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Young Children's Mathematical Activities at Preschool and Home in Japan

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Abstract

Research indicates that mathematical understanding before formal schooling influences later attainment. This study investigated the mathematical activities of preschool-aged children in Japan, a neglected topic despite the high mathematical attainment of Japanese children. Preschool activities were investigated using surveys, observations, and staff interviews; activities at home and use of non-preschool educational providers were investigated using surveys of parents. The results showed that preschools overwhelmingly followed the government curricula, seeking to develop children's interest in and sense of number, quantity, and shape through activities embedded in play and daily life; more directed teaching using workbooks was rare. Many children frequently engaged in informal mathematics-related activities at home. An unexpectedly high proportion of children engaged with learning materials from non-preschool educational providers. Results were broadly consistent across the two locations studied, despite the contrasting attainment of children in these areas in national mathematics tests. The results demonstrate that preschools in different parts of Japan avoid directed mathematical teaching. Further research is needed into the development of the mathematical understanding of preschool-aged children in Japan, especially in relation to non-preschool educational providers.

Keywords

Mathematics
Preschool
Early childhood
Home learning environment
Japan

Japanese children have a longstanding record of high attainment in mathematics, as measured by international tests. The causes of this attainment have often been sought in school education, a hypothesis supported by studies evidencing the excellence of mathematics instruction in Japanese schools (Stigler and Hiebert 1999; Perry 2000; Corey et al. 2010). Comparatively little attention has been paid to the possible contribution of the preschool years to Japanese children's mathematical attainment. Yet elsewhere there is evidence that young children's mathematical skills and understanding before entry to formal schooling significantly influence their later mathematical attainment. In this light, better knowledge is needed about the mathematics-related activities of preschool-aged children in Japan, in order to move toward understanding how these might contribute to later mathematical attainment. This study advances such knowledge by delineating mathematics-related activities of young children in two locations, stemming from three important sources: preschool, home, and private non-preschool providers.

Early mathematical skills and later attainment

Studies in various countries have indicated strong associations between mathematics skills before entry to formal schooling and later mathematical attainment. In Finland, Aunola et al. (2004) found that 5-to-6-year-old children's maths skills (especially counting ability) at entry to preschool were positively related with maths performance in primary school year 2 (ages 7-to-8). In England, Aubrey, Dahl, and Godfrey (2006) similarly found that maths skills at age 5 (primary reception year) were positively related with national maths test results at ages 7 and 11. In the U.S., Jordan et al. (2009) found that higher number competence in kindergarten (age 5) predicted higher mathematics achievement in primary school year 3, while Nguyen et al. (2016) found that higher mathematical competencies (especially advanced counting skills) at pre-kindergarten (ages 4-5) predicted higher mathematical achievement in primary school year 5.

In what ways may young children acquire mathematical skills before formal schooling? A number of studies have pointed to the roles of the home learning environment and the preschool. Regarding the home, Skwarchuk, Sowinski, and LeFevre (2014) found in Canada that informal home numeracy practices such as games predicted children's non-symbolic arithmetic performance, while formal home numeracy practices such as teaching about arithmetic predicted children's number knowledge. In the U.S., Vandermaas-Peeler et al. (2018) found that parents and children engaged in various types of mathematics during games, cooking, and nature activities at home over one month; process activities such as size estimation/comparison, measuring, and sequencing were much more frequent than number activities such as counting. Children improved their scores in numeracy tests done before and after the month's activities. Regarding preschools, Wang at al. (2013) found that children from U.S. low-income households performed better in mathematics assessments if exposed to maths activities at preschool, and Lehrl, Kluczniok, and Rossbach (2016) found that attendance at German preschools assessed as offering high quality mathematical stimulation was associated with better adding and subtracting skills to age 9, though the effects tended to be small. International evidence thus suggests that both home and preschool contribute to young children's development of mathematical skills.

To date, research has neglected the possible role of non-preschool educational providers in preschool-aged children's acquisition of mathematical skills. However, this deserves investigation, especially in Japan, given the widespread use of activities such as Kumon mathematics by elementary school-aged children (Ukai 1994: 88).

