What do young children know about number and what should they know?

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Settings for early years education in England

Before starting to describe the results of the research, it is appropriate to describe the educational provision for children in the early years in England. Children are required to be in full-time education when they are 5 years old, starting in or before the next school term after their 5th birthday. This means that all pupils have arrived in school by the September term start for the Year 1 class, which will take all pupils who reach their 5th birthday during the previous academic year up to September 1st. However very few parents leave it as late as age 5, if only because they are scared that by then there will be no places left in the primary school that they wish their child to attend. The Government has achieved its aim of having places available among a variety of providers for all parents who wish their 4-year-olds to attend some form of education, and are close to achieving the same goal for all 3-year-olds.

The most common pattern in London, and in many other areas, is for children to attend a Nursery class attached to a primary school (often for half-days only) starting in the term after they become 3 years old. They then go on to a full-time place the following September in the Reception class when they will be between 4 and 5 years old (all primary schools must have a full-time Reception class to receive at least those children who have their fifth birthdays earlier in the year). This gives the pattern:

Ages 3/4 years: *Nursery class*

Ages 4/5 years: *Reception class*

Ages 5/6 years: *Year 1 class.*

Not all schools organise the classes by age; sometimes there are children aged 3-5 in a single class.

However there are many other settings for education before the age of 5, including one or more of the following:

- attendance part-time or full-time at a nursery school, public or private;
- part-time attendance at a playgroup organised either by a group of parents, publicly funded education workers or a private organisation;
- being looked after outside the home by a registered childminder or family member;
- being looked after at home by a parent, paid carer (nanny) or family member.

Provision of education outside the family is subject to national regulations and inspection for the Foundation Stage, which covers children aged 3-5 years. The education in Year 1 classes for 5-6 year-old children in primary schools has to meet the requirements of the Key Stage 1 statutory guidance, which specifies the national curriculum in 10 subjects for children in Years 1 and 2.

At the end of the Foundation Stage (the end of Reception class, age 5) teachers have to have completed a Foundation Stage Profile for each child to pass onto the Year 1 teacher to indicate what he or she has achieved by the end of this stage. National tests in English and Mathematics, set centrally but administered and marked by teachers, take place at the end of Key Stage 1 (end of Year 2, age 7). As from 2006 assessment at the end of Key Stage 1 will be by teacher assessment, but it is expected that many teachers will, as in the pilot, use the national tests to make sure that they are using the correct standards. Results for the school and for individual children have to be communicated to parents, and school results go to the Local Education Authority, and when an inspection is due, to the group of school inspectors appointed by the national inspection agency.

Curriculum: The Foundation Stage

Curriculum regulations for children aged 3 to 5 are listed in a document called *Curriculum Guidance for the Foundation Stage* (DfES, 2000). (This can be downloaded from websites of the government Department for Education and Skills, `www.dfes.gov.uk` , and of the Qualifications and Curriculum Authority, `www.qca.org.uk` ; the website of the inspection agency, Ofsted, is `www.ofsted.gov.uk`.)

These specify six *areas of learning:*

- Personal, social and emotional development
- Communication, language and literacy
- Mathematical development
- Knowledge and understanding of the world
- Physical development
- Creative development.

Of course these areas of learning are not intended to be addressed in separate activities, but it is expected that these will underpin all the provision and planning for children in the Foundation Stage.

Within each of the areas of learning are one or more strands of attainment (13 in all) which make up the Foundation Stage Profile. There are three strands within mathematical development:

- Numbers as labels and for counting
- Calculating
- Shape, space and measures.

Within each of these three strands of development there are five *early learning goals*, which are expectations for the end of the Reception year, aged 5+.

Thus there are 15 early learning goals for mathematics, which include:

- Count reliably up to 10 everyday objects
- Recognise numerals 1 to 9
- Order numbers up to 10
- Find one more or one less than a number from 1 to 10
- Use developing mathematical ideas and methods to solve practical problems.

For each child, achievement of the early learning goals is assessed as the major part of the Foundation Stage Profile. The assessment is intended to be made informally by practitioners (teachers or others) using observation and discussion during normal classroom activities.

To assist practitioners to plan for and assess the progress of younger children, there are *stepping stones* described within each strand of attainment which lead up to the early learning goals (sometimes towards more than one of them).

For example leading up to the early learning goal

- Count reliably up to 10 everyday objects (age 5+)

there are some stepping stones:

- Use some number names and number language spontaneously (age 3)
- Willingly attempt to count, with some numbers in the correct order (age 4)
- Count out up to 6 objects from a larger group (age 5)

Of course some children will not achieve the early learning goals by the end of the Reception class, but the stepping stones can then be used to report their progress. Alternatively it is recognised that some children will achieve the early learning goals before the end of the Reception class, at which point they can be moved onto the mathematics objectives for Year 1.

