The power and potential of the humble calculator in primary mathematics

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"The issues relating to calculator use reach the very core of mathematics instruction."

(Usiskin, 1999)

A number of articles have been written in recent years about the use of calculators in primary mathematics in New Zealand (Biddulph, 1991, 1992, 1996; Coleman & Snape, 1999; Lindale & Biddulph, 1991; McChesney, 1995; Storey, 1994). Perhaps this is not surprising when *Mathematics in the New Zealand Curriculum* (Ministry of Education, 1992, 14)

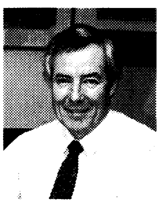
> *... assumes that both calculators and computers will be available and used in the teaching and learning of mathematics at all levels... Calculators are powerful tools for helping students to discover numerical facts and patterns, and helping them to make generalisations...*

The various articles above (i) explore the value of calculators for helping primary children develop greater understanding of mathematics, number in particular, (ii) describe the kinds of barriers that need to be overcome to develop such understanding, and (iii) suggest some calculator learning tasks that challenge children to think about number. Despite these publications, our impression is that calculators have not yet become an established part of primary mathematics classrooms. We think that McChesney (1995) was right when she wisely predicted a "...difficult road ahead for the simple calculator".

We believe it is possible that many teachers have not yet had the opportunity to consider the idea of using calculators in the classroom in any depth. Teachers may also believe (as we used to) that calculators would hinder the development of children's learning in mathematics. Now, having experienced the benefits of using calculators to help children's and student teachers' understanding of mathematics, we are enthusiastic converts!

We concur with Coleman and Snape's (1999) conclusion that many teachers would appreciate further professional development in this important area. Change often occurs as a result of personal experience. A valuable exercise (Hepburn, 1996) we have used with our student teachers is asking them to complete the following equation (so it is true): 43 x   = 100, without using the ÷ button (of course, a quick way to calculate the missing number would be to divide 100 by 43). As our students become engrossed in doing this they discover that they are revising and/or learning about decimal numbers, place value, estimation, and understanding the nature of multiplication and its relation to division (all of which are part of the number strand in the MiNZC document). They may also discover the value of recording their attempts (linking to the mathematical process 'communicating mathematical ideas' in MiNZC, p.28). Above all, our student teachers discover that using the calculator did not stop them thinking (a common concern); rather, their thinking was stimulated and challenged. A statement we find helpful to remember is, "Calculators do not think; they simply follow instructions".

We wonder if some of the resistance by some teachers to the use of calculators is because calculators are perceived to be a tool for children to get out of learning mathematics. Using calculators to



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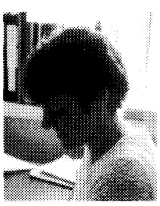

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help with the understanding of mathematics is not about using a calculator to work out sums. Rather, they can be used in a variety of ways that stimulate thinking and mathematical understanding. But what are some of these ways? This issue seems to be summed up in Usiskin's (1999) question, "How should we make use of this extraordinary technology to further the mathematics education of our students?"

In this paper we try to address this question by providing a few examples of how the calculator can be used at various levels of the primary school. In doing so, we draw upon the work of various development and research projects, and upon our own experiences of working with primary school children. But first, we offer some guidance about purchasing calculators.

What Kind of Calculator?

Given that calculators are relatively inexpensive (200 or so could be purchased for the price of one computer), schools may appreciate some advice about features needed in a calculator to be used by 5 to 10-year-olds. Following an earlier publication (Biddulph, 1992), we suggest the following:

1. It should be a simple calculator, but with fairly large keys.
2. The keys themselves need to have a hard surface, rather than the rubbery kind that are tempting to pick at.
3. It should be solar-powered to avoid hassles with batteries needing to be replaced.
4. It is advisable to have not only the memory buttons, but also the -/+ button so that children can eventually programme in negative numbers.
5. It needs a constant function, that is, if you key in 1 + = = = the display should show 3 (the number gets bigger by 1 every time you push the = button).

Some Suggestions for Using Calculators with 5 and 6-Year-olds

1. Spot the difference

Children could play this game in pairs after a teacher demonstration. It involves keying in a series of numbers on the calculator, one of which is out of order or not part of the pattern, e.g. 1 2 3 4 5 9 7 8

This involves the child in numeral recognition, and the order of numerals.

2. Counting bounces

This is a game in which the calculator can be used to tally the number of times another child bounces a ball, or catches a ball, or hops on one foot, etc. The child with the calculator begins by keying in 1 + and then, each time the other child successfully bounces the ball, keys in =. This activity can help a child develop their understanding of adding 1.

(Note: Your calculator must have a constant function for this to work – see 'What Kind Of Calculator? No.5.' above).