Preschool education, participation and mathematics-related curriculum in Japan

Formal schooling in Japan starts with entry to elementary school at age 6. Before this, almost all children in Japan attend preschool.[1] Preschools in Japan are of three types: day-care centres (*hoikuen*), kindergartens (*yōchien*), and early childhood education and care (ECEC) centres (*nintei kodomo-en*). Day-care centres are administered by the Ministry of Health, Labour, and Welfare (MHLW), and accept children from age 6 weeks to 5 years old. Generally, only children with no caregiver at home are accepted. Day-care centres are typically open from 7 a.m. to 7 p.m., though hours vary. Kindergartens are administered by the Ministry of Education, Culture, Sports, Science, and Technology (MEXT), and accept children from age 3 to age 5. They are typically open from 9 a.m. to 2 p.m. ECEC centres, also under MEXT, offer both kindergarten and day-care programmes (Sakakihara et al. 2015).

The national curricula for day-care and kindergarten programmes provide identical guidance in relation to developing mathematical understanding, which is located in each curriculum's section on 'environment'. Both state the aim of 'enriching children's sense of number and quantity', which involves their 'having an interest in number, quantity, and shape in their everyday lives' (Kōseirōdōshō 2008: 18-19; Monbukagakushō 2008a: 6). This is elaborated by ministry guidance on interpreting the curriculum. The MEXT guidance is one page long and explains that kindergarten teachers should create an environment that enriches and enlivens children's experiences of number, quantity and shape. It gives examples of how children can become familiar with number and

quantity, through experiences such as confirming the number of people to whom snacks are distributed, or comparing the heights of heaps of sand. It also encourages teachers to help children notice the shapes that they encounter in their environment, and appreciate the usefulness of numbers (Monbukagakushō 2008b: 111). The MHLW guidance is more succinct, but the content is similar (Kōseirōdōshō Koyōkintō/jidōkateikyokuhoikuka 2008: 79-80). Neither ministry's guidance defines 'number' or 'quantity'. However, examples in the guidance imply 'number' in the senses of quantitative qualities of phenomena, and linguistic terms for these, not in the sense of formal or informal symbolisation of number; while guidance examples imply understanding of 'quantity' as either a set of discrete items, or a continuous quantity such as a height or volume (without mention of units of measurement). Both ministries emphasise an environment that encourages children to build up experiences of number, quantity and shape, and to notice how they can be meaningful. Neither ministry suggests that preschools should teach any form of mathematics in a more intentional or directed way.

Mathematical activity at preschool and at home in Japan: previous studies

Studies of preschools in Japan stretch over several decades, though very few examine attempts to develop mathematical understanding. The vast majority have indicated that preschools focus on the social, emotional, and physical development of children, without teaching formal academic skills (Peak 1991: 65-74; Lewis 1995: 18-35; Tobin, Hsueh, and Karasawa 2009). The exception was a study by Holloway (2000), which found that a small minority of preschools studied did teach mathematics formally. However, while most studies have noted the absence of formal academic teaching, they have not provided information about informal activities to develop mathematical understanding.

Two studies focusing specifically on mathematical activities were conducted by Sakakibara (2014a, 2014b) in a small number of private kindergartens in and near Tokyo. 14 classes of either three-year-old or four-year-old children at seven kindergartens were observed five times each in 2001-2002 (Sakakibara 2014b: 18), and 10 classes of five-year-old children at six kindergartens were observed twice each during 2002-2003 (Sakakibara 2014a: 21). Sakakibara found that number activities such as counting were quite frequently observed at the kindergartens researched. These activities were almost always embedded in other types of activity (most often singing, arts and crafts, exercising, taking attendance, or class gathering), rather than being themselves the focus of the activity. While number activities were frequent, arithmetic or pattern activities were rarely observed. The kindergartens in these studies thus appeared to conform to the intended government curriculum.