Curriculum: Key Stage 1

Once children are in Year 1 they come under the requirements of Key Stage 1 which covers Years 1 and 2 (ages 5 to 7), the first two years of compulsory education. This is governed by the statutory national curriculum and the national assessment in English and mathematics which takes place at the end of Year 2.

However the detailed curriculum for 5 to 6 year-olds in Year 1 is mainly determined by a non-statutory Framework for Mathematics which was introduced during 1999/2000 as part of a National Numeracy Strategy (DfES, 1999). (This document also refers to Reception classes but although many Reception teachers still find it useful to refer to, the advice has been superseded by that in the Curriculum Guidance for the Foundation Stage (DfES, 2000)).

The Framework includes 32 mathematics objectives for Year 1, many of them split into several parts, arranged under similar headings to those in the Foundation Stage:

- Numbers and the number system (9 objectives)
- Calculations (9 objectives)
- Solving problems (7 objectives)
- Measures, shape and space (7 objectives).

Of these 32 objectives, 12 are *key objectives* which are expected to be assessed. Some examples of these key objectives for the end of Year 1 (age 6+) which are linked to the stepping stones (ages 3-5) and early learning goals (age 5+) quoted earlier are:

- Count reliably at least 20 objects.
- Read and write numerals from 0 to at least 20.
- Order numbers to at least 20 and position them on a number track (number line)
- Within the range 0 to 30, say the number which is 1 or 10 more or less than any given number.
- Use mental strategies to solve simple problems set in 'real-life', money or measurement contexts, using counting, addition, subtraction, doubling and halving, explaining methods and reasoning orally.

Again although these are expectations for the end of Year 1, it is recognised that some Year 1 children will be still trying to achieve the early learning goals for the previous year and others will be working on the key objectives for Year 2 or 3.

Teaching methods: The Foundation Stage

These are not laid down in detail but there are a number of principles suggested, some under the generic sections and some under the subject sections of the Curriculum Guidance document (DfES, 2000). They include:

- Some activities should be planned by adults and others initiated by children.
- Some activities should be explicitly mathematical in purpose, in others mathematics will used for some other purpose.
- Practitioners should observe and respond using knowledge of next steps.
- Reception teachers may do mathematical activities with small groups of children at different times of the day but should move towards a daily maths lesson (45 minutes with the whole class) by the end of the year to prepare children for experiences in Year 1.

Many examples to illustrate these principles are given in the Curriculum Guidance materials. One which relates to the early years goals quoted earlier is:

> *Kim and Edward were playing a game to see how far they could throw a beanbag. They made a number track, first to ten, then adding numbers to 17 when they realised they could throw the beanbag further than they had expected.*

This demonstrates the intention of linking play activities to the early learning goals within the areas of experience. Here mathematics is used in an activity which is about physical development but which is also a fun activity for children. This provides a natural forum to extend children's number knowledge for an authentic purpose. A similar example occurs in many nursery classes or nursery schools where there is an outdoor area with bikes, which are a popular play activity and enhance physical development. The bikes are often marked with numerals, so that when children come to put the bikes away in the assigned places (these can be labelled with sets of dots, numerals and/or names), then they can be practising matching spoken or written number words, symbols and cardinalities.

Another example of authentic use of both ordinal and cardinal number is where, as children arrive in the classroom, they pick out a card with their name and photograph and place it on a number line next to those cards for children who have already arrived. The child can then say, for example 'I am number 7 today' and the teacher can demonstrate that she can tell how many children are present by reading off the last card on the line.

A second example quoted below involves the use of a doll or puppet, which again is frequently used by teachers to enable children to feel confidence as they can show the puppet how to do something that they have mastered. Children seem to enjoy the humour when the puppet gets it wrong.

> *One of the children's favourite games was helping the teddy to learn to count. The practitioner used the teddy bear to count: "One, two, four, five". William and Leah shouted out: "He missed the three!" They began making up their own jumbled sequences of numbers, and correcting each other.*

The DfES also produce booklets of activities for Nursery and Reception classes. These are matched to the early learning goals but are divided into whole class activities, small group activities and individual activities. There is an accompanying video which is part of the training for early years practitioners. One activity on the video shows nursery children in a play activity about a garage; some children are acting as mechanics, supervisors or car owners. The teaching assistant is using this to help children with number ('have you checked all four wheels? — count them for me') and with correct spatial language, for example with a 'mechanic' lying *under* the car, others working at the *front* or *back* of it, children having to ask for equipment stored on the *highest*, *middle* or *lowest* shelf, and so on. In another activity at the start of the Reception Year (ages 4/5), about 20 children are sitting round in a circle (another group are working with the teaching assistant) and the teacher offers them in turn boxes of different sizes and weights and asks them to feel them and to guess how many objects are inside. Some large heavy boxes have only 5 objects and some small light boxes have 27 objects , etc. The aim of this, is partly to practise counting, but also to try to differentiate number from size and weight and to learn to use the relevant vocabulary for number, size and weight.

