# Establishing the Extent of Number Knowledge Children have on Entrance to Formal Schooling

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*This paper reports on research in progress on children using calculators as part of their mathematics learning during their first two years at school. An interview was developed and administered to 12 children on entrance to school in 1993, in order to determine the effect of classroom learning on their mathematical knowledge during the two year period. The outcomes of these interviews show that 10 of the 12 children interviewed commenced formal schooling already having knowledge of most of the stated number concepts for prep level.*

## Introduction

Recommendations to make use of calculators in mathematic curricula at all levels of schooling have been made for well over a decade by the National Council of Teachers of Mathematics (1980 & 1989); Cockcroft (1982); Curriculum Development Centre & Australian Associatiion of Mathematics Teachers (1987); the last of which has been endorsed by the Australian Education Council (1991).

Despite these recommendations, there are very few actual examples of calculator use being systematically incorporated into the core mathematics curriculum in primary schools, particularly in the first two years of formal learning. Therefore until recently there has been little research into the effects of calculator use at these levels. One example of such research was the *Calculators in Primary Mathematics* research project funded by the Australian Research Council, Deakin University and the University of Melbourne (see, for example, Groves & Cheeseman, 1993; Groves, 1993b, 1994), which investigated the effect of the introduction of calculators on teacher practice and long term learning outcomes of children.

The purpose of this present study is to investigate the extent to which calculator use, in a classroom which encourages exploration of number in open-ended situations, allows children to demonstrate mathematical learning in advance of standard expectations at prep and year 1. The teachers in the classrooms where the research is being carried out had previously participated in the *Calculators in Primary Mathematics* project.

There has been considerable research which shows that children commencing formal schooling are mathematically literate in that they have already developed their own strategies for using the four basic operations in real life problem situations (see for example Brush, 1978; Hendrickson, 1979; Houlihan & Ginsburg, 1981; Yeoman, 1987; Young-Loveridge, 1987; Biddulph, 1990; Groves & Stacey, 1990). The first stage of this study is to establish the extent of number knowledge the children have on entrance to formal schooling, in order to determine the effect of classroom learning on the mathematical knowledge of children later in the two year period.

## Research method

Towards the end of 1992 the proposed research for 1993 and 1994 was explained to the parents of the in-coming prep children for 1993. Parents were asked to discuss any concerns they had and were requested to allow their children to participate in the research.

The interview format originally trialled was based on typical prep (the first year of school in Victoria) number activities and expectations from curriculum statements produced in Victoria and else-where, but was not sufficiently challenging and an extended interview was developed.

This interview allowed for collection of comprehensive data on developing number knowledge of each child, the nature of childrens' thinking and the ways in which they approached the set tasks. These interview tasks reflect expectations of prep and year 1 level curriculum statements. Language used in questioning was kept simple and straightforward and tasks interesting and motivating.

Six girls and six boys were randomly selected for an initial interview. A boy and girl were chosen from the highest, average and lowest perfomers to take part in the full study.

The children were interviewed individually in a screened corner of the double classroom used by the prep children. Child-sized classroom furniture was used allowing face to face contact by interviewer and child.

Each child was encouraged to talk about number, to use materials, to draw or write and no time limit was set for each child when interviewing. If a child's response to a question was quick and correct another task was given to monitor further understanding of the number concept but once a child was unable to answer a set task in a particular area of number a new topic was explored.

New materials, such as a tub of tiny blue, red, green and yellow teddies and a set of seven different sized owls were used in an endeavour to make the interview enjoyable and as relaxed as possible.

Other materials used included sets of cards with various numerals, money (both coins and notes), apples and jelly beans, six worksheets and a pan balance.

The children had access to pencil, paper, worksheets and concrete materials as needed.

## The Interview

The interview consists of twenty-two pre-set questions which allow for extension if the individual child shows potential to answer more than requested initially. (This interview format was also used mid and end of prep year and early in year 1 with the same six children). Twenty of these questions were used at the first interview. Each question contained several tasks as well as extension tasks.

Question 5 is cited as an example ( * denotes an extension).

5a) I had 4 biscuits and I was given 1 more. How many biscuits did I have altogether ?

[If the child was unable to answer, then part b) was asked using teddies.]

b) I had 4 green teddies and I was given 1 more. How many teddies do I have altogether?

c) What number is 1 more than 8 ? What number comes after

d*) 19 e*) 79 f*) 499 g*) -1 ?

