Calculators in Primary Mathematics: Changing Expectations and Curriculum Issues *

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The National Statement on Mathematics for Australian Schools supports an increased emphasis on developing number sense through mental computation in recognition of the role of the calculator. The Calculators in Primary Mathematics project is a long-term investigation into the effects of the introduction of calculators on the learning and teaching of primary mathematics. The project commenced in 1990 at prep and grade 1 level, with 45 prep to grade 3 classes in six schools participating in 1992. All children in the project are "given" their own calculator to use whenever they wish. Their teachers are provided with systematic professional support, although they are not provided with curriculum materials or classroom activities. This paper focusses on changes in teachers' expectations of children's mathematical performance and curriculum issues arising from these changes.

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Introduction

For well over a decade, calculators have been recognised as having the potential to profoundly change the curriculum and the nature of mathematics teaching, with widespread agreement amongst mathematics educators that calculators should be integrated into the core mathematics curriculum (National Council of Teachers of Mathematics, 1980, p.9; Cockcroft, 1982, p.109; Curriculum Development Centre and The Australian Association of Mathematics Teachers, 1987).

In everyday life, of the three available methods of computation, mental and calculator computations are the ones typically used. However, paper-and-pencil methods still receive the most emphasis in schools. The emergence of calculators and computers serves to highlight the lack of congruence between school mathematics and real mathematics (Willis & Kissane, 1989, p.58).

Recently, powerful attempts have been made to change this situation in

Australia. The National Statement on Mathematics for Australian Schools (Australian Education Council, 1990) endorses the 1987 national policy on calculator use, recommending that all students use calculators at all year levels (K-12) and that calculators be used both as instructional aids and as learning tools. In line with world-wide trends, the national statement has an increased emphasis on developing number sense through mental computation, partly in recognition of the role of the calculator.

The Calculators in Primary Mathematics project is a long-term investigation into the effects of the introduction of calculators on the learning and teaching of primary mathematics.

The project incorporates the Victoria College Calculator Project and the Calculator Aware Program for the Teaching of Number, which commenced around the beginning of 1990, when six schools, supported by Victoria College (now Deakin University), Melbourne University and the Catholic Education Office, introduced calculators at the prep and grade 1 levels. The project has moved up through the schools and will include grade 4 in 1993. In 1992,

there are 45 classes from prep to grade 3 involved in the project. All children in the project are "given" their own calculator to use whenever they wish. Their teachers are provided with systematic professional support, although they are not provided with curriculum materials or classroom activities.

The investigation focusses on the extent and purpose of calculator use; changes in teachers' expectations of children's mathematical performance and consequent changes in the curriculum; long-term implications for numeracy; and changes in teachers' beliefs and teaching practice.

Previous conference papers (Groves, Ferres, Bergfeld & Salter, 1990; Groves, 1991; Groves, Cheeseman, Clarke & Hawkes, 1991) have referred to the variety of uses found for the calculator in the lower primary school; the extent to which teachers have become aware of children's abstract concepts of number; and the move towards a more open style of teaching and learning by many teachers in response to what they perceive as the needs of their children.

This paper reports on classroom observations of children; changes in prep to grade 2 teachers' expectations of children's mathematical performance; and curriculum issues arising from these changes. It focusses on three areas where we have hypothesised that children who have been involved in the calculator project would perform in advance of usual expectations : - large numbers, negative numbers and understanding decimal notation.

Some examples of children using large numbers, negatives and decimals

The purpose of introducing the calculators is not to make children dependent on calculators, but rather to enhance that elusive quality "number sense", by providing children with a rich mathematical environment to explore.

Classroom observation reveals that many young children are dealing with much larger numbers than would normally be expected, as well as, in many cases, negative numbers and, to a lesser extent, decimals.

Using the built-in constant function on the calculator allows counting by any chosen number, from any desired starting point. One prep teacher initiated an activity number rolls, which became popular with many other teachers through the network meetings and newsletters. Long strips of paper were used to vertically record counting on by a constant. Many children began by counting by 1's and continued to do so. Others, however, moved on to counting by numbers such as 5, 10 or 100. At least one child observed that counting by 9's usually leads to the units digit decreasing by one each time, while the tens digit increases by one.