Teaching methods: Key Stage 1

When the children are in Year 1 teachers are expected to adopt the lesson format of the National Numeracy Strategy which means that there is a 5-10 minute session at the start of each daily 45-minute lesson to practise oral/mental skills. Then the teacher introduces the work to the whole class using interactive teaching methods, asking children to explain their strategies for solving problems rather than imposing a single method. Again the emphasis is on mental methods. It used to be the case that formal written methods of calculation were introduced much earlier than in many other countries but they are now delayed until children are older. However children in Year 1 would be expected to understand and use horizontal format for recording calculations (e.g. $7 - 3 = 4$).

For part of most lessons, children will then work individually or in groups on tasks related to the lesson objectives but differentiated according to their level of attainment. Finally there is a 10-15 minute plenary session with the whole class to tackle any problems, consolidate, and lead on to the next lesson. Children will get weekly homework.

Teachers are encouraged, again through training videos and guidance documents, to use a range of equipment with large versions for the whole class and smaller versions for individual children, with number lines, 100-squares, counting sticks with 10 divisions but no numbers marked, sets of digit cards, etc.

Empirical evidence relating to attainment of objectives

As part of a five year longitudinal study, the Leverhulme Numeracy Research Programme, we have followed about 1500 children through from Reception to Year 4, observing their lessons and assessing their progress through a sequence of tests. The pupils in the survey include all children in the age-cohort in 40 different primary schools, 10 in each of four varied local education authorities (LEAs) in different regions of England. By the fifth year of the study 36 of the original 40 schools were still participating; the ones dropping out were generally representative of the sample. Two LEAs were large counties, one in a very prosperous area in Southern England and one in a less prosperous old industrial area in Northern England. Both included rural, suburban and urban schools. The two remaining LEAs were in cities and included prosperous suburban schools alongside deprived inner city schools.

The ten schools in each LEA were selected by quota sampling to ensure a range of schools according to five variables (size, religious affiliation if any, socio-economic status of intake, attainment in national mathematics tests, and a judgement of mathematical effectiveness from a local advisor). Thus the sample contains every type of school from small rural church schools to large inner city multi-ethnic schools. The mean national test result of our schools at age 11 is within 1% of the national mean.

The numbers of pupils who completed each test at a specific time vary between 1500 and 1700. However due to absence and school mobility over five years clearly these are not always the same children (the complete database for each cohort contains over 2000 children). This sample is generally used to calculate the facility of items in each test administration.

We were unable realistically to assess the children in Reception as we had to rely on tests which could be administered by the teacher reading out questions to the whole class, or by a teaching assistant to a small group of children, with children writing their answers in specially designed booklets. However children were assessed in October towards the start of Year 1 at age 5, and in June towards the end of Year 1 at age 5/6, as well as in October of Year 2 (age 6), and so on.

A sequence of tests, one for each year group, was used which were derived from instruments developed from earlier research by members of the team (Hart (Ed.), 1981; Denvir & Brown, 1986; Askew *et al.*, 1997). The items had in almost all cases been designed for one-on-one diagnostic interviews and based on the primary number curriculum and reviews of related research. These items were later adapted for whole class settings, and were thus extensively trialled in both formats. A few new items were trialled and added to improve the match with the updated National Curriculum. However as will be seen below they do not always match the detail of the specific objectives, not least because the objectives were published after the tests had already been used. The reliability (using Cronbach's alpha) was found to be very high (of the order of 0.94). Denvir and Brown (1987) had earlier checked the reliability by comparing pupils' performance on interviews and class tests using many of the items.

Items were designed to assess conceptual understanding and cognitively based skills in numeracy. As with the National Numeracy Strategy, the emphasis was on mental rather than written processes, and contextual as well as purely numerical items were included. Most items required short open responses but a small number were in multiple choice format.

The tests were designed both to contain a large number of common items from one year to the next (including a few items which were assessed in each year from Year 1 to Year 6), and to have the same uniform distribution of item facilities within each test. The reason for this unusual design was that equal mean numerical gains were made by children at different attainment levels. Gains could therefore be compared fairly between schools with different types of intake.

The same test was used at the start and end of each year. It was orally administered by teachers from a provided script, with pupils answering in specially designed booklets. The number of items in the test varied from 41 in Year 1 to 75 in Year 4.

Tests were marked centrally by trained students onto OMR forms which were scanned into the computer. All items were marked simply as correct, wrong or omitted, using a marking schedule. Different types of checks were made on the reliability of this process.

Although the results are not completely reliable with young children, they do provide some evidence as to what percentage of children at the start of Year 1 have met the early learning objectives intended for the end of Reception, and what percentage of children at the end of Year 1 have met the Year 1 objectives.

For example three of the *early learning outcomes* quoted earlier were the ability to:

- Count reliably up to 10 everyday objects.
- Recognise numerals 1 to 9
- Order numbers up to 10.