Number tasks at the first interview were related to:

- counting, including the understanding of cardinal and ordinal numbers;
- reading and writing numbers;
- recognition of pattern, money and shapes;
- estimation;
- addition and subtraction both mentally and with concrete objects;
- division as sharing – for example, 'Can you share 12 teddies between 2

people so that they have the same number ?'.

## Results of the Interview

The twelve children's performance on the first interview on entrance to school indicates that these particular 5 year olds entered school with a considerable extent of number knowledge.

Table 1 shows the number of tasks each child attempted in the interview, the number answered correctly and the number of extension tasks attempted. The more confident the children were, the more tasks and extension tasks they attempted within the twenty questions. Some children were apprehensive and slow to respond, while others were calmly confident and eager to do as many of the tasks as possible.

**Table 1:** Number of tasks attempted and answered correctly by children in interview on entry to school

| | Helen | Ruth | Cate | Dani | Sonia | Clare | Dean | Todd | Troy | Hal | Clay | Sam |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. tasks attempted | 57 | 57 | 49 | 51 | 45 | 59 | 51 | 59 | 69 | 54 | 54 | 50 |
| No. tasks correct | 54 | 52 | 38 | 45 | 32 | 50 | 36 | 57 | 64 | 51 | 42 | 38 |
| No. extensions answered | 8 | 7 | 2 | 3 | 3 | 6 | 5 | 9 | 19 | 3 | 5 | 2 |

Table 2 shows number skills understood by these twelve children on entrance to school.

Rote counting by all children was well beyond curriculum expectations for prep level. All children counted beyond 10, two children beyond 100.

All children understood the concept of cardinality (i.e. that the last number word in a set of teddies represented the number of teddies as a whole), while 11 were able to find the third step or the seventh teddy in a row, thus demonstrating an understanding of the concept of ordinal number.

There was a wide variance in numeral recognition by this group, as well as in their ability to write numerals.

Real money was used for recognition of coins and notes. Four of the children may not have experienced handling money, as they were unable to do tasks related to recognition of money and addition and subtraction of coins where the numbers were no greater than 10.

**Table 2:** Children's performance on selected tasks form the interview

| Task | Helen | Ruth | Cate | Dani | Sonia | Clare | Dean | Todd | Troy | Hal | Clay | Sam |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Counting* | | | | | | | | | | | | |
| Highest number reached | 100 | 50 | 29 | 29 | 20 | 29 | 23 | 109 | 109 | 50 | 39 | 29 |
| Cardinality | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| Places teddy on 3rd step | √ | √ | | √ | | √ | √ | √ | √ | √ | | √ |
| Finds 7th teddy | √ | √ | √ | √ | √ | | √ | | √ | √ | | |
| Finds 28th teddy | | | | | | | | | √ | | | |
| *Reading and writing numerals* | | | | | | | | | | | | |
| Reads & orders to 10 – highest number read | 25 | 10 | 10 | 10 | 8 | 26 | 5 | 74 | 126 | 10 | 100 | 10 |
| Writes 1, 5 & 8 | √ | √ | | | | √ | | √ | √ | √ | √ | |
| Other numerals written | | | 100 | | | | | | | | 100 | |
| *Recognising pattern, money and shapes* | | | | | | | | | | | | |
| Repeats pattern of shapes | √ | √ | √ | | | √ | √ | √ | √ | | √ | √ |
| Repeats pattern of teddies | | | | | | | | | √ | | | |
| Names coins (6) | √ | √ | | 4 | | √ | | √ | √ | √ | 4 | 2 |
| Largest note named | | | | | | $20 | | $20 | $50 | | | |
| No. shapes recognised | 3 | 3 | 3 | 4 | 3 | 4 | 5 | 3 | 3 | 3 | 4 | 3 |
| *Estimation* | | | | | | | | | | | | |
| 25 teddies in a tub | √ | | | √ | | | | √ | √ | √ | | |
| Length & width of a card using teddies | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| *Addition and subtraction to 10* | | | | | | | | | | | | |
| Addition — mental | √ | √ | | | √ | √ | | √ | √ | √ | √ | √ |
| Addition — materials | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | v |
| Subtraction — mental | | | | | | √ | | √ | √ | √ | √ | √ |
| Subtraction — materials | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| *Division as sharing* | | | | | | | | | | | | |
| Share 12 teddies between 2 (or 3) people | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| Share 36 teddies between 2 people | √ | | | | | | | √ | | | | |

Shapes used for recognition were a square, triangle, circle, rectangle and an oval. The square, triangle and circle were able to be named by eight children, while

three also named the rectangle and Dean recognised all five shapes.