Many children counted into the thousands and tens of thousands, while others counted backwards. During a classroom visit, Daniel, a prep child supposedly engaged in a quite different activity, wanted to show how he could count by 50's to 4000 on his calculator. Before he could be stopped, he had reached 64 250, which he was able to read aloud without hesitation. In another prep grade, Ben had counted up to 17 900 by 100's on his number roll. When asked what number would be reached after pressing equals two more times, he wrote 18 100, although he read it as eighteen hundred and one.

Many children, while using their calculators to count backwards, discovered negative numbers. In a prep class which had been discussing and drawing "What lives underground?", Alistair said "Minus means you are going underground". He recorded some "underground" numbers. When questioned what would be the first number above the ground, he said "zero". "Underground numbers" have been used and discussed freely in many classrooms. A grade 1/2 teacher devised an ordering activity number line-up, which involves a small group of children entering numbers of their choice into their calculators and then sorting themselves into ascending order. More and more children are added to the "line-up", with each new child needing to find their correct position. Children frequently include negative or very large numbers in this activity and exhibit a quite sophisticated knowledge of the number system.

Grade 2 children were confronted by decimals while discussing how to make a pictograph of the results of a tree survey they had carried out. A group of 7 children had found 64 trees of a particular category and needed to cut out pictures of 64 trees to paste onto the chart. When asked by the teacher how many trees each child in the group would need to make, children used their calculators and found that 64 ÷ 7 = 9 . 1428571. The teacher recorded the answer and asked what it meant. A child quickly replied: "It is nine and a bit so if we made ten each we would have some left over - actually we would have 6 left over".

A grade 2 child, Sebastian , after playing a game of stepping stones on the classroom floor went away to make a set of his own stepping stone numbers. His teacher had used whole number steps, with numbers in the range 0 to 25. Sebastian also began his steps at 0. He chose, however, steps of tenths, reading them as "point 1, point 2 ", etc. He managed the step after 0 . 9 in this way: He said "point 9, point 10, no that's 1". Having made the bridge, he then continued easily. A problem arose when Sebastian began to use his stepping stones in an actual game because the operations he chose took him below zero. He stopped for a moment to consider what would happen if the numbers "hadn't been points". Soon he had produced stepping stones for counting backwards into the negative decimal numbers.

Interviews with children

It is not possible for teachers to ignore occurrences such as those described above - especially if they are relatively frequent, rather than isolated examples. In an effort to help teachers discover the extent to which children across the whole spectrum were understanding what they were doing with their calculators, interviews were conducted in 1991 with a 20% random sample of children at each of the grade levels across two of the six schools. The questions used were drafted by teachers at a network meeting. These questions, while retaining their original flavour, were extended in scope by members of the project team in an effort to probe further into children's level of understanding. Results for questions relating to reading large numbers and decimals are shown in Table 1.

Table 1   Percentages of children able to correctly read given numbers at different grade levels

LevelItems and responsesPrepItem74126203(n = 29)% correct4674Grade 1Item203143562 7501 000 000(n = 24)% correct58462112Grade 2Item8737232945 . 7(n = 23)% correct1001006539

In addition, 9% of grade 2 children when asked "how big is 5 . 7 " gave a correct response (e.g. "a bit bigger than 5 ").

Grade 2 children, when asked to read – 5 , gave a correct response in 30% of the cases (e.g. " 5 below zero). A response of "take away 5" was regarded as incorrect.

Interview results indicate that significant numbers of children can read numbers which are usually considered well beyond the curriculum at each of the grade levels. Many children show some understanding of negative numbers, while many can also correctly read a decimal, but very few can approximate it with a whole number.

Teachers' expectations

Measuring teachers' expectations

Changes in teachers' expectations of children's mathematical performance and consequent changes in the mathematics curriculum provide one of the major foci for the project. Data on teachers' expectations is being collected through interviews and an extensive written questionnaire.

The questionnaire contains 121 specific attainment targets, relating to number, at levels of difficulty ranging from what would be usually accepted as relevant to prep children (e.g. count aloud to 10) to ones which would normally not be seen as part of the primary mathematics curriculum (e.g. correctly approximate to 3 significant figures a number on a calculator display). The choice of items was based on a selection of attainment targets from the Number strand of the UK National Curriculum (National Curriculum Council, 1988). The items have been arranged at random, to avoid preconceptions about levels of difficulty.