Table 1 indicates the percentages of children who were successful in answering questions on counting, labelling numbers on a number line and writing numerals. It should be noted that the percentages successful probably overestimate the actual figures as low attaining children were probably less likely to be tested because of absence or unwillingness of a few teachers to include them.

The table offers only a summary of the content of the item — clearly the details of the way in which the item was presented will also influence the results. However there is not space here to discuss the exact methods of presentation and their effects. Although the questions are not closely related to the goals, the results suggest that the early learning goals are indeed satisfied by more than 75% of children by the start of Year 1. They also suggest that almost all children can write the numerals 1 to 9 as well as recognising them. Indeed many children have clearly progressed well beyond these goals.

Table 1. Percentages of children who are successful on questions involving counting, labelling points on the number line and writing numbers, at the beginning and end of Year 1 (n>1400)

Counting	Year1 October Age 5:1-6:1	Year1 June Age 5:9-6:9
How many bikes? (5)	95	99
Draw more flowers (3 more needed) to make 8	84	91
Draw 7 flowers	76	91
Labelling points on the number line		
Label 4 on 1-10 line	93	98
Label 8 on 1-10 line	90	98
Label 7 on 1-50 line	24	56
Label 38 on 1-50 line	10	34
Writing numbers from spoken numbers		
Write 9	89	98
Write 89	66	92
Write 76	66	90
Write 30	39	79
Write 200	34	67
Write 109	17	43

Another early learning goal was related to counting on or back:

- Find one more or one less than a number from 1 to 10.

The equivalent key objective for the end of Year 1 extended the range and also included adding or subtracting 10:

- Within the range 0 to 30, say the number which is 1 or 10 more or less than any given number.

Questions which broadly relate to these are shown in Tables 2 and 3.

Table 2. Percentages of children who are successful on counting on or back questions at the beginning and end of Year 1 (n>1400)

Counting on	Year 1 Oct Age 5:1-6:1	Year 1 Jun Age 5:9-6:9
2 more than 4	73	91
1 more than 9	73	89
3 more than 6	48	77
1 more than 89	22	62
7 more than 8	21	56
1 more than 109	46	17
Counting back		
1 less than 8	70	85
3 less than 8	48	71
6 less than 8	35	63
1 less than 76	32	66
1 less than 30	21	58
1 less than 200	2	11

Table 3. Percentages of children who are successful on addition and subtraction questions at the beginning and end of Year 1 (n>1400)

Addition	Year 1 Oct 5:1-6:1	Year 1 Jun 5:9-6:9
3 boys and 4 girls	61	83
Box of 5 cakes and 1 more?	39	62
Add 10 to 9	16	55
5 on bus and 8 more get on	17	50
Add 10 to 92	3	22
Add 100 to 9	4	17
Subtraction		
12 on bus, 5 get off	15	46
Take 10 from 50	8	34
Take 100 from 400	7	29
Take 10 from 700	0.3	5

Again the results in Table 2 suggest that about 70% of children have achieved the early leaning goal by the start of Year 1, and that many have achieved more. However in relation to the Year 1 key objective, Table 2 shows that only 58% can take one from 30 and Table 3 indicates that only 55% can add 10 to 9 (and even fewer add 10 to 50, although this is admittedly outside the required range).

Another early learning goal which relates to Table 3 concerns problem-solving:

- Use developing mathematical ideas and methods to solve practical problems.

The Year 1 key objective equivalent is more specific:

- Use mental strategies to solve simple problems set in 'real-life', money or measurement contexts, using counting, addition, subtraction, doubling and halving, explaining methods and reasoning orally.

It is clear from Table 3 that some word problems are only possible for about half the age group or even fewer at the end of Year 1 (subtracting numbers to 20 is included in the Year 1 objectives.)

The results therefore generally suggest that the early learning goals are generally about the correct difficulty, but that some of the Year 1 key objectives are found to be difficult for many children. On the other hand some children have progressed well beyond them, as is shown in Table 4 relating to multiplication and division items.

Table 4. Percentages of children who are successful on multiplication and division questions at the beginning and end of Year 1 (n>1400)

Multiplication and division	Year 1 Oct 5:1-6:1	Year 1 Jun 5:9-6:9
Ring half the marbles	35	64
10 cakes, ? boxes of 5	24	61
4 lots of 3	22	53
3 boxes of 10 apples	12	46
4 lots of 5	10	38
4 boxes of 10 and 3	6	28

The fact that a very small number of children at the beginning of Year 1, aged 5 (or possible just 6), could find the answer to the last question shown was interesting because many older children found this difficult. We were able to follow this cohort of children up to Year 4 (age 8/9), using some of the same questions in the tests at the start and end of each year. In the Leverhulme Numeracy Research Programme we were also following an older cohort in the same schools from Year 4 up to Year 6 (age 11) using some of the same questions. Table 5 shows the percentages of children successful in each year group for a small number of items which were included in the tests from Year 1 to Year 4 and in some cases also for the older cohort of children in Years 5 and 6. In this table the results for each Year are given both in October and June (e.g. 1(o), 1(j) indicates the Year 1 percentage for October and June respectively), and the italic data is from the older cohort and therefore not the same population of pupils (although they are broadly equivalent as from a different cohort in the same schools).

