WHAT DO CHILDREN BELIEVE ABOUT CALCULATORS?

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This study looks at two groups of children – those for whom the calculator is a part of their everyday mathematics at school and those for whom it is not. The research methodology adopted was that used in the innovative Victorian science study (1990). Children at grade three level were asked to complete statements about calculators, sometimes by writing and sometimes by drawing. The analysis categorized the children's responses into mutually exclusive types, which were then assigned integer 'level' labels. These categories were then tested for cohesion using an IRT partial credit analysis. The last stage of the analysis was to construct descriptors for each of the categories, thus establishing a developmental continuum for beliefs about calculators. While the number of children was only a few hundred, it is clear that further investigations of children's beliefs in this area would contribute significant information for those implementing a 'calculator aware' mathematics curriculum in their school.

The calculator is seen by educators as an instructional aid as well as a computational tool (AAMT, 1988). But what do the users, the children, think? Research into so-called 'misconceptions' would indicate that children do indeed hold views about the content and processes they encounter in their schooling (see for example, Confrey (1990) for a review of this research). There appears to be no research however, investigating children's ideas or opinions regarding either the use of calculators or exactly how a calculator functions.

Surely most, if not all, children are exposed to calculators in different situations in their classroom mathematics, or in the 'real' world? Such exposure will be the foundation of children's beliefs about what calculators are and what they are for. The present study is a preliminary attempt to collect such data and perform such analyses as will help in determining the nature of children's beliefs about calculators. As Ausubel said '[T]he most important single factor influencing learning is what the learner already knows' (Ausubel, 1968: vi).

The evidence of research into learner beliefs (prior to teaching in science) shows that they are indeed critical to the outcomes of instruction and have been well documented (Adams, Doig and Rosier, 1991). In mathematics learning however the role of affective variables has not received the same attention. In his review of research into affective variables McLeod (1992) categorizes this research into the following categories: beliefs about mathematics; beliefs about self; beliefs about mathematics teaching and beliefs about the social context. However none of the reported studies focus on learners' beliefs about calculators or their role in mathematics learning.

RESEARCH QUESTIONS

The investigation reported here forms a small part of a larger study involving number and calculators which is an adjunct to CAN-like projects being conducted by Deakin University (Groves, Cheeseman, Allan and Williams, 1992). While this project has sought to answer many questions, the specific foci selected for this report are a description of children's beliefs about calculators. In order to achieve this, the following questions were posed:

1 **Question 1 What can a calculator do?** The purpose of this question is to explore the range of uses that children believe exist for a calculator. While most adults would think that a calculator is for computation, children's experiences of mathematics at this age level are still dominated by counting, basic addition and subtraction, fractions and to some degree exploration of the number system.

2 **Question 2 Does a calculator always give the correct answer.** The purpose of this question is to explore the degree to which children trust their calculators. While adults are ready to believe in the machine's infallibility children, who are apt to press the wrong key more often, may be less willing to put their trust in one.

3 **Question 3 How can you check your work?** The purpose of this question is to explore the range of strategies that children use for checking their work. Do they rely upon another 'go' with the calculator, or do they have alternative methods? Many critics of children's use of calculators argue that the children become dependent upon them, but is this so?

4 **Question 4 Can a calculator teach you?** The purpose of this question is to explore whether children believe that they can learn from a calculator. While it is true that there are guides available to assist teachers to teach *with* the calculator (Open University, 1982), whether children think that they learn *from* a calculator is unclear. Perhaps the children in this study can shed some light on the matter.

5 **Question 5 The inside workings of a calculator.** The purpose of this question is to explore what children believe happens inside a calculator when a button is pressed. Are there little people inside? Or is it simply a collection of wires and batteries? Children's drawings are always revealing of their inner ideas, and this question, while not implying that children should be taught binary arithmetic or electronics, should enable us to gauge to what extent there may be a 'black box' view of calculators emerging.

METHODOLOGY AND INSTRUMENTATION

To gather information on children's beliefs at year three (approximately nine years of age) would usually involve one-to-one interviews. However to gather sufficient data to be able to make justifiable inferences makes interviewing not feasible. Fortunately there has been developed recently techniques for gathering and analyzing such data using interview-like written formats and modern statistical tools. To date these have been used in science and social science only but there was no reason to doubt that the technique would apply equally well to mathematics. For a full description of these formats and their application to science see Adams, Doig and Rosier (1991) and for partially similar methods in mathematics Streefland and van den Heuvel-Panhuizen (1992) and Tirosh and Stavy (1992). The particular format selected for this investigation was that of a short story entitled 'What happened last night'. In this story an alien visitor asks questions of the child (reader) who responds by completing 'gaps' left in the text. In all administrations the entire story was read to the children by the author then the children read and completed the story in their own time, approximately thirty minutes.

SUBJECTS

The subjects were from four Melbourne (Victoria) schools. Two schools were where the children had had complete access to calculators and two non-calculator schools matched on socio-economic variables. The number of subjects in each school is presented in Table 1.

Table 1: Number of year three subjects in calculator and non-calculator schools.

