eight legs and two longer tentacles, Teacher Y simplified the numbers by saying that the octopus has eight legs, and the squid has ten legs after discussion with the children. She then invited all the children to stretch their legs out as illustrated in Figure 7 before she asked how many squids, they could form using all their legs. Following this, she explained that every five children will form one 'squid' since they will have ten legs in total. When everyone was ready for the game, Teacher Y took up the position in the middle of the circle and counted

the legs by singing 'Ichijiku Ninjin counting song' instead of using numbers. Because there are ten types of vegetables in that song and each leg was counted as one of the ten vegetables, one 'squid' would be formed every time Teacher Y finished singing the song. She started singing by touching and counting the legs of each child sequentially, in clockwise direction [Figure 8 near here]. Each time she finished counting the legs of five individuals, she moved their legs together and hugged them before announcing to the class that they had formed a squid [Figure 9 near here]. Having 29 children present on that day, together with Teacher S, the class managed to form six 'squids' in total.

In Activity 4, it was apparent that Teacher Y had been inspired by the boy's action of stretching his legs back and forth to develop the activity into one that is not only interactive and fun but could also enhance children's understanding of base-10 concept. For instance, Teacher Y provided mathematical support to the children as she incorporated base-10 into the activity by grouping ten legs of five children together to form a 'squid' and singing the 'Ichijiku Ninjin counting song' while counting the legs. In order to form as many 'squids' as possible, Teacher Y had all the children participated and used all their legs as the manipulatives when counting and forming the 'squids'. Considering the involvement of all the children in this game, each child's contribution is essential, as the number of 'squids' formed, and the content of the mathematical support provided by Teacher Y would be determined by the number of children present on that day.

Discussion

In this study, we have examined and presented how Japanese kindergarten teachers support children in developing base-10 understanding through informal learning activities, such as games, school performance rehearsal and daily routine. In contrast to previous studies, in which teacher support focused on counting and shapes (e.g., Sakakibara 2014; Cave 2022), this study reveals that Japanese kindergarten teachers also incorporated complex mathematics content (e.g., base-10 concept) into their support. Interestingly, they did not use written numerals nor manipulatives, like Chips, Unifix cubes, blocks, which are commonly used by teachers to help children learn base-10 concept (Fuson et al. 1997; Puchner et al. 2008). Instead, they used children as the manipulatives to incorporate base-10 into their support. In fact, having children readily available in the classroom makes them an ideal manipulative for teachers to use to help children develop base-10 understanding in a more engaging and meaningful manner.

While Japanese teachers use children as the manipulatives, their support tends to involve the participation of all children in the class, as well as encouraging teamwork and cooperation among the children. There seems to be a role for each child in the class to

play and contribute to the support, which reflects another key aspect of the support, ‘every child’s contribution is essential’. Since early childhood education in Japan places a high value on social development and cooperation (Hegde et al. 2014), this key aspect may reflect the strong emphasis teachers place on these values. Further, this suggests that Japanese kindergarten teachers may prioritize nurturing children’s social skills as one of their primary goals, while supporting children in learning base-10 concept becomes an unconscious secondary objective because they seldom explicitly support children’s mathematical learning, despite they hold mathematical competence in high regard as part of their culture (Sakakibara 2014). Does it mean that such support is not as effective as those of formal schooling, in promoting children’s base-10 understanding?

In fact, many researchers maintain that children can develop base-10 understanding more effectively through formal systematic learning, together with the use of common manipulatives, like Chips, Unifix cubes, wooden tiles and blocks (Fuson et al. 1997; Puchner et al. 2008). In contrary, the support provided by Japanese kindergarten teachers through informal learning activities could have a facilitative effect on children’s base-10 understanding. For instance, those support often developed in activities that connect meaningfully with children’s lives, and by using all children in the class as manipulatives, children can be stimulated to participate actively, which could increase their awareness of base-10 counting during the activities and later promote their understanding of base-10 concept. In fact, Ong et al. 2022 have demonstrated that Japanese kindergarteners could solve not only complex addition containing two-digit addends (e.g., $21+17$), but could also use advanced arithmetic strategies, such as decomposition strategy, to solve these problems. This finding suggested that they have already acquired a solid understanding of base-10 concept. Surprisingly, Japanese kindergarteners rarely acquire mathematical knowledge in non-preschool educational institutions (e.g., Kumon and Benesse) (Cave 2022). It is therefore plausible that Japanese kindergartens are crucial platforms that provide children with opportunities for learning through social psychological processes that involve not only teachers guiding and supporting them, but also young children interacting with peers and teachers collaboratively to construct and modify their mathematical knowledge as they transform their participation and contribute to their own informal learning activities. Ultimately, this is likely to contribute significantly to their understanding of base-10 concept.

Conclusion

To conclude, it is evident that even though formal/systematic teaching is not conducted in Japanese kindergartens, teachers frequently embed not only basic mathematical concepts (Cave 2022; Sakakibara 2014), but also complex concepts like base-10, as

reported in this study, into various informal learning activities to support the mathematical development of young children. In other words, contrary to previous studies, which primarily focus on the impact of formal math education (e.g., rote learning) on older children's base-10 understanding, this study advances our knowledge about mathematical development among young Japanese children, in particular their acquisition of base-10 concept through informal learning. Besides that, such knowledge can be extended to the English-speaking countries where many young children struggle to learn numbers and counting due to the inconsistencies in the English number system. By integrating those two common aspects, namely, 'children as the manipulatives' and 'every child's contribution is essential' into teacher support or by engaging English-speaking children in those activities reported in this study would enable them to learn base-10 concept more effectively and meaningfully than simply memorizing the numbers and number structure. Therefore, this study contributes to and furthers literature in this aspect. However, it also has several limitations that need to be addressed. For this reason, this study offers several fruitful directions for future research.

First, we acknowledge the important role of free-choice/child-led play and activities in the mathematical development and learning of young children. This study, however, aimed only to identify and examine teacher-directed group/whole class activities. Future research should attend to the impact of free-choice/child-led play and activities in kindergarten on mathematical development and learning among young Japanese children.

Second, the small sample and five months of observation involved in the present study limits generalization of the results. In fact, future research can include more kindergartens, children of different age groups, as well as extending the period of observation to one academic year to capture more variation and complexity of the support. Finally, the support in this study also seems to revolve around music and children's body movements. Therefore, exploring how music and body movement related activities in Japanese kindergartens can impact not only children's base-10 understanding but also other mathematical knowledge, could be another good starting point.

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Figure 1. Teacher Y stopped at the 10th child (circled in yellow) while the other children looked on (circled in red).



Figure 2. Teacher Y stopped at the 20th child (circled in yellow) and explained to the class that there were 20 children from 1st to the 20th.



Figure 3. Teacher S displayed three right fingers to represent 30 and five left fingers to represent 5, which equaled the total number of children in that class (35 children).



Figure 4. Teacher S displayed three right fingers to represent 30 and two left fingers as 2.



Figure 5. The children stood up sequentially and made a pose when the vegetables that they were representing were mentioned in the 'Ichijiku Ninjin counting song.'



Figure 6. The 10th boy in the row (circled in black) made his pose before all the ten children in the same row started to hop to the other end of the hall one by one.



Figure 7. Teacher Y invited all the children to stretch their legs.



Figure 8. Teacher Y started singing by touching and counting the legs of each child sequentially, in clockwise direction.



Figure 9. Teacher Y moved their legs of five individuals together and hugged them before announcing to the class that they had formed a squid.



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