There is interesting data for the item notd earlier: 'There are 10 apples in a box. *[Teacher shows picture of a box of apples with 10 apples in it.]* How many apples are there here? *[Teacher shows picture of 4 boxes with 3 extra loose apples.]*' On this item about 6% of children aged 5 can outperform the lowest 8% of children at age 11. This and results for other items shown in Table 6 demonstrate that the curriculum for Year 1 and Reception considerably underestimates what some children can do. This is also shown, although in a slightly less dramatic way, by Aubrey (1993, 1994).

Table 5. Percentages of children who are successful on questions included in tests at the beginning and end of each year from Year 1 to Year 4 (n>1300) (2(o), 2(j) indicates the tests in October and June of Year 2 etc. The numbers in italic refer to the statistics for an older equivalent cohort of children progressing from Year 5 to Year 6 in the same schools.

Write 200

1(o)	1(j)	2(o)	2(j)	3(o)	3(j)	4(o)	4(j)	5(o)	5(j)	6(o)	6(j)
34	67	79	89	93	96	98	99	*97*	*99*	*100*	*98*

Write 109

1(o)	1(j)	2(o)	2(j)	3(o)	3(j)	4(o)	4(j)	5(o)	5(j)	6(o)	6(j)
17	43	56	85	88	95	96	98				

4 lots of 5

1(o)	1(j)	2(o)	2(j)	3(o)	3(j)	4(o)	4(j)	5(o)	5(j)	6(o)	6(j)
10	38	37	66	72	87	83	89				

4 boxes of 10 apples and 3 apples

1(o)	1(j)	2(o)	2(j)	3(o)	3(j)	4(o)	4(j)	5(o)	5(j)	6(o)	6(j)
6	28	35	59	62	75	77	84	*77*	*80*	*81*	*92*

1 less than 200

1(o)	1(j)	2(o)	2(j)	3(o)	3(j)	4(o)	4(j)	5(o)	5(j)	6(o)	6(j)
2	11	19	53	60	78	82	91	*87*	*94*	*95*	*97*

Take 10 from 700

1(o)	1(j)	2(o)	2(j)	3(o)	3(j)	4(o)	4(j)	5(o)	5(j)	6(o)	6(j)
0.3	5	7	29	32	52	56	71				

Data for the two items '4 boxes of 10 apples and 3 apples' and 'Write 1 less than 200' for both cohorts are also shown in Figure 1 to demonstrate the learning curves for the two items.

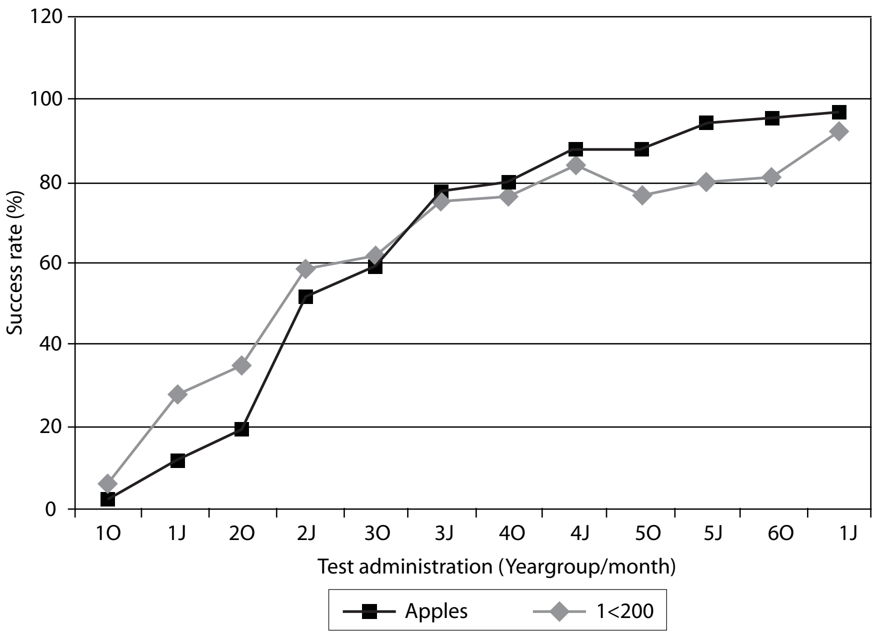

Figure 1. Percentages of children who are successful on two questions included in tests at the beginning and end of each year from Year 1 to Year 6 (n>1300). (2O, 2J indicates the tests in October and June of Year 2 etc.) The data for Years 5 and 6 are obtained from an older equivalent cohort of children progressing from Year 5 to Year 6 in the same schools, while the Year 4 data represent the mean percentages across both cohorts in Year 4.