There is little research on how parents and other caregivers in Japan try to develop preschool-aged children's mathematical understanding. Fujibuchi (2012) carried out a questionnaire survey of mothers of three- to five-year-old children in urban and rural Fukuoka prefecture in 2010. He found that informal mathematical activities such as counting the number of stairs, counting numbers in the bath, chanting numbers in picture books, or sharing out items equally were reported by over half the 646 respondents; 26% reported that their child could write numerals up to 11 or above, and 22% that their child could write numerals up to about 10. On the other hand, only 13% reported that their child had engaged significantly with formal mathematical learning classes.

Other available information has also indicated that few Japanese preschool-aged children engage with formal mathematical learning through non-preschool educational providers. The Gakken group, one such provider, runs a research institute which issues annual reports on children of preschool and school age, based on its own surveys. According to its August 2017 survey of 400 five-year-olds, 5.8% were using distance learning materials and 5.3% were attending a study class outside preschool, while 1.3% were attending abacus class (Gakken Kyōiku Sōgō Kenkyūjo 2017).

Studies to date thus provide a limited and geographically patchy picture of Japanese preschool-aged children's mathematical activities. Although preschool education in Japan has features such as national curricula that encourage standardisation of practice, studies have also

shown that there is scope for significant variation in philosophy and practice (Holloway 2000; Tobin, Hsueh, and Karasawa 2009). Recent studies of Japan in disciplines such as sociology and anthropology have also emphasised the importance of attending to regional and other types of variation, avoiding a simplistic view of Japan – a country of 127 million people – as monolithic (Sugimoto 2015). Research must therefore consider possible regional variation in preschool-aged children's mathematical activities.

Research aim and questions

This study aimed to delineate the mathematical activities of preschool-aged children in two locations in Japan, across the most important contexts where they might be expected to engage in such activities: preschool, home, and through engagement with private non-preschool educational providers. In so doing, it addressed the following research questions:

- To what extent did children engage in mathematical activities in the various contexts examined?
- In what kinds of mathematical activities did children engage at preschools and at home?
- What regional commonalities or variations were evident in mathematical practices and activities?

Research subjects and method

Research was conducted in two locations in different prefectures in central Japan, as part of a larger study that also looked at formal mathematics teaching in the first two years of elementary school (to be reported elsewhere). The prefectures were selected on the basis of their contrasting performance over a decade in the mathematics section of the Japanese government's National Academic Attainment Survey (NAAS: *zenkoku gakuryoku chōsa*), introduced from 2007. The results of children in prefecture A have consistently been among the highest in Japan, whereas those of children in prefecture B have consistently been among the lowest.[2] This raised the question whether mathematics-related practices and activities among preschool-aged children might differ between the two prefectures.

The study adopted a case study approach using multiple sources of evidence (Yin 2014: 17), including observations of preschool activities, interviews with preschool staff and parents of first year elementary school children, and questionnaire surveys administered both to preschools and to parents. This approach was adopted in order to gather different kinds of complementary data by a variety of means, with a view to achieving more trustworthy findings through triangulation (Bryman 2016: 384-386), as well as gaining a picture of children's mathematical activities that combined breadth (from surveys) with depth (from observations and interviews).

Observations and interviews

In prefecture A, the author carried out field research from February to May 2018 in a small city of less than 50,000 population, called Wakahashi. After examining information about all preschools in the city through the city website, a total of five preschools were selected by purposive sampling, with a view to providing a reasonably representative sample of the diversity of provision in the city by including both kindergartens and day-care centres, and public preschools (run by the city) as well as private (run by non-profit organizations). One private kindergarten, as well as one public and three private day-care centres, were visited for between 1 and 3 hours during one morning each. During that time, the author observed the four-year-old and/or five-year-old classes, and took continuous handwritten field notes on organisation, resources, and activities of children and teachers, with particular attention to mathematics-related content observed.[3] These handwritten

notes were then used to type up expanded field notes on the same day. The author also obtained supplementary information about activities related to number and quantity, and the preschool's approach to such activities, from at least one member of staff at each preschool (either a teacher of the relevant age group, or a principal or vice-principal, or both) through a short semi-structured interview in Japanese. The author wrote detailed summaries in English (with transcription of key passages in Japanese) of interviews that were recorded with interviewees' consent. Non-recorded interviews were summarised immediately after the interview.