At the beginning of each year of their involvement in the project, teachers are asked to indicate, for each of the items, their expectations of children at the beginning and end of that year. They do this by indicating whether they expect all, most, some or none of the children to be successful on the item. Their own completed questionnaires are then returned to the teachers at the end of the year for them to indicate, in the same manner, children's actual performance by the end of the year, and to make other comments. In the long-term, the questionnaires will be analysed on the basis of number of years of involvement in the project, to

determine what changes, if any, occur in teachers' expectations at each grade level.

This paper reports on a preliminary analysis of 1990 and 1991 data, at the prep to grade 2 levels. It compares teachers' expectations for the beginning and end of the year with their reports of what actually happened. The total number of questionnaires for 1990 and 1991 was 35, representing 13 teachers in 1990 and 22 teachers in 1991. At the time of filling in the questionnaires, 13 teachers were at prep level, 12 at grade 1 and 10 at grade 2. Data from the 5 teachers who were involved in the project at the same grade level in both years is also compared to provide some preliminary information on changes in their expectations. Only the 22 items relating to large numbers, negatives and decimals will be discussed here.

Reporting the questionnaire data on teachers' expectations

For the purpose of reporting the data here, the responses relating to the number of children expected or actually able to perform a task was mapped onto a linear numerical scale as follows:

None = 0 Some = 1 Most = 2 All = 3 .

The mean response for teachers at each grade level was then calculated, and these means were used to display the data for a few selected items graphically (see Figures 1 to 8 below).

The means were also used to calculate the difference between the actual performance and that expected by the teachers at the end of the year. These differences are tabulated in Tables 2 to 4 below. The differences indicate the extent to which more (or less) children were actually able to do the tasks than had been anticipated by their teachers.

Large numbers

A total of 11 items on the questionnaire related to what could be termed large numbers at the prep to grade 2 level. Summary data showing the difference between the means of children's actual performance, as reported by teachers, and teachers' expectations for the end of the year is given in Table 2. The differences between the means are given for each item, at each grade level.

As only two of the differences are negative, it can be seen that on these items children consistently outperformed teachers expectations.

Table 2 Differences between children's actual performance and teachers' expectations on items related to large numbers

Item DescriptionMean difference*numberof taskPrep
(n=13)Gr 1
(n=12)Gr 2
(n=10)13Know that "four hundred and two" is written as 402 and know why

neither 42 nor 4002 is correct.0.30.00.016Count from 389 to 407.0.70.30.219Correctly read 14 560.0.30.50.020Know the value of the 2 in 521 400 .0.10.40.321Know that 5200 is 5 thousand 2 hundred, or 52 hundred, or 520 times ten .0.40.50.032Know that 78 is 7 tens and 8 ones.0.50.00.236Write in figures four thousand and seventy three.0.30.30.344Correctly read 1810 .0.30.40.055Correctly read numerals to 1000 .0.20.5- 0.183Count in 10's from 960 to 1050 .0.30.4- 0.298Know the next number to appear on the trip meter of a car after 06399.0.30.30.2* mean difference between teachers' reports of children's actual performance and their expectations, using the scale of None = 0 ; Some = 1 ; Most = 2 ; All = 3 .

A few items have been selected for further analysis below.

ITEM 16: COUNT FROM 389 TO 407

Figure 1 Mean values of teachers' expectations for beginning and end of year compared with children's actual performance on Item 16 for different grade levels

Figure 1 indicates graphically the differences between teachers' expectations for children at the beginning and end of the year and their actual performance for Item 16 (count from 389 to 407). This item reveals the greatest discrepancy at any grade level between teachers expectations and children's actual performance, with a difference of 0.7 at the prep level between the means for children's actual performance as reported by teachers and their expectations for the end of the year. Grade 1 teachers' expectations for the beginning of the year are close to prep teachers' expectations for the end of year, while grade 1 expectations for the end of year are closer to actual performance at the end of prep. The grade 2 data shows a narrowing of the gap between teachers' expectations and actual performance, possibly reflecting the fact that such counting is now regarded as being much more part of the mainstream grade 2 curriculum.

ITEM 32: KNOW THAT 78 IS 7 TENS AND 8 ONES

Figure 2 Mean values of teachers' expectations for beginning and end of year compared with children's actual performance on Item 32 for different grade levels

Figure 2 reveals a similar effect for Item 32 (know that 78 is 7 tens and 8 ones), where there is a difference of 0.5 in the means for prep children's actual performance as reported by teachers and their expectations for the end of the year, but no difference at grade 1 and only 0.2 at grade 2. However, in this case, there is very little room for a difference at the grade 2 level, as the mean for the expected performance at the end of the year is already 2.7.