The graph in Figure 1 again draws attention to the data in Table 6 that shows that small numbers (2% and 6% respectively) of children at the start of Year 1 (age 5) are in these items ahead of 40% of children at the start of Year 3 (age 7), 20% of children at the start of Year 4 (age 8), 10+% of children at the start of Year 5 (age 9) and about 5% of children at the end of Year 6 (age 11).

It is also interesting to note from Figure 1 that for younger pupils the question about the apples is easier than writing down the number 1 less than 200, whereas the opposite is true for older children. This is perhaps because they do not formally encountered written numbers in the hundreds until Year 2 whereas they build up some idea of the structure of 'tens and units' in numbers up to 100 a little earlier. However once they have learned about hundreds numbers they find that item fundamentally easier. Certainly the steep rise in Year 2 does reflect that both items are central to the Year 2 curriculum.

A further point to note from Table 5 and Figure 1 is the slower rate of growth (in the case of one item, '4 lots of 5' the gradient even turns negative) between June and October than between October and June. This becomes less pronounced if consideration is made of the unequal time intervals (about 7.5 months between testing dates in October and June, and only 4.5 months between June and October), but does not disappear. It is presumably due to the long summer holiday between July and September, which seems to affect most the items which will depend more on recall than understanding.

Empirical evidence relating to individual children's attainment

The trends noted above in relation to individual items in the tests were also visible when we examined the overall attainment and progress of individual children.

Here so as to make the results over different years groups comparable although some of the items in the tests changed from year to year, we used the common items across consecutive tests to define a single scale which we called 'mathematical age' . This process makes some assumptions and therefore introduces some sources of unreliability.

Figure 2 shows the distributions of mathematical age for the two cohorts separately, as the younger cohort progressed from the start of Year 1 to the end of Year 4, while the older cohort progressed from the start of Year 4 to the end of Year 6.

It can be seen that the mathematical ages of children at the start of Year 1 (age 5) range over the equivalent of more than 5 years of development, from almost 8 years old down to just over 2 years old. The labelling of the scale at the lower level is speculative since we do not have performance data for 2 year-olds, but not necessarily misleading in the sense that the boxplots show that it is likely to be three years later at the start of Year 4 before the performance of those children meets the norms for 5 year-olds.

There appears to be an anomaly in that the children at the start of Year 1, where in October the mean age is 5 years 7 months, have a median mathematical age of less than 4.5 years. However this is to balance the results at the end of Year 1 on the same test where children will have a mean age 6 years 3 months in June but a median mathematical age of about 6.3 years, and at the start of Year 2 where the median mathematical age is still about 6.3 years but the mean actual age is 6 years 7 months. It mainly reflects the fact that more than 1 year's learning takes place between October and June but much less over the summer.

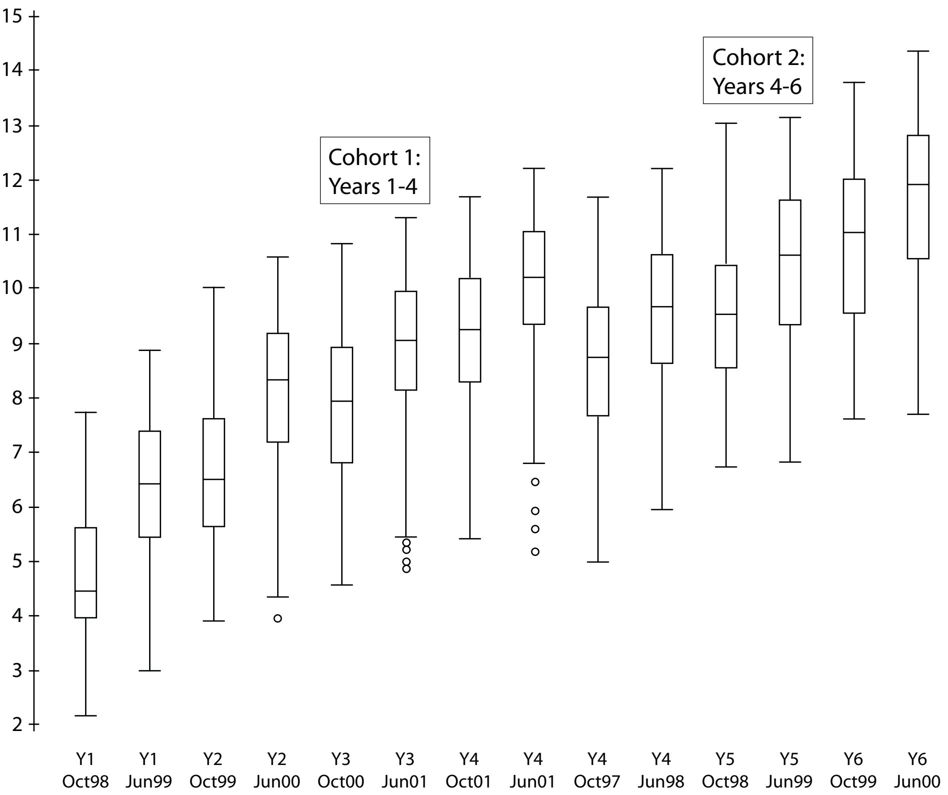

Figure 2. Distribution of 'mathematical age' in each of the two cohorts of children as Cohort 1 goes from Years 1 to 4 and Cohort 2 goes from Years 4 to 6.