In prefecture B, the author carried out field research from May to August 2018 in a city of between 100,000 and 150,000 population, called Sakura, in the same way as in Wakahashi. One public kindergarten, two private day-care centres, and one private early childhood education and care centre (four preschools in total) were visited for observations and interviews.

Continuous observation over a morning allowed gathering of data on the preschool environment and a range of activities, which could include some that were regular or even daily (e.g. taking attendance, teacher-organised games, free play inside or outside), frequent (e.g. out-of-school walks), and/or seasonal (e.g. graduation ceremony preparation). Visiting each preschool once limited the range of activities observed at each; nonetheless, a wide range of activities were observed across the total of nine visits.

The author sought to bring to the observation the prepared gaze of a non-Japanese outsider, informed by extensive literature on Japanese preschools and by several years' experience working and conducting qualitative research in Japanese schools, but without having made previous observations in preschools. The author's fluency in spoken and written Japanese and his familiarity with Japanese educational settings seemed to help interviewees feel at ease, while his position as a white non-Japanese researcher may have encouraged them to be more explicative in their responses than they might have been to someone perceived as more familiar with Japanese preschools. It cannot be ruled out that interviewees might have felt the need to present themselves as conforming to the expectations of curriculum and conventional practice; however, their ready and elaborated articulation of their thinking and practice suggested that responses were grounded in reflection over time.

Analysis of observation and interview data was iterative. Initial analytic thoughts were noted immediately after writing up observation field notes or conducting interviews. Reading of field notes and interview summaries was then used to tentatively identify themes and patterns, including number and quantity embedded in play and daily activity, teachers' emphasis on stimulating children's interest in number and quantity in this way, and their disavowal of explicit teaching. Short analytic memos were used for further reflection, and development of themes. Next, field notes and interview summaries were coded; codes were developed during coding rather than pre-defined. Codes were then categorised to generate themes, and these results were compared with the earlier analytic memos and used to produce a final analysis. This approach exploited the systematicity of coding while minimizing the risks of fragmentation and decontextualization of data that coding approaches can invite (Bryman 2016: 583).

Surveys

In order to gain a broader picture of preschool practices and complement the qualitative data gained through observations and interviews, a questionnaire survey about mathematics-related practices was conducted by post in July-August 2018. Questionnaires were sent to all preschools in the two cities that had not already been visited, that accepted children over age 3, and that enrolled 20 or more children. To allow comparison with a metropolitan area, questionnaires were also sent to all preschools accepting children over age 3 and enrolling 20 or more children in one ward of a large city in central Japan, called Tokai, in a different prefecture to those in which Wakahashi and Sakura are located. Information about preschools was obtained from each city's website. Responses were anonymous and the response rate was 44 percent (32 out of 73).

To gain information about children's mathematics-related activities outside the education system, an anonymous questionnaire survey was conducted in July 2018 of all parents of first and second year children at three elementary schools in Wakahashi (155 children) and two in Sakura (276 children). One school in Wakahashi and one in Sakura were subjects of the author's fieldwork research; the other schools were selected after consultation with local educational practitioners on the basis that they were not unrepresentative in terms of their social makeup and school characteristics, and could provide good research access. The survey asked about activities before and after entering elementary school. Parents of elementary school children were surveyed because they could give answers about the entirety of their children's preschool years, unlike parents of children still at preschool. It was considered that the risk that parents would recollect inaccurately was small, given the relatively simple questions asked, and given that first year elementary children had completed preschool only 3 months before, and second years only 15 months before. Parental response rate regarding first year children was 70 percent (146 from 208); regarding second year children, 69 percent (153 from 223); total, 69 percent (299 from 431).

Questionnaire survey design was aided by semi-structured interviews conducted in March 2018 with parents of 7 first year children at the elementary school that was the main research focus in Wakahashi. Interviews were also requested with parents in Sakura, but none agreed to the request.

