TO WHAT EXTENT DO GRADES 3 AND 4 CHILDREN MAKE SPONTANEOUS USE OF CALCULATORS FOR COMPUTATION?

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INTRODUCTION

The availability of hand-held calculators in the general community in recent years has changed people's computational methods. Calculators are readily available in most households and places of business and are used for many tasks by members of these groups. Of the three available methods of computation (mental, pencil-and-paper and calculator), mental and calculator computations are commonly used in everyday life. However, children in school have not always been encouraged to use calculators in their mathematics classes. Paper-and-pencil methods still receive the most emphasis in schools (Department of Employment, Education and Training, 1989, p. 69).

Surveys of Victorian primary school teachers in the early 1980s (Ferres, 1981, pp. .220-221) revealed that only 7 % supported the introduction of calculators in Grades 1-3 and 91% demanded the understanding of the four operations before their general use in the classroom.

Whilst a follow-up survey in 1990 (Ferres, Groves and Stacey, in preparation) indicated a significant change in attitude with 76% of primary teachers now supporting the introduction of calculators in Grades Prep. to 3, 58% admitted to rarely or never using them in their mathematics classes.

As previously reported at MERGA 13 and 14, two Melbourne based calculator projects* began in 1989 and 1990 to promote the use of calculators in mathematics classes from the beginning of primary schooling and to examine the effects of such availability and use on various aspects of mathematics programs and their impact on children's mathematics learning. In each of the six project schools, all children were given a calculator for their own use in mathematics classes commencing in Prep. The usual range of concrete materials was also made available and used within the normal class mathematics program. By 1991, the "calculator" classes had extended to Grade 2 in the project schools.

DATA COLLECTION IN 1991

In each of the "calculator classes", systematic data on actual calculator use have been collected through teachers' weekly record sheets, specific questions as part of teacher interviews at various times in the project, and from samples of children's work collected at

* The Calculator-Aware Program for the Teaching of Number (University of Melbourne) and the Victoria College Calculator Project (Burwood) commenced in late 1989 and early 1990 respectively. A joint successful bid for Australian Research Council (ARC) funding in 1992 and 1993 has now provided support and continuity under the new title of **Calculators in Primary Mathematics.**

each grade level. In 1991, the major data collection focus involved the testing and interviewing of Grades 3 and 4 children in the project schools. These children had not been previously part of the calculator project and would therefore provide a control group for future comparisons with our "calculator" children. During second and third terms, these Grades 3 and 4 children completed a written test as well as a test on calculator usage. A random sample of 10% of these children at each grade level also took part in a task-based interview involving number recognition, choice of computational method or device, and real world problem solving involving multiplication and division. Fifty-five children were interviewed on a one-to-one basis by the author and other members of the project team. This paper concentrates on a section of the interview that was aimed at collecting data from which some observations may be made regarding children's preferred computational methods in context-free situations.

Would children from a calculator-rich learning environment tackle a series of computations differently from children from non-calculator classes? Would "calculator children" be more reliant on their calculators to complete these arithmetical tasks? Would the level of achievement vary between the two groups of children being observed? These long-term questions cannot be answered at this stage but will be addressed when all data have been collected and analysed at the completion of the project.

METHOD

The random sample of 55 of the Grades 3 and 4 children were given a 25 - 30 minute interview on a one-to-one basis with a member of the project team. The setting was outside of the classroom usually in a location free from interruption and distraction (interview room, unoccupied office, library). Throughout the interviews, children were free to use whatever calculating devices they chose. Structured materials in the form of Multi-base Arithmetic Blocks (MAB) and Unifix cubes were provided. Pen-and-paper, the use of calculators and doing it "in your head" were also described as acceptable methods. It was pointed out that some questions may be new or seen to be difficult and it was permissible to pass on to the next item accordingly. In this section of the interview, each of the twenty-four items was displayed on a flashcard one at a time and the student was encouraged to complete the arithmetical procedure using the method or device that was seen to be appropriate for them. It was stressed that there was no obligation to use all available materials and they should feel free to select whatever method with which they were comfortable. Each child's preferred choice of calculating device was recorded together with his or her answer. These were classified as "mental" (sub-classified to include "automatic response" and use of "fingers"), "written" (including both standard and non-standard algorithms), "calculator", "materials" (MAB and/or Unifix), and "other" (such as dots and jottings). It was observed that some children abandoned an initial method in preference for a subsequent one. The latter one was recorded as the preferred device unless it was also abandoned. In such cases, the "other" category was used.

