Title	Singapore pupils' knowledge of numbers at the beginning of first school year
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SINGAPORE PUPILS' KNOWLEDGE OF NUMBERS AT THE BEGINNING OF FIRST SCHOOL YEAR

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Abstract: As part of the International Project on Mathematical Attainment (IPMA)[1] the complete cohorts of Primary One pupils from three schools in Singapore were tested on their knowledge of numbers at the beginning of the school year. A test comprising of 7 items was used to measure pupils' knowledge on counting numbers to twenty, basic addition and subtraction facts and ordinal numbers. Background information on pupils' pre-school learning was also sought from the schools. In this paper, pupils' performance will be reported and relation to their pre-school learning investigated.

Introduction

Singapore joined the International Project on Mathematical Attainment (IPMA) in January 1999. This project is a longitudinal and international one (Burghes, 1998a). At present Brazil, Czech Republic, England, Finland, Greece, Holland, Hungary, Ireland, Japan, Norway, Poland, Russia, Singapore and United States of America are participating in the project. The aim of this project is to monitor the mathematical progress of children from their first year of compulsory schooling throughout primary school. It hopes to study the various factors that affect that progress, with the ultimate aim of making recommendations at an international level for good practice in the teaching and learning of mathematics.

The Study

Sample

A total of 1016 pupils studying in three primary schools in Singapore are participating in the IPMA. The subjects are entire cohorts of Primary One pupils studying in these schools in 1999. Table 1 shows the distribution of the subjects by school and gender and Table 2 shows the distribution of the subjects by the types of pre-school institutions. These data were collected from school records.

Table 1

School	n(girls)	n(boys)	n(total)
1	191	-	191
2	180	212	392
3	194	239	433
Total	565	451	1016

[1] This project is funded by the Academic Research Fund, National Institute of Education, Nanyang Technological University, Singapore RP 21/98 BK and the University of Exeter, UK.

Table 2: Distribution of the subjects by school and type of pre-school attended

School	PAP	Private	Childcare Institution	Madrasah	Others
1	82	106	0	2	1
2	304	76	5	1	6
3	190	205	38	0	0
Total	576	387	43	3	7

Method

Instrument

At the beginning of the school year, these pupils were tested on their knowledge of numbers. The test administered to the pupils comprised of seven items. It was constructed by the IPMA team (Burghes, 1998b) in UK. The following is a description of the tasks.

Item 1: to complete the picture so that it has 7 dots.

Item 2: to identify the number marked on the number line.

Item 3: to complete addition and subtraction number sentences: finding the sums, differences, second addend, first addend which is zero, and subtrahend.

Item 4: to order a given set of numbers less than 20 from small to big, and to identify the odd numbers among them

Item 5: to locate positions from left and right; to recognise a triangle.

Item 6: to add with sums less than twenty; to subtract with minuends less than twenty; to locate the answers on the given number line.

Item 7: to find the next term in a given simple number pattern (arithmetic progressions).

Data collection & analysis

In a school all the primary one pupils were given the test scripts at the same time. Their teachers read through the test prepared on overhead transparencies, question by question, allowing sufficient time for pupils to answer the question before proceeding to read the next item. Teachers were allowed to paraphrase the items so that pupils' performance was not affected by language competency. The whole exercise took about 30 – 40 minutes.

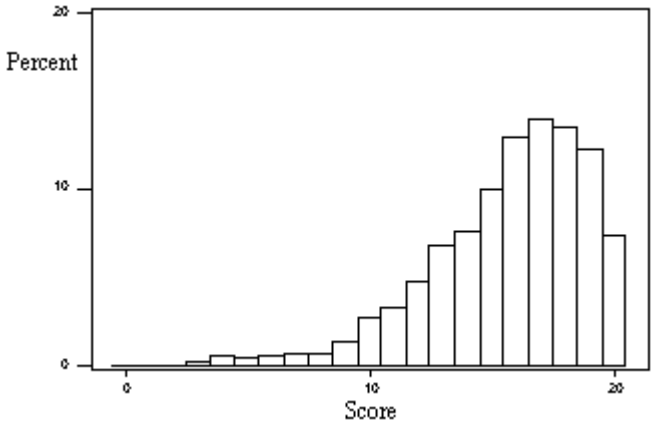
The test scripts were scored by the researchers. The answers were marked either right or wrong. A score of one was given to a correct response and zero for an incorrect response. The maximum test score was twenty. The Minitab statistical software was used to analyse the data. The mean and standard deviation of the test score, histogram and item difficulty indices were obtained. The relation of test scores to types of pre-school attended was also examined.