ITEM 83: COUNT IN 10'S FROM 960 TO 1050

Figure 3 Mean values of teachers' expectations for beginning and end of year compared with children's actual performance on Item 83 for different grade levels

Item 83 (count in 10's from 960 to 1050) is one of the only two items relating to large numbers for which children do not meet grade 2 teachers' expectations at the end of the year (see Figure 3). However, at both of the other grade levels, this item produces a positive difference between children's performance and teachers' expectations.

The other item yielding a negative difference (– 0.1 at the grade 2 level) is Item 55 (correctly read numerals to 1000), which shows a similar pattern to Item 83 (see Table 2 for summary data).

ITEM 98: KNOW THE NEXT NUMBER TO APPEAR ON
THE TRIP METER OF A CAR AFTER 06399

Figure 4 Mean values of teachers' expectations for beginning and end of year compared with children's actual performance on item 98 for different grade levels

Item 98 (know the next number to appear on the trip meter of a car after 06399) is an example which requires an understanding of place value concepts as well as skills in counting and reading numbers. Despite the difficulty of the item, some teachers at all three grade levels report that some children in their classes are able to do this task (see Figure 4). It should perhaps also be noted that the only grade 1 teacher to expect some children to be able to perform the task at the beginning of the year was one of the only two at this level in 1991 who was a member of the project at the same grade level in 1990.

Negative numbers

Four items on the questionnaire related to negative numbers.

Table 3 Differences between children's actual performance and teachers' expectations on items related to negative numbers

Item number	Description of task	Mean difference* Prep (n=13)	Gr 1 (n=12)	Gr 2 (n=10)
9	Know the answer for 2 - 6	0.1	0.3	0.2
59	Know that - 3 is the number immediately to the left of - 2 on a number line marked off in 1's	0.0	0.3	0.0
60	Understand what is meant by - 7 on a calculator display	0.4	0.6	0.2
118	Count backwards in 10's from 50 to - 70	0.2	0.2	0.1

* mean difference between teachers' reports of children's actual performance and their expectations, using the scale of None = 0 ; Some = 1 ; Most = 2 ; All = 3 .

Summary data showing the difference between the actual and the expected end of year means for each of these items, at each grade level, is given in Table 3.

The item which showed the greatest difference between teachers' expectations and children's actual performance was Item 60 (understand what is meant by - 7 on a calculator display). The difference was the greatest at the grade 1 level where teachers appeared to have a lower expectation for children at the end of the year than did the prep teachers, although there was an increase in expectations across the grade levels for the beginning of the year. Despite the differing expectations, there appeared to be little difference across the year levels for children's actual performance (see Figure 5).

ITEM 60: UNDERSTAND WHAT IS MEANT BY - 7 ON A CALCULATOR DISPLAY

Figure 5   Mean values of teachers' expectations for beginning and end of year compared with children's actual performance on item 60 for different grade levels

Understanding decimal notation

A total of 7 items on the questionnaire related to understanding decimal notation.

Table 4   Differences between children's actual performance and teachers' expectations on items related to understanding decimal notation

Item DescriptionMean difference*numberof taskPrep
(n=13)Gr 1
(n=12)Gr 2
(n=10)4Know which is bigger 0.75 or 0.8 .0.10.30.412Know that there are infinitely many decimals between   0.4 and 0.5 .0.00.10.151Round off 14.13 to the nearest whole number .0.00.20.361
Know that   1/3   = 0.3333333 on a calculator.0.00.10.189Round off 0.18 to the nearest tenth .0.00.00.296Count from 0.1 to 1.1 in 0.1's.0.20.10.497Correctly approximate to 3 significant figures a number on a calculator display .0.30.40.4* mean difference between teachers' reports of children's actual performance and their   expectations, using the scale of None = 0 ; Some = 1 ; Most = 2 ; All = 3 .

Summary data showing the difference between the actual and the expected end of year means for each of these items, at each grade level, is given in Table 4. It can be seen that differences in this area are smaller than for the previous two areas, reflecting the fact that very few children are able to do these tasks.