Estimation of objects to 10 posed no problem for any child, five children made close estimates of 25 teddies, four estimated around 17 and three were not prepared to make a guess.

All children were able to solve addition and subtraction problems to 10 using concrete materials. Nine responded correctly mentally to addition to 10 and six to subtraction tasks.

The higher achievers were confident and quick in response to tasks presented. Some were apprehensive and slow to respond to tasks even though re-assurance that they were doing well was given constantly. Dean was found to have a hearing impairment when tested during Term 1 of 1993. This could well have added to his apprehension and slow response at this time.

To find out where these children were in terms of a number curriculum, it was necessary to measure their attainment levels against a prep curriculum statement. At the time there was no detailed Victorian curriculum statement, while the school curriculum statements from the 6 schools involved in the *Calculators in Primary Mathematics* project differed in expectations of outcomes for this level.

**Table 3.** Attainment levels of children on entry to school (based on UK National Curriculum)

| Target | Attainment | No. of children |
|---|---|---|
| *Level 1* | | |
| AT2 | Count to at least 10 | 12 |
| AT2 | Read numerals to at least 10 | 10 |
| AT2 | Write numerals to at least 10 | 10 |
| AT2 | Order numbers to at least 10 | 11 |
| AT2 | Know that the size of a set is given by the last number in set | 12 |
| AT3 | Add using objects, numbers no greater than 10 | 12 |
| AT3 | Subtracting objects, numbers no greater than 10 | 12 |
| AT3 | Add or subtract using coins, numbers no greater than 10 | 8 |
| AT4 | Give reasonable estimate of number of objects (up to 10) | 12 |
| | | 10 |
| AT5 | Copy repeating patterns with 1 digit numbers represented by objects | |
| AT5 | Continue repeating patterns with 1 digit numbers represented by objects | 10 |
| AT5 | Devise repeating patterns with 1 digit numbers represented by objects | 1 |
| *Level 2* | | |
| AT2 | Understand the meaning of "a half" | 12 |
| AT3 | Use addition facts up to 10 | 7 |
| AT3 | Use use subtraction facts up to 10 | 5 |

A curriculum statement was developed based on the United Kingdom National Curriculum Statement (National Curriculum Council, 1988) representing expectations for 5 to 7 year olds. All of Level 1 attainment targets are included in this table but only those children could do are listed in Level 2.

This statement was comprehensive in that it covered the expectations in other curriculum statements thus enabling the children's attainment levels to be measured in all number areas. Another

reason for using this statement is that at a later stage in this study, teacher expectation data from the *Calculator in Primary Mathematics* project will be used. As this data is also based on the UK National Curriculum statement, the results will be relevant to the overall study.

This curriculum statement used will be validated (and modified if necessary) by carrying out a detailed comparison with the Victorian Curriculum and Standards Framework. At this stage preliminary comparison suggests there are similar expectations for prep and year 1 in the area of number.

Table 3 shows the number of children who have attained the listed number targets for prep year level and those targets reached at level 2. It can be seen that most children have knowledge of the number concepts in a prep curriculum on entry to formal schooling.

## Conclusion

This research has established the extent of the number knowledge the children in the study had on entrance to formal schooling, thus providing a basis for further study on the effect of the use of calculators on children's learning in mathematics during the first two years of school.

Although there was a variance in performance on some tasks all twelve children demonstrated understanding of all or most of the number concepts listed in the Curriculum Levels statement for the end of the Prep year.

There may be many reasons for children's prior learning, such as a range of informal number experiences in the home environment; activities provided by parents and older siblings; pre-school programs; television programs such as Sesame Street and Playschool; Nintendo games; card games; story books and songs.

These factors will tend to increase rather than decrease, therefore the classroom teacher and those responsible for implementation of the mathematics program in schools need to plan learning activities taking into consideration prior learning. Children do not need to cover skills already mastered, but need encouragement to explore number allowing them to demonstrate their mathematical learning in advance of standard expectations.

The outcome from this study reinforces research that maintains number knowledge typical of children at this level is underestimated and that curriculum is not well matched to children's abilities.

Even at this early stage this study supports the need to reform early childhood mathematics curricula in number (Groves & Stacey, 1990; Wright, 1992).

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