Results & Discussion

Overall performance

As shown in Figure 1, the distribution of the test scores is skewed to the left thereby showing that the majority of the pupils could do most of the items in the test easily. The mean score of the test is 15.64 with a standard deviation of 3.34. The modal score is 17 and the median score is 16.

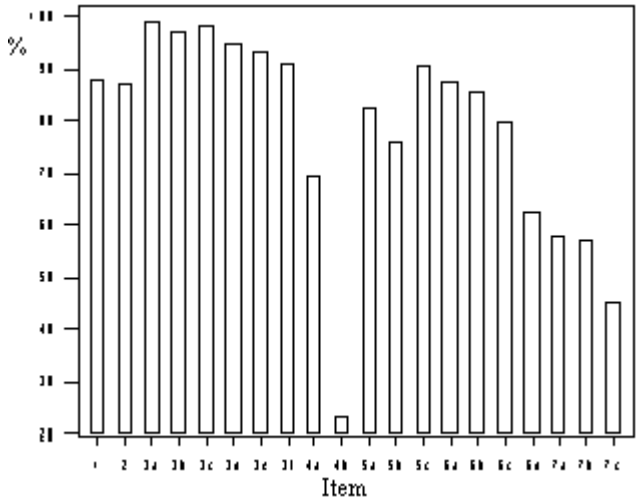
Figure 1: Histogram of Scores



Item analysis

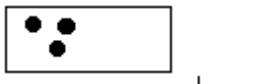
Figure 2 shows the difficulty index of each item (% correct based on the entire sample) in the test. Pupil performance on each item is discussed.

Figure 2: Difficulty Indices

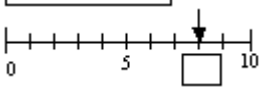


Counting

1. *Complete the picture so that it has 7 dots.*



2. *What is the number shown?*



Pupils found the above items relatively easy. They were able to represent a given number using dots. Although number lines are seldom used in primary mathematics classroom, 87% of the pupils were also able to identify the number on the given number line.

Addition and subtraction (less than 10)

There are six incomplete number sentences in item 3. The number sentences and their respective difficulty indices are stated below.

2 + 3 = _____ (99.0%)	*8 - _____ = 3 (93.5%)*
3 + 4 = _____ (98.3%)	*4 + _____ = 9 (94.5%)*
4 - 1 = _____ (97.0%)	*_____ + 7 = 7 (91.0%)*

Generally, most Primary 1 pupils were able to complete correctly the given addition and subtraction number sentences. They found it more difficult to find the missing number to the left of the equal sign, especially when the missing number is zero.

Compare and order numbers less than 20

4. 12, 7, 15, 4, 1, 10, 18

(a) Write these numbers in order of increasing size

(b) Circle all the odd numbers.

The difficulty indices of 4(a) and 4(b) are 69.5% and 22.9% respectively. Pupils seemed to have difficulty ordering 7 numbers simultaneously. For example, some pupils could order the first five numbers correctly (1, 4, 7, 10, 12, 18, 15) while others could only manage to order the first three numbers correctly (1, 4, 7)

As expected, less than a quarter of the pupils were able to circle the odd numbers. It must be noted that the concepts of odd and even numbers are not taught in the Primary One, let alone in the beginning of the year.

Ordinal numbers and identification of shapes

5. 

(a) Write the letter A on the third shape from the left.

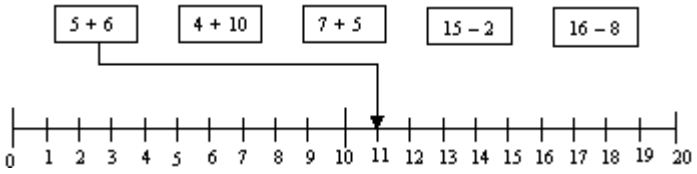
(b) Write the letter B on the fourth shape from the right.

(c) Write the letter T on any triangle.

82.5% of the pupils were able to locate positions from the left while 76% of them were able to locate positions from the right. 90.4% of them were also able to recognise triangle from given shapes such as squares, circles and pentagons.

Addition and subtraction (Less than 20)

6. Show with an arrow the answer to each sum. The first one has been done.



As expected, pupils found the four tasks increasingly more difficult. 87.6% of the pupils were able to add ones to ten. 85.4% were able to add 2 single digits with sum more than 10. Pupils found it relatively more difficult to carry out subtraction. 79.6% of the pupils were able to subtract without renaming while only 62.4% of them were able to subtract with renaming.