RESULTS

Table 1: Results and preferred calculating methods of grades 3 and 4 children* (n-55).

NO.	QUESTION	CORRECT	INCORRECT•	PREFERRED CALCULATING METHOD						
				AUTO RESPONSE	MENTAL	FINGERS	CALCULATOR	MATERIALS	WRITTEN	OTHER#
1	7 + 5	93	7	60	18	13	0	5	4	0
2	20 + 30	93	7	64	29	4	2	0	2	0
3	100 - 10	91	9	64	27	0	9	0	0	0
4	3 x 5	100	0	67	24	2	4	0	2	0
5	36 - 13	85	15	9	35	6	30	9	9	2
6	12 + 3	92	8	31	28	4	31	3	0	3
7	3 x 99	76	24	2	18	2	69	0	4	5
8	How many 3's in 30?	72	28	14	50	13	17	2	0	4
9	1024 - 23	68	32	8	52	4	28	2	0	6
10	30 + 10	89	11	38	47	0	6	4	0	5
11	52 - 18	51	49	6	41	10	26	6	10	1
12	15 + 4	15	85	2	37	10	31	4	0	16
13	225 + 76	69	31	2	42	8	23	2	17	6
14	2000 - 1	56	44	11	83	0	4	0	0	2
15	321 - 164	46	54	0	32	2	46	5	10	5
16	62750 + 50	53	47	2	63	2	31	0	2	0
17	7 x $3.53	26	74	0	10	8	53	0	6	23
18	14 x 20	75	25	0	34	23	29	0	2	11
19	$153 + 4	15	85	0	9	2	65	0	7	17
20	34 x 26	53	47	0	15	3	48	10	10	14
21	20 + 40	17	83	7	50	0	22	0	0	21
22	3 - 7	24	76	6	64	7	4	2	0	17
23	$2.50 + $3.50	70	30	2	56	2	17	0	7	16
24	$12.38 + $2.52	53	47	4	40	4	26	0	11	15
			Mean (%)	17	38	5	26	2	4	8

• Includes 'unable to complete', 'unable to interpret answer', 'impossible'
Includes 'no idea'
* All values are percentages

Table 1 displays the twenty-four arithmetical items, the percentages of children obtaining correct/incorrect responses and the preferred calculating methods used in each question. "Mental" procedures (including "automatic response" and use of "fingers") were preferred on average by 60% of children while 26% elected to use calculators. "Structured materials" and "written" procedures were not generally favoured by these Grades 3 and 4 children (2% and 4% respectively).

Table 2: Preferred calculating methods on successful questions*

PREFERRED CALCULATING METHOD						
AUTO RESPONSE	MENTAL	FINGERS	CALCULATOR	MATERIALS	WRITTEN	OTHER
3	34	5	35	1	3	19

* Questions in which at least 70% of all children were correct. (Mean percentage values)

Table 2 presents the results on those items where at least 70% of children were successful in obtaining the correct answer. Once again, "mental" methods predominated being favoured by 67% of children with almost half of them being identified as applying "automatic response" techniques. "Calculators" were preferred by 19% of the sample while "materials" and "written" procedures were used by only 2% and 3% respectively.