ITEM 4: KNOW WHICH IS BIGGER 0.75 OR 0.8

Figure 6   Mean values of teachers' expectations for beginning and end of year compared with children's actual performance on item 4 for different grade levels

Item 4 (know which is bigger 0.75 or 0.8) is one with which many children in middle primary school would experience difficulty. Nevertheless, some teachers at all three grade levels reported that at least some children were able to do this task (see Figure 6).

ITEM 96: COUNT FROM 0.1 TO 1.1 IN 0.1'S

Figure 7   Mean values of teachers' expectations for beginning and end of year compared with children's actual performance on item 96 for different grade levels

As described in an earlier section of this paper, some children successfully extended counting using the constant function to counting by decimals. Teachers' responses to Item 96 (count from 0.1 to 1.1 in 0.1's) confirm this, although, not surprisingly teachers had not expected such a result (see Figure 7).

Item 97 (correctly approximate to 3 significant figures a number on a calculator display) was one of a small number of items on the entire questionnaire where it appears that some teachers misunderstood the question. It seems most unlikely that prep to grade 2 teachers would really expect children to be able to do this at the end of the year, far less the beginning of the year, nor that they actually observed children doing this (see Figure 8).

The most plausible explanation is that the term "3 significant figures" did not convey any sense that decimals were involved - which is a fault of the questionnaire!

ITEM 97: CORRECTLY APPROXIMATE TO 3 SIGNIFICANT FIGURES
A NUMBER ON A CALCULATOR DISPLAY

Figure 8 Mean values of teachers' expectations for beginning and end of year compared with children's actual performance on item 97 for different grade levels

Changes in teachers' expectations

It is to be expected that if children exceed teachers' expectations on certain items, then these teachers will change their expectations over time. While it is too early to draw conclusions on the basis of the limited data available for 1990 and 1991, it still seems worthwhile to look at the responses from the five teachers who were part of the project at the same grade level in both 1990 and 1991.

Only teachers' expectations of children's performance at the end of the year has been analysed here, as this is the most likely area where their prior experience of children's actual performance is likely to have an effect. Rather than attempt to analyse the data for individual items, a mean for each teacher's responses across all items for each of the three areas of large numbers, negative numbers and understanding of decimal notation has been calculated for 1990 and 1991 (see Table 5).

Table 5 Comparison of five teachers' end of year expectations on large number, negative and decimal items in 1990 and 1991

Teacher	A		B		C		D		E	
Grade	Prep		Prep		Prep		Grade 1		Grade 1	
Year	90	91	90	91	90	91	90	91	90	91
Large numbers*	0.4	0.5	0.1	0.0	0.2	0.5	0.9	1.5	0.4	0.9
Negatives*	0.2	0.2	0.2	0.2	0.2	1.0	1.0	1.2	0.4	1.2
Decimals*	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.3	0.0	0.0

* mean expectations for children at end of year across all items relating to this area, using the scale of None = 0 ; Some = 1 ; Most = 2 ; All = 3 .

Table 5 indicates that one of the three prep teachers (Teacher B) showed either no change or a negative change in her expectations from 1990 to 1991. Teacher A showed a slight positive change for large numbers only. However, Teacher C showed substantial changes in her expectations, particularly for large numbers and negatives. Both of the grade 1 teachers changed their expectations for large numbers and negatives, with Teacher E having the largest change in expectations of 0.8 for negative numbers. Teacher E includes the following comment at the end of her 1990 questionnaire :

I feel I have been underestimating the upper reach of some children.

Calculators have identified more specifically the range of abilities within the group. I feel children should not be limited to work within a given range of numbers at a given grade level and calculators have certainly confirmed that children can use, understand and be motivated by large numbers.

Another grade 1 teacher, who moved to grade 2 in 1991, commented in a similar vein in 1990:

My expectations have changed enormously. It has changed and challenged both the children and myself. There now seems to be no limits to what we can do in our theme work. I am surprised by the children's understanding of concepts - particularly place value, numbers and decimals (including money). My main expectation was for children to use the calculator as a tool and this was achieved very early by the grade.

A prep teacher, who also changed grades in 1991, added:

Many more children were using larger numbers than I expected. … This calculator project has enabled the brighter children to extend their thoughts on number work through open-ended tasks and problem solving activities.