Now, the sceptics amongst us might be thinking that we can facilitate this particular learning without a calculator. This is true, but we would contend that the calculator is *another* tool for helping children develop their understanding in mathematics. We wouldn't think of limiting children's access to tools such as pencil and paper, and concrete objects. Similarly we shouldn't limit their access to the very common simple calculator.

3. Favourite number

Several children could key into their calculator any number between 0 and 10 (or more, depending on the understanding of the children). After checking each other's number, they could then arrange themselves in a line from smallest to largest number. As well as developing number sense this also involves children in communicating and co-operating with one another.

4. Name 5

Have a fish pond drawn on a piece of card roughly in the shape of an hour-glass. In other words, there are two connected parts to the pond so that the cardboard fish can 'swim' from one part to the other. Let the children arrange the fish with, say, 3 in one part and 2 in the other. Having worked out the total number of fish, they could 'record' this on their calculator, i.e. 3 + 2 = 5

They could then make a more permanent record on paper. The value of this task is that the children's actions in pressing the calculator keys models the form of number sentence they need to write. The calculator acts as a useful bridge between the hands-on work and the abstract recording of their findings.

Some Suggested Calculator Tasks for 7 and 8-Year-olds

1. Patterns

Encourage the children to find and record as many different patterns as they can using their calculator. For example, some children have found that 1 + 2 = = = will give all the odd numbers, and that + 2 = = = will give all the even numbers. Some teachers get their children to record their patterns on long strips of paper, called number rolls (Groves & Cheeseman, 1995). These might then be decorated or dyed and put on display. In these sorts of activities children can be asked questions that encourage the identifying of patterns (e.g. in even numbers the ones digit follows a pattern of 2, 4, 6, 8, 0, 2, 4...). Prediction skills can also be fostered, for example, "What do you think will come next?".

Other children have derived all the doubles (i.e. 1+1=2; 2+2=4; 3+3=6; etc) and the squared numbers (i.e. 1x1=1; 2x2=4; 3x3=9; etc), while others still have constructed number rolls to figure out the 10x table (+10 = = = etc. leading to 1x10=10; 2x10=20; 3x10=30; etc) and various other tables (including, in one case, the 50x table!) This latter activity of constructing the various times tables can be done in quite meaningful contexts. For example, the 3x table can be constructed from counting the legs on various numbers of 3-legged stools, the 4x from counting the feet on 4-legged animals, the 5x from counting the fingers on hands, the 6x from counting the legs on insects, and the 8x from counting the tentacles on octupi or the legs on spiders.

In these activities children can use the calculator as a support to their one-to-one counting, for example, count 3 legs on the stool, then key in 3; now count another 3 legs on another stool, key in + 3 = . The child might like to check that the calculator is right!

2. Wipe out

This is a task designed to help children understand place value. Ask children to put, say, 14 on their calculator. Now invite them to wipe out or get rid of the '1' in one turn (that is, without deleting the 14 and replacing it with 4). See if they can get rid of the '2' in 25, the '3' in 38, etc. in the same way. For capable children, the task could be extended into the hundreds. Indeed, many of these activities can be adapted for different levels. For example, Wipeout can also be used with decimal numbers – wipe out '7' in 143.75 etc.

3. Moving digits

This activity is designed to help children see what happens when a number is multiplied or divided by 10, or 100. For instance, they can find that the effect of multiplying a number by 10 is that the digit(s) move one place to the left on the calculator [if 5 is x 10 then the 5 shifts one place to the left, and a zero fills the ones place]. Similarly, they can find that the effect of dividing a number by 100 is that the digit(s) move two places to the right [if $250 is divided by 100 it becomes $2.50].

4. Discovering identity

The identity principle is the idea that a number retains its identity (i.e. remains the same) under certain operations. Children can be helped to see that for a variety of numbers (many examples can be done relatively rapidly on the calculator) the following seem to be the case:

- adding or subtracting zero does not change a number (i.e. the identity number or element for addition and subtraction is 0).
- multiplying or dividing a number by one does not change the number (i.e. the identity number or element for multiplication and division is 1).

They may also discover that subtracting any number from itself always results in zero, and dividing any number by itself always results in one.

Some Possible Activities for 9 and 10-year-olds

1. Getting into decimals

Calculators can be used to help children learn about decimal numbers. An idea developed by Thompson & Walker (1996) is the use of individually wrapped, square, processed cheese slices that are divided into tenths (and hundredths!) - a great way to demonstrate that one hundredth is smaller than one tenth. If the use of cheese does not appeal, then 10 x 10 paper grids can be used. The children appear to readily accept that the square of cheese can be divided into ten pieces and thus one of these pieces is one tenth of the original piece. A connection may then be made to the decimal number equivalent to one tenth (i.e. 0.1). The children are asked, "What did we do to get this strip (1/10) of cheese?" "We divided the one piece of cheese into ten pieces." "O.K. then, what does the calculator say about this? Let's enter 1 ÷ 10 =. What appears on the screen?" Hopefully the children will make the connection that 1 ÷10 = 0.1.