Some of the items were deliberately structured above the usual content requirements of these grade levels. For instance, items involving decimal expressions and negative numbers have been included to provide a benchmark for comparative purposes when those children from the "calculator classes" are interviewed in 1992 and 1993. It is therefore not surprising to find low performance levels on these questions from these sample members. Tables 3 and 4 display the performance results and preferred calculating methods on those items where less than 30% of children were correct.

Table 3: Preferred calculating methods on unsuccessful questions#

PREFERRED CALCULATING METHOD						
AUTO RESPONSE	MENTAL	FINGERS	CALCULATOR	MATERIALS	WRITTEN	OTHER
32	29	6	19	2	3	4

Questions in which less than 30% of all children were correct. (Mean percentage values)

Table 4: Analysis of preferred calculating methods on unsuccessful questions

NO.	QUESTION	SUCCESSFUL %	UNSUCCESSFUL CALCULATING METHOD %	
12	15 ÷ 4	15	Mental Calculator	89 63
17	7 x $3.53	26	Mental Calculator	80 50
19	$153 ÷ 4	15	Calculator	77
21	20 ÷ 40	17	Mental Calculator	93 58
22	3 - 7	24	Auto Response Mental Fingers Calculator	67 69 75 50

Item 12, "15 ÷ 4", with only a 15% success rate, was performed mentally by 37% of students. Only 11% of these students were correct. Of those who used calculators, only 37% were able to obtain and read the answer correctly. Items 17 and 19 involved computations with money. It is interesting to note that a high percentage of students elected to use their calculators on these questions (53% and 65% respectively). 50% on Item 17 and 77% on Item 19 were unable to read the correct answers from their calculators.

Item 21, "20 ÷ 40", with only a 17% success rate, was generally attempted either mentally or by calculator. 93% of children who used "mental" procedures were incorrect. Typically, the order of performing the operation was reversed to give a whole number answer. Of those who used calculators, 58% were unable to read the correct answer often claiming to have pressed the wrong buttons or by just ignoring the decimal point. 76% of children were unable to correctly complete Item 22, "3 - 7". Invariably, the order was reversed to produce "4" or it was seen to be an "impossible" operation.

CONCLUSION

These results indicate that, wherever possible, the sample children used "mental" computation (including "automatic response" and "fingers") in preference to "calculators" with little or no attempt to use "written" or "materials". This contrasts markedly with a computation preference survey of Grade 5 students conducted in U.S.A. (Reys, Reys and Hope, in press) that showed written procedures to be the preferred method for undertaking computation. It would be interesting to survey Grade 5 children in our project schools to see whether or not the additional year of schooling conditions children to make more use of the standard pen-and-paper algorithms.

This year, a random sample of 10% of Grades 3 and 4 children from the six project schools will be interviewed. All Grade 3 children have been part of the calculator project since their first year at school and it will be of interest to make comparisons of achievement on the same 24 items and preferred computational methods. Among the hypotheses for the long-term study is an expectation that the "calculator children" will select appropriate procedures more frequently and make more effective use of calculators. In particular, it is asserted that these children will successfully use mental computation more often. Those items requiring knowledge and understanding of large numbers, operations involving money, decimal and negative numbers, which were not well done in the 1991 sample, will attract closer attention when analysing the data collected in 1992 and 1993. Early trends from all data obtained from the various sources in the project so far indicate that many of the "calculator children" develop an interest in and understanding of these concepts well before their counterparts.

An important objective of primary school mathematics should be to develop number sense. (Everybody Counts, 1989).

> Number sense can be described as a good intuition about numbers and their relationships. It develops gradually as a result of exploring numbers, visualising them in a variety of contexts, and relating them in ways that are not limited by traditional algorithms. (Howden, 1989, p.11).

The availability and use of calculators in primary mathematics classes may contribute to the achievement of this worthwhile aim. Continued monitoring of the impact of calculators on children's development of mathematical skills, concepts and problem solving abilities together with changes to content, will remain a central issue in this project and any subsequent studies.

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