Surveys were analysed by totalling response data and calculating the percentage of respondents, as presented below.

Ethical considerations

Information about the purpose and procedures of the research was provided to all participants, as approved by the university ethics committee, and it was made clear to both adults and children that participation was voluntary and could be withdrawn at any time. Preschool observations took place with parental consent obtained through preschool principals. During observation, the author attended to signs of verbal or non-verbal reluctance to continue participating.

Practices and activities at preschools

Findings from the surveys are presented first, to provide a broad picture of practices and activities, followed by the more detailed picture obtained from observations and interviews.

Preschool questionnaire survey results

The questionnaire first asked about the preschool's approach to developing interest in and a sense of number, quantity, and shape in children in the five-year-olds' class. The phrasing of the answer options was primarily designed to ascertain how many preschools' approaches were confined to following the national curriculum guidance, by focusing on children's interests and experiences (second option) and how many went beyond this guidance by regularly using teaching materials to try to develop children's abilities more intentionally (third option). Preschools were asked to choose all applicable options (maximum three); results are in Table 1.

Table 1

We do not try to develop the children's interest in or sense of number, quantity, and shape.	0%
We try to develop the children's interest in and sense of number, quantity, and shape through experiences of number, quantity, and shape in play and daily life.	97%
We regularly use teaching materials for developing basic ability related to number, quantity, and shape.	12.5%

All responding preschools chose the second option, which was consonant with the government curriculum, except for one preschool which left all three options blank. Only a small minority (three preschools in Sakura and one in Tokai) indicated a more intentional teaching approach (option three).

Next, the questionnaire asked how often preschools provided certain experiences related to number, quantity, and shape in their five-year-olds' class. Preschools were again asked to choose all boxes that applied. Results are in Table 2 (figures do not always amount to 100% due to rounding).

Table 2

	Daily or almost daily	**Often** (on average about twice a month or more)	**Not often** (on average less than about twice a month)	**Never or almost never**	**No response**
1. We let children become aware of number of people when attendance is checked	72%	16%	6%	6%	0%
2. We let children play with building blocks, Lego, etc	88%	9%	0%	0%	3%
3. We let children become familiar with number when sheets	47%	47%	6%	0%	0%

of paper etc are counted in craft activities					
4. We let children become familiar with numbers in counting songs or songs where numbers are expressed physically	13%	31%	38%	13%	6%
5. We have children use workbooks that develop basic ability relating to number, quantity, and shape	6%	6%	3%	78%	6%
6. We have children calculate using the abacus	3%	0%	0%	91%	6%

The design of these survey questions was influenced by the surveys conducted by Sakakibara (2014a); items 1-4 were also influenced by what my preschool observation data indicated were particularly common maths-related activities. The number of questions was deliberately kept small, to avoid imposing a burden on busy preschool staff and reducing response rate. Though this imposed limitations on question topics, these were accepted, because the study did not aim to dissect all preschool maths-related activities in detail. The results were consistent with Sakakibara's findings, in that children were reported to become familiar with number, quantity, and shape mainly through activities embedded in daily life and play activities (items 1 to 4), rather than through intentional teaching activities (items 5 and 6), which were much less common. These results were consistent across all three locations where the survey was conducted.[4] This suggests that such an approach is likely to be widespread throughout Japan.

Data from preschool observations

No explicit teaching of number, quantity or shape was observed at any of the preschools visited. However, environments, resources, and/or activities that allowed children to experience number, quantity or shape were observed at all preschools, regardless of location.

The environments at seven preschools presented children with symbolisation of numbers (usually as numerals). Wall displays showing the birthday (month and date) of each child in a class were observed at four preschools (two in Wakahashi and two in Sakura). This encouraged familiarity with numerals up to 31, especially since the names of months in Japanese all include a number (from

'one-month' [*ichigatsu* = January] to 'twelve-month' [*jūnigatsu* = December]). At five preschools (two in Wakahashi and three in Sakura) teachers used clock face numerals to tell children when activities would start or end. At one kindergarten in Sakura, activity tools such as trowels and graters were numbered from 1 to 10, and were tidied away according to numeral by the children into spaces also labelled with numerals from 1 to 10. Symbolisation of numbers also featured in some activities observed. In one Wakahashi kindergarten class of five-year-olds, children drew lines in numerical order between dots numbered 1 to 10, to make a picture; all seemed to do this without difficulty, thus showing understanding of the order of numerals. In a Wakahashi day-care class of five-year-olds, a number of children were observed playing *sugoroku*, a board game similar to ludo, requiring players to advance their counters the number of squares thrown on a dice.