This is an example of a general result that the increase in scores between the start and end of a school year was about twice as large in the younger classes than in the older ones. Looking at this another way, the increase in the number of children who could succeed on an average item between October and March was about 20% in Years 1 and 2 and gradually fell to about 10% in Years 5 and 6. It is difficult to explain this difference — it could be physiological and reflect the fact that the age 5-7 is thought to be a period of rapid brain growth. Alternately it could reflect the fact that as children start formal schooling there is a great deal to learn quickly and so they are in a sense catching up, but later the learning that occurs is marginal, developing from an existing base. Or it could be that the early concepts of number and addition are simply easier to learn than ones which come later (e.g. multiplication, rational numbers) and hence are more easily learned.

Figure 2 also demonstrates that the most advanced five year olds at entry are performing almost at the level of average 8 year-olds, and more than three years ahead of the median. The results for the end of Year 1 are similar with the highest attaining students achieving almost at the level of an average 9 year old. The range is broadly similar but the increased challenge in mathematics work during that year may be responsible for the relatively large rise in the median. The range continues to widen until it is about 7 years at age 11 (Year 6).

It can also be seen that the results for the older cohort are slightly lower at the start and finish of Year 4 than for the younger cohort, suggesting that the National Numeracy Strategy introduced when the younger group were in Year 2 was having a small effect.

As part of the Leverhulme research we also observed more than ten lessons a year in 5 classes in each cohort, focusing especially on six case-study children in each class. This gave us a way of relating test results for some children to the work the same children did in class. The six pupils were selected with the assistance of teachers so that two were above average in attainment, two average, and two below average. The remainder of the classes in each cohort (around 70) were observed only once each year.

We could not always see evidence of the 5-year range of attainment in the planning and teaching in the classroom since many teachers kept closely to the scheme of work specified by the Numeracy Strategy and hence it is not always clear to teachers how much extra children already know. Aubrey (1993, 1994) also demonstrated that teachers often underestimate children's mathematical knowledge on starting school. However in some classrooms in the Reception and Year 1 classes that we observed in the Leverhulme Project teachers set more open tasks which enabled children to demonstrate the full extent of their understanding and skills.

One example was in the Reception class in Pinedene school, a large multi-ethnic city school with slightly below average national test results where children came from a wide range of social backgrounds. A child had brought into school a 'rainstick', a hollow tube with many tiny beads which fall through sieves and sound like rain when the tube is turned over. The teacher had found a transparent version in a toyshop and the 4 and 5 year-olds were fascinated to pass it round and watch and listen to the beads falling. Children drew the rainstick and 'wrote' about it with the help of the teacher and teaching assistants. The teacher also asked the children in small groups about the shapes involved, and asked them to estimate the number of beads (probably over a thousand).

In the group of about 6 children I observed, different children estimated quite different numbers; one boy said nine because it was the biggest number, others guessed numbers between ten and a hundred, one said a hundred and one a thousand. The teacher asked the children to each write their guess on the board, which allowed some discussion about larger numbers and how they were written (while a hundred was correctly written, a thousand was written as 110 but the teacher didn't correct it). It was clear that the children were very excited about these large numbers.

But when Scott's turn came he said 'infinity'. The teacher asked what he meant by that and he explained that if you tried to count the beads you would go on for ever, so it was infinity. The teacher explored the answer, asking Scott whether there were really so many you would never come to the end. He admitted that you would come to an end but it might take about three weeks. He then said that perhaps there weren't quite infinity, but a very large number 'like fifty-three'.

While Scott had almost certainly grasped the idea of infinity from discussions which took place at home, it was interesting that he could see that it might apply in the rainstick bead situation. Nor did he forget the concept; we also observed Scott in Year 4 doing an exercise which required drawing an object in the classroom and deciding the numbers of lines of symmetry. Scott carefully chose the circular clock and again noted that the number of lines of symmetry was infinity.

It is clear that Reception children were intellectually challenged and intrigued by the rainstick task; in contrast Reception children in other schools, were mainly occupied in routine counting and writing exercises up to 10 or at most 20.

It is interesting to look at Scott's test results as compared to the mean for his class and for the whole sample, all shown in Figure 3.