These are only a few of many similar comments provided by teachers in response to the open-ended comment section of the questionnaire and in tape-recorded interviews.

Curriculum issues

As can be seen from the data reported above, some young children in the calculator project are encountering and dealing with numbers of a type they would not normally be expected to meet until middle or upper primary school, or even junior secondary school in the case of negative numbers. For many teachers one of the intimidating aspects of calculator use is the possibility that children may encounter very large numbers, negative numbers and decimals "before they are ready". Teachers who have now become comfortable with calculators in their classroom take the opposite view. They see their previous curriculum constraints as imposing artificial boundaries on the children. A prep / grade 1 teacher comments that:

Once upon a time in grade 1 we didn't extend beyond 50 at the most when we were counting. The understanding was thought to be limited for children of that age and, once they ran out of fingers and toes, that was as much as we expected them to do. But they really do have an understanding now, and they can translate what they are finding out on their calculator into concrete materials.

These changing expectations must, in the long-term, be reflected in changes in the mathematics curriculum. For example, one of the project schools had only just completed a review of the mathematics policy at the commencement of the project. Within a term, some teachers were already claiming that the presence of the calculator made it impossible to adhere to their policy and that they already foresaw changes being required, especially as the children moved up through the school. At another project school, where there is less adherence to a formal policy statement, the deputy principal now foresees changes at the next review of the mathematics policy, but feels the real impact of the project will not be felt until the project children have moved up to at least the middle primary grades.

Nevertheless, while the presence of the calculator appears to allow children to display a knowledge of mathematics which surprises their teachers, many children, especially early in their prep year, are still struggling with number recognition and are very uncertain about all aspects of the calculator. The wide range of skills and understandings present in any classroom appears to be highlighted by the presence of the calculator. Some teachers report reluctance in making major alterations to the curriculum because they want to cater for the children who they perceive as struggling. The new realisation of the range present in their classrooms presents some teachers with difficulties, especially if they feel they must adhere to a rigid curriculum.

Other teachers recognise the changes brought about by the calculator and welcome the way in which the mathematics curriculum has expanded. A grade 1/2 teacher sums up the views held by some teachers that not only has the content of their mathematics changed, but also the extent to which the content is child-centred and more open-ended.

I'm a lot happier to go where the children want … it's a lot less teacher directed… The calculators have enabled us to do that … You don't have to structure things so that you know the answer will be within their reach… If the children want to find out stuff, I say "go for it"… because I'm not so worried about them finding out things they won't understand anymore… I used to think what's the point of kids talking about thousands… because they're not going to know what they are talking about … After having done this for quite a while now I think they do understand what they're talking about to a certain extent - enough anyway to use it for their own needs. And they will get to understand it as they get older. But why impose artificial boundaries … and say "you're not allowed to know any numbers beyond 1000"? It's so stupid and that's what we used to do … I think I'm being a lot more open-ended with their activities… I'm putting more on them to do more finding out. I'm just sort of starting them off. In some ways we are still structure driven when we play games … but the activities I try and do with them are the ones they can take themselves where they want to go … You never know what's going to happen.

Conclusion

The presence of calculators and an awareness of the ways in which children use them in their classrooms has stimulated teachers to re-assess their expectations of children.

An exciting research question which needs to be addressed is the extent to which the calculator is causing changes in children's development of number concepts or merely revealing a state of affairs which has always existed. Some teachers clearly attribute the perceived changes to the presence of the calculator, while others, like this prep/1 teacher, believe that:

The capabilities must have always been there … we just haven't exposed them to enough. The calculator … tells me that the children are capable of much more than we expected from them … It's obvious! We're not creating miracles. The miracles were there all the time.

Teachers, while not as yet perhaps addressing the broader curriculum issues, are being led by the children into exploring content beyond their

previous expectations. The changes which are occurring are gradual and will take some time before they are formally incorporated into curriculum statements.
We believe the movement into new content areas is happening because the calculator is providing a rich mathematical environment for children to explore. The calculator enables children to readily deal with a wider range of number than is available through the use of concrete materials alone. It also supports children working at their own level. Calculators confront children and teachers with surprises, such as answers to apparently simple divisions resulting in long strings of decimals. These surprises often initiate inquiry and investigation. As a result, many teachers are using more open-ended approaches in their mathematics teaching and are more willing to let the children initiate and direct the course of mathematical activity.

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