Calculator schools	Non-calculator schools
Total subjects = 105	Total subjects = 94
Total subjects = 199	

ANALYSIS

As outlined earlier, the methodology used was that of written responses to leading questions. This meant that two hundred scripts each of five responses had to be prepared for analysis. The procedure used was that pioneered by Adams and Doig (Adams et al, 1992) in their study of science beliefs. First all responses to a particular question are read to give an overall 'feel' for the range of responses. Theoretically each response is unique, but in practice responses tend to 'group' themselves in a qualitative sense. Thus after the initial reading, it is possible to describe tentative qualitative categories. All responses are then placed into one of these mutually exclusive categories. If necessary this process is repeated until all responses can be accommodated. Each category is now given an integer 'level' label, which describes its ranking from being the most to the least sophisticated response. The level labels cannot be equated across questions, and in some cases two qualitative responses have been assigned to the same level. The analysis of the labelled data was via the Quest®interactive analysis program (Adams and Khoo, 1992). The analysis was of two forms, a simple frequencies analysis and a Rasch partial credit analysis (Wright and Masters, 1982). The application of this model enables the construction of a developmental continuum for the set of questions as a group. This is entitled the 'Beliefs about calculators' continuum.

RESULTS

Below are the response percentages by category for the children, in both calculator and non-calculator schools. For each question the highest value label indicates the response considered to be the most sophisticated.

Table 2: Question 1 What can a calculator do?

LABEL	%	DESCRIPTION
3	34.7	+/–/*/÷
2	40.2	sums/get answers
1	22.1	maths/make life easier
0	3.0	uninterpretable

The purpose of this question was to explore the range of uses that children have for a calculator. By year three most of the numerical experiences of Victorian children have been to do with counting, with some work on addition and subtraction, mainly non-algorithmic, and fractions. It is no surprise then that the overwhelming majority of children believe that either 'sums' or calculating (addition was the operation most frequently mentioned) are the major uses for calculators.

TABLE 3: Question 2 Does a calculator always give the correct answer

LABEL	%	DESCRIPTION
3	62.8	no
2	18.1	sometimes
1	10.1	yes
0	9.0	uninterpretable

The purpose of this question was to explore the degree to which children trust their calculator to give the correct answer. While the tendency of adults is to consider the 'yes' option as being more correct, those students who said 'sometimes' indicated that there was the possibility of human error. The high percentage of children responding 'no' would appear to indicate that incorrect keying is a problem with young children, and also vindicates the 'sometimes' responses.

TABLE 4: Question 3 How can you check your work?

LABEL	%	DESCRIPTION
2	39.2	mental calculation/paper&pencil /concrete materials
1	54.3	do it again/ask someone
0	6.5	uninterpretable

The purpose of this question was to explore the range of strategies that children use for checking their work. The most surprising responses were those which simply suggested asking someone (usually mum) rather than any attempt to try again. Those suggesting a further attempt (do it again) appear to believe that a keying error had occurred. On the other hand, a large group suggested that they had alternative strategies at their disposal.

TABLE 5: Question 4 Can a calculator teach you?

LABEL	%	DESCRIPTION
3	11.1	no
2	12.1	sometimes
1	50.8	yes
0	26.1	uninterpretable

The purpose of this question is to explore whether children believe that they can learn from a calculator. While one might be tempted to say 'yes, of course' a number of children who said 'no' did so with the explanation that the calculator gave the answer, but the person had to know 'which button to push'. The 'yes' group usually suggested that one needed only to memorize the calculator's answers to questions to learn.

TABLE 6: Question 5 The inside workings of a calculator.

LABEL	%	DESCRIPTION
4	3.5	circuit complete (with 'brain')
3	6.5	button/wires/ screen/batteries
2	50.8	circuit (generalised)
1	3.0	animism/ mechanical
0	36.2	uninterpretable

The purpose of this question was to explore what children believe happens inside a calculator. Children's ideas about what happens encompasses a wide range. Mechanical or animistic notions are rare, but not unexpected for children of this age. Most children knew, or felt that, there was some sort of circuit, although these were not expressed in standard form by any means. The inclusion of a 'brain' in a response was taken as indicating the highest level of response, and the rarity of this response indicates that this was a very difficult question.

CONCLUSIONS

The questions and their responses reported here, while only a subset of a larger study, do indicate that there are reasons to believe that there is a widespread set of beliefs being developed by children. The hidden-curriculum involved when children use tools such as the calculator must in some way interact with the taught curriculum and the effects of such interactions can only be interpreted if the underlying ideas of the children in question are known and taken into account. The large number of responses suggesting that calculators are only for 'sums' is certainly an example of the curriculum influencing opinion, while the implied high incidence of keying errors appears to be working against children's routine use of calculators. On a more positive note is the finding that so many children have developed a range of alternative computational methods, despite the availability of calculators, a finding generally not predicted.

In regard to teaching or learning with, or from, a calculator, it is a sad fact that these children equate teaching with 'telling the answer' and learning with 'memorizing the answer'. No response indicated that a calculator could be used for exploring numbers, patterns or operations, despite teachers, in the calculator project schools especially, using calculators for such activities. The only explanation that springs to mind is that by grade three the curriculum has turned from numbers *per se* to operations with them and exploration has been 'left behind'.

Is the calculator a 'black box'? Nearly every child who gave an interpretable response indicated that there was some form of circuitry inside the case. Most gave wires, batteries, buttons, and display panels as part of their circuits (all of which are reasonably visible) but a few indicated that there was a 'brain' inside to do the work. The exact nature of the workings was not specified; should we be concerned? Is there a place for understanding the tools we use as well as how to use them?

From a research perspective, the high number of responses that were uninterpretable indicates that better questions need to be formulated and follow-up interviews conducted. While some findings are interesting in themselves, others do have curriculum implications and need to be further investigated. This is particularly true of fractions, which were not mentioned in any response at all. Decimal fractions are an area ready to be explored with calculators, but there was no evidence of children's acquaintance with these at all, which, considering the wide use of this form of fraction in the real world seems inexplicable.

(The second form of analysis, providing a 'Beliefs about calculators' continuum, is not included here due to space restrictions, but will be presented at MERGA itself).

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