Other activities allowed children to experience number in the sense of quantitative qualities of phenomena, often together with linguistic terms for number. At one day-care centre in Sakura, a teacher counted aloud the number of paper rounds she gave each child for an activity. At one day-care centre in Wakahashi, the teachers of the five-year-olds' class organised a game whereby children jogged around to music and then had to make circles containing a given number of people when the music stopped; four the first time, and subsequently three, five, and seven. The vast majority of children seemed to have little trouble doing this, suggesting their conceptual grasp of these numbers.

In some activities, teacher-initiated activities involved not only number in the above sense, but also comparisons of quantities (in the sense of larger or smaller numbers of items in a set). On one out-of-school walk from a Wakahashi day-care centre, children had to collect up to five pebbles. One child then asked a teacher whether three pebbles was okay, and the teacher implicitly introduced the concept of larger and smaller numbers for different quantities by replying that fewer than five was okay. A game of dodgeball at another day-care centre in Wakahashi allowed a teacher to compare the number of children in each team at the start of the game; when some children were 'out' of the game, the teacher commented that the number in the team had become fewer. Later, the teacher of the four-year-olds' class had children make paper chains of ten links each for the approaching graduation ceremony, skilfully encouraging children who made chains with fewer or more links than ten to compare the quantities.

In both the dodgeball game and the paper chains activity, teachers had children count items (team members or chain links) to establish the number word for the amount in the set (team or chain) by one-to-one matching of items and number words in the correct order. In other observations, counting had a more ambiguous character, appearing to operate at least in part as recitation of the number sequence for a cultural or social purpose. For example, at one Sakura day-care centre, a teacher turned a skipping rope for children while chanting a skipping song whose translated meaning went, 'Mr Postman, good morning, ten postcards have fallen to the ground. Let me pick them up for you, one, two, three, four, five, six, seven, eight, nine, ten, thanks very much.' I also observed children making unprompted use of counting to organize turn-taking on the two swings in the preschool playground; they counted to 30 or 40, and then said 'Change'.

Sandpits and taps gave children at all preschools opportunities to experience and compare quantities of substances, such as sand or water. However, teachers were not observed encouraging such comparison.

Children also had many opportunities to experience and make use of a wide variety of shapes. At five preschools where free play time was observed, some children were playing with building blocks, usually of a range of shapes, including cuboids, cylinders, triangular prisms, and arches. Children were also observed making use of jigsaw puzzles, construction toys, and cuboid or cylindrical plastic containers for sandpit play.

Data from preschool staff

When asked what role they thought a preschool might have in supporting the development of children's abilities in relation to number and quantity, staff responses were consistent, regardless of location or type of preschool.[5] They did not favour formal teaching of children, but stated that children should notice number and quantity, and become interested in them, through play. They stated that teachers could help this process by strategic use of the language of number and quantity: for example, by telling children to take three sheets of craft paper, or to make groups of three, or by asking children how many of the cherry tomatoes they were growing at preschool had turned red. The words of one day-care centre principal in Wakahashi were representative: 'We aren't teaching the children in a forced way, but I think they are learning numbers naturally as they play'.

Summary of preschool findings

Data from surveys, observations, and interviews were highly consistent across locations and preschool types. They showed that preschools were fulfilling the intended curriculum, by seeking to stimulate children's interest in and sense of number, quantity, and shape through experiences embedded in play and daily life. No evidence of formal teaching was found from observations and interviews, and very little from surveys.