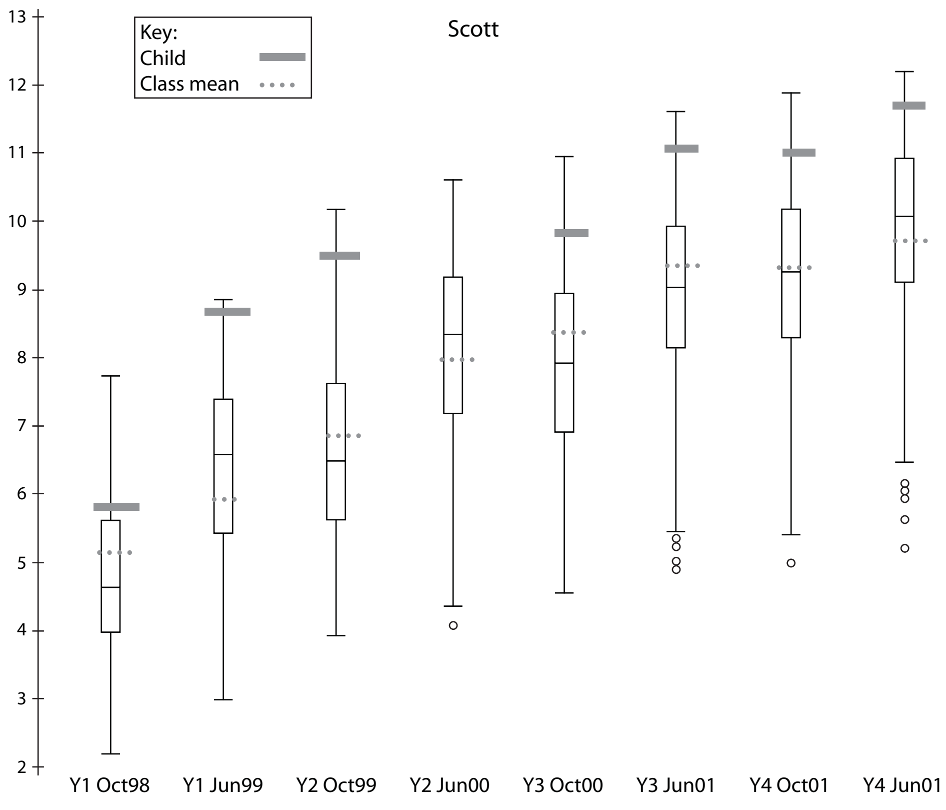

Figure 3. Scott's mean mathematical age as shown in his test results from Year 1 to Year 4.

Figure 3 shows that as expected Scott's marks were generally well into the top quartile, and were particularly high at the end of Year1. They are not especially high at the start of Year 1 but we suspect that he might have been distracted during the test; the teacher he had that year was newly qualified and found it difficult to control the class of 30 5-year-olds (in fact she decided to leave teaching at the end of the year).

The effect of the teacher can be seen since the class mean for Scott's class at the start of Year 1 is well above the median, probably because children had experienced the exciting teaching in the Reception class by the teacher with the rainstick, quoted above. However by the end of Year 1 where there was the weak new teacher, the class mean has dropped considerably, while Scott has greatly improved his score. While the class mean continues to oscillate about the median, Scott's marks remain generally high with no particular relation with the mean score for the class. (He was absent for the test at the end of Year 2).

Conclusions

I have in this article described curriculum and assessment frameworks in England for children aged 3 to 6. The results of the Leverhulme Numeracy Research Programme suggest that while the targets for the Reception year (aged 4 to 5) are appropriate, those for Year 1 (aged 5 to 6) may be challenging for the lower attaining half of the children (and for some teachers). On the other hand the fact that the highest attaining 5 year olds are achieving the same as average children aged 8 suggests that we should be differentiating the curriculum to a greater degree than is suggested in the official guidance, and providing work of greater challenge. This can be done by asking more open questions and not limiting the curriculum to the specified objectives for that year group.

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Resumo. Depois de um breve resumo da estrutura do sistema educativo em Inglaterra para os primeiros anos de escolaridade, e das linhas orientadoras do currículo e dos métodos de ensino em Matemática para as crianças dos 4 aos 6 anos, o artigo relata alguns resultados do Leverhulme Numeracy Research Programme, um projecto longitudinal do King's College London, que nos fornece informações sobre o desempenho de crianças de 5-6 anos em áreas específicas dos números. Um resultado chave refere-se ao grande leque de desempenhos, sendo os resultados de algumas crianças comparáveis com os das crianças mais velhas para as mesmas questões.

Palavras-chave: Numeracia; 1º ciclo do ensino básico; Ensino e aprendizagem.

Abstract. After a brief outline of structure of the early years sector in England, and of the guidance which relates to curriculum and teaching methods in mathematics for children aged 4-6, the article reports on some results of the Leverhulme Numeracy Research Programme, a longitudinal programme at King's College London, which inform us about the attainment in specific number areas of 5 to 6 year-old children. A key finding relates to the wide range of attainment, with some children's results comparing well with those of much older children on the same questions.

Key-words: Numeracy; Primary school; Teaching and learning.

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