It must be pointed out that column addition and column subtraction are not taught in Primary One. The pupils are expected to use number bonds to carry out these types of computation in class.

Skip counting

7. *What is the next number?*
   (a) 3, 6, 9, 12, _____
   (b) 20, 18, 16, 14, _____
   (c) 2, 6, 10, 14, _____

Only about half of the pupils were able to answer these questions correctly. The difficulty indices are 57.6%, 57.3% and 45.3% respectively. It seems that pupils found it easier to count on by twos and count back by threes than count on by fours.

Relation of test scores to pre-school type

The pupils were predominantly from PAP and private kindergartens. Table 3 is a cross-tabulation of the mean and standard deviation of the test scores for the 3 schools and the 2 dominant pre-school types.

Table 3: Mean and stand deviation of test scores by school and pre-school type

Pre-school type		School 1	School 2	School 3
PAP	mean	16.33	14.08	16.18
	std. dev.	(2.68)	(3.87)	(2.95)
	# pupils	82	304	190
Private	mean	16.62	15.04	16.77
	std. dev.	(2.42)	(2.95)	(2.62)
	# pupils	106	76	205
All 5 types included	mean	16.53	14.20	16.54
	std. dev.	(2.53)	(3.74)	(2.77)
	# pupils	191	392	433

Slightly more than half the Primary One pupils in Schools 1 and 3 are from private kindergartens. The majority of pupils in School 2 (78%) are from PAP kindergartens and their test scores have the largest standard deviation of 3.87.

We note that, overall, the mean test scores of School 1 and 3 are both about 16.5 marks, 2.3 marks higher than that of School 2. Since the study was done at the beginning of Primary One, differences among schools can only be interpreted as the differences arising from the type of pupils that the schools tend to draw – their socio-economic status, family support, etc.

The mean test scores of pupils from private kindergartens are 0.3, 1.0 and 0.6 marks higher than the mean test scores of pupils from PAP kindergartens for Schools 1, 2 and 3 respectively. Thus, there are greater differences among schools than between the pre-school types within the schools. Since

the differences between pre-school type vary with schools, it suggests that any effect from pre-school type may be confounded with other unknown factors.

It should be emphasised that since the pupils from these 3 schools do not constitute a random sample from the 1999 Primary One cohort of Singapore, the conclusions drawn above, based solely on the test results from the 3 schools, may not be generalised to the entire Primary One cohort.

Conclusions

In Singapore, children generally enter Primary One with considerable knowledge in arithmetic. The two or three years of pre-school education seems to give children a head-start in mathematics in school. The mathematical knowledge of a typical child at the beginning of Primary One as revealed by the study may be described as follows:

He is able to count to 20. His knowledge of ordinal numbers does not lag far behind counting but he does find it relatively more difficult to name the relative position from the right than from the left. He is able to distinguish triangle from other basic shapes such as circles, squares and pentagons. He is able to compare and order numbers but is confused when there are too many numbers to compare and order simultaneously. He is unlikely to know what is an odd or even number. Even though he has not memorised the arithmetic facts, he is able to use counting-based strategy (e.g., using fingers) to find the correct sums and differences. However, he tends to view ' = ' as an activity rather than equivalence. Hence, he finds it easier to complete number sentences such as

2 + 3 = ____ , 6 - 4 = _____ than 2 + ____ = 5, ___ + 3 = 5 ; ____ - 4 = 2 and 7 - _____ = 5.

For addition and subtraction less than 20, he has no difficulty finding the sums and differences if no renaming is required. His performance deteriorates when renaming is required, especially in subtraction. Lastly, his ability in skip counting is not as well developed as his ability in addition and subtraction.

The study also shows that an atypical child in Primary One can be one who has mastered all the above skills or one who has relatively little arithmetic knowledge. Teachers teaching Primary One must be aware of the diversity in children's pre-school mathematics knowledge that they bring to the classroom and build on their experience. Differential teaching may be necessary.

It should be mentioned that this study does not provide sufficient evidence to conclude that the pre-school type has an effect on pupil performance in mathematics at the beginning of Primary One. As there were greater differences among schools than between pre-school type within the school, the differences in performance may be attributed to other confounding factors such as locality of school, social economic status of pupils, family support, etc.

References

Burghes, D. (1998a) *Co-ordinators Manual – International Project on Mathematical Attainment*. United Kingdom: University of Exeter (Centre for Innovation in Mathematics Teaching).

Burghes, D. (1998b) *International Project on Mathematical Attainment – Test One*. United Kingdom: University of Exeter (Centre for Innovation in Mathematics Teaching).