Mathematics-related activities at home

The questionnaire survey of parents first asked about children's experiences of number, quantity, or shape at home, before the children entered elementary school. Decisions about which experiences to ask about were based on the findings of Fujibuchi (2012), data from interviews with parents in Wakahashi, and consultation with the author's Japanese friends. Parents were asked to tick the boxes applicable in the case of their child. The results of the questionnaire are reported in Table 3.

Table 3

	Frequency of activities **before your child entered elementary school** (include activities that did not continue very long)			
	Frequently (About once a week or more, on average)	**Sometimes** (About once a month or more, on average)	**Not very often** (Less than once a month, on average)	**Never or hardly ever**
Played with building blocks, Lego, and such like	68%	23%	8%	1%
Counted in the bath together with a family member	74%	21%	3%	2%
Participated in dividing up food, sweets, etc between two or more people	49%	27%	18%	6%
Counted objects in daily life	54%	30%	12%	4%
Counted items in picture book illustrations	34%	34%	24%	8%
Had contact with numbers in children's TV programmes	59%	25%	10%	6%

Despite some small variations, the pattern of activity frequency was broadly consistent across locations and year groups, and indicated that most children often engaged in a range of mathematics-related activities at home before they entered school.[6] The commonest activities were counting in the bath and playing with building blocks or Lego, but several other types of activities were engaged in weekly by about half or more of children.[7] These results thus suggested that many children often have informal experiences of quantity and shape at home before they enter school, corroborating the findings of Fujibuchi (2012) in a different part of Japan.

Mathematics-related activities from non-preschool educational providers

The questionnaire survey also asked parents about their child's experience of mathematics-related cognitive development materials from non-preschool educational providers. The survey explicitly asked about experience of two well-known providers, Kumon and Gakken, with an additional

response box for 'Other'. In this last box, a significant number of respondents mentioned experience of materials from the Benesse organisation, and a few mentioned experience of abacus classes, so these have been noted separately in the results table below (the 'Other' category may include other, undisclosed users of Benesse materials, given the frequency with which they were mentioned without solicitation). Table 4 shows the numbers and percentages of first year elementary school children who were reported as engaging in such activities in the year before entering school (aged 5).

Table 4

	Number of children (from 146 respondents in total)	Percentage of children
Kumon	8	5%
Using Gakken Learning Materials	11	8%
Using Benesse Learning Materials	10	7%
Learning Abacus	2	1%
Using Other Learning Materials about Number, Quantity, or Shape (could include Benesse or abacus)	23	16%
Total (after subtracting 3 because 3 children were recorded as doing more than one activity)	51	35%

The percentage of children experiencing such activities was much higher than found in previous surveys such as those by Fujibuchi (2012), or Gakken (Gakken Sōgō Kyōiku Kenkyūjo 2017). This was true for both locations, even though the total percentage of children was higher in Sakura (40%) than in Wakahashi (28%). This suggests that previous surveys have failed to capture the extent of children's engagement in such activities, and that further investigation is needed, especially since these levels of engagement might have an influence on the development of children's mathematical understanding.

The scope of this study precluded detailed investigation of the materials children might encounter through such activities, but an indication was gained from analysis of the content of Gakken's commercially available workbooks on numbers. The colourful workbook for five-year-olds, for example, was 80 pages long, and included many simple exercises that involved counting pictures of up to 30 familiar objects, writing numerals up to 30, using ordinal numbers up to 10, and decomposing numbers up to 10 (Gakken Plus 2017). These exercises were much more systematic in directing mathematical learning than the activities observed at preschools; they were quite similar to those found in first year elementary school mathematics textbooks.

Discussion and conclusion

How is the mathematical understanding of young Japanese children developed before the start of formal schooling? This study helps to lay the foundations for an answer to this question, by illuminating the most important institutions and activities that are likely to play a part in the process. This is an essential basis for more narrowly focused future studies.

The first institution involved is preschool, which is key because it is attended by virtually all young Japanese children. This study indicates that the intended mathematics-related curriculum is being carried out in the preschools studied, and that children are gaining substantial exposure to experiences of number, quantity and shape as a result. Consistency with earlier findings in other parts of Japan increases confidence that the results of this study have nationwide applicability.