"How should we make use of this extraordinary technology to further the mathematics education of our students?"

A number line could then be constructed linking the common fractions to their decimal numbers. Thompson & Walker (1996) suggest developing a number line one metre long. Hundredths are easily located on this number line (1/100=1cm if the number line is 1m long) as are other common fractions (1/4 = 25cm = 0.25; 1/2 = 50cm = 0.5; 1/5 = 20 cm = 0.2; and so on). Remember, ordinary fractions are converted to decimal fractions by dividing the top number by the bottom number.

2. What's my number?

This activity extends ideas to do with decimals, and is played in pairs. It requires a calculator with the constant function. One child puts a number into her/his calculator, divides it by itself, and then pushes equals, e.g. 5 ÷ 5 = . The result, of course, is 1. The partner then tries to figure out what number was originally keyed into the calculator. This is done by keying in a possible number and pushing equals [e.g. 4 =]. The number 0.8, or .8 appears on the screen. Since this is not one, it follows that 4 could not have been the original number. The partner then tries another number (WITHOUT DELETING ANYTHING), e.g. 6 = . The result this time is 1.2, which is a bit more than one, so 6 must have been too much. Again, without deleting anything,, the partner may now try 5 =. At last the caculator shows 1, so the original number must have been 5. This activity too can be extended to include larger numbers and later, decimals.

2. Range game

This game helps children develop number sense by getting them to think in terms of total numbers. For example, 5 x what number falls within the range 101 to 119? This can lead to a consideration of the smallest and largest number within the range. The game can be varied to make it as easy or challenging (including decimals) as desired.

Some Final Comments

Do not ***formally*** *teach calculator use:*

Some mathematics programmes that we have come across advocate that children be taught how to use the calculator, that is, that they be instructed what the various keys are for and how they should be operated. We advise against this, for two reasons. First, although it seems logical to begin this way, it is very behaviourist and does not take account of the psychology of children's learning in mathematics. In our experience, and the experience of others who have been involved in calculator projects, children can learn about many of the calculator functions themselves. If given the opportunity to explore the calculator, it is amazing what children can figure out; if one child discovers a new function, then the word can spread around the class like wild-fire. Second, problem solving should permeate the whole mathematics programme, which means that children should be able to approach calculators in a problem solving manner too. They should, for instance, have a chance to ask themselves, "I wonder what this does?" or "I wonder how that works?" If approached this way, then the teacher can challenge the children with a range of problems, such as, "I wonder what would happen if you....?"

None of these comments, however, preclude helping children informally to know what various keys do. For example, you can say to a child, "If you want to find out what six lots of 15 is, then you will have to go 6 x 15 = (that is, 6 times 15 equals...)."

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Children may work beyond your expectations:

Do not be surprised if children go well beyond what you think they are normally capable of in mathematics. For example, some of your children may begin working with very large numbers, or may get into negative or decimal numbers, at a younger age than you would expect them to. This can be a scary thought for those not confident with their own knowledge of negative and/or decimal numbers. However, maybe this can be viewed as an opportunity to model the learning process, for example, "That's a really good question – let's find out!"

Always have calculators available:

A calculator should be regarded as just another piece of equipment and be available during most mathematics learning sessions. Ideally, each child should have his or her own calculator. Some schools include a calculator on the children's list of materials that they need to buy. Others have invested in class sets so that there is at least one calculator between two children.

Retain conventional mathematics learning equipment:

As we suggested earlier in the paper, the calculator should not replace the usual mathematics apparatus and materials. Rather it should complement place value blocks, pattern boards, Cuisenaire rods, multi-link cubes, buttons, bottle tops and the like.

If you have not tried using the calculator with your children before then we suggest that you begin in a small way so that you get a feel for its potential. We wish you all the best. Please feel free to contact us, or your nearest friendly mathematics adviser, if you have any queries, concerns, comments or success stories.

References

Biddulph, F. (1991) Do calculators have a role in primary mathematics education? SAMEpapers 1991. Hamilton: Centre for Science and Mathematics Education Research, University of Waikato.

Biddulph, F. (1992) Learning with a calculator: Possibilities for 5 and 6-year-olds. Hamilton: Centre for Science and Mathematics Education Research, University of Waikato.

Biddulph, F. (1996) Convincing preservice teachers about calculators. In P. C. Clarkson (Ed.) *Technology in mathematics education.* Proceedings of the 19th