The second institution examined is the family home. Here too, the study indicates that a large majority of young Japanese children have very or fairly frequent experiences of number, quantity, and shape, although a small but significant minority have less frequent experiences. Again, the results are consistent with earlier studies elsewhere in Japan.

Thirdly, the study examines engagement with mathematics-related activities from non-preschool educational providers. Here the results indicate much higher levels of engagement than shown by previous studies. This raises questions about how far such activities may affect the development of children's mathematical understanding, and shows the need for further research.

Although the prefectures in which the two research sites were located show contrasting mathematics performances in Japan's National Academic Attainment Survey (NAAS), practices and activities at preschool and in the home were similar in both locations. This suggests that the causes of differing NAAS performance may not lie in these practices and activities. Engagement with mathematics-related activities from non-preschool educational providers was significantly higher in Sakura, which is located in the lower-performing prefecture, than in Wakahashi, located in the higher-performing prefecture, suggesting no simple relationship between engagement in such activities and performance in the NAAS.

The study's results show the variety and complexity of young Japanese children's mathematics-related experiences, and make clear how challenging it is likely to be to tease out the relative effects of different institutions and activities. They also suggest fruitful directions for future research.

First, given almost universal preschool attendance in Japan and findings on the effects of preschool elsewhere, this study's data suggests that mathematics-related experiences at preschool may well help young Japanese children gain a good experiential understanding of aspects of number, quantity and shape, and this foundation may contribute towards Japanese children's high mathematical attainment in later years. More research on children's mathematical skills and understanding during preschool could illuminate this contribution further.

On the other hand, the fact that a minority of children seem to have less frequent experiences of number, quantity, and shape at home may point to a possible cause of later inequalities in mathematical attainment. These inequalities may also be explained in part by differing levels of engagement with non-preschool educational providers. However, caution must be exercised about the latter hypothesis, especially given that this study finds no relationship between such engagement and NAAS results. Future research should attend to the detail of children's experiences.

Finally, this study's data shows that young children in Japan are exposed to mathematics-related experiences in a considerable variety of ways. This variety may in itself benefit children in the development of their mathematical understanding (Skwarchuk, Sowinski, and LeFevre 2014: 80). Research is needed to explore and elucidate these processes. This study highlights how not only in Japan but elsewhere, a comprehensive picture of the complexity of young children's mathematical experiences is essential, if we are to grasp how their mathematical understanding develops.

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[1] It can be calculated from government data (Monbukagakushō 2016, 2017 and Kōseirōdōshō 2017) that roughly 97% of children attending the first year of elementary school in 2017 were attending a preschool in 2016.

[2] To preserve participants' anonymity, pseudonyms have been used for all locations and preschools, and some details that might inadvertently allow identification of the locations, such as population size, have been provided in broad terms. The NAAS is taken by children in their final (sixth) year of elementary, and final (third) year of junior high school. Note that the average marks of children in the highest and lowest performing prefectures are normally within 10 percentage points of each other.

[3] At most preschools, both four-year-olds and five-year-olds were observed (with more focus on five-year-olds, the oldest children), but at one day-care centre in Wakahashi, mainly the four-year-olds were observed, while at two day-care centres in Sakura, only the five-year-olds were observed. This was due to the schedules of the preschools on the days visited. Classes may contain children who were the stipulated age at the start of the preschool year but then had their next birthday.

[4] There was one exception: in Wakahashi preschools, item 4 (numbers in singing) was uncommon. Results for Sakura, Wakahashi, and Tokai are available at DOI: 10.5281/zenodo.4384727.

[5] 'Quantity' and 'number' were not defined in the interviews by either interviewer or interviewees.

[6] 66% of children engaged at least weekly in three or more activities, and 48% in four or more activities. Results of the parent surveys by location and year group are available at DOI: 10.5281/zenodo.4384727.

[7] In Japan, people enter the bathtub after washing and rinsing themselves. Young children bathe with a parent, who tells them to enter the bathtub and count to a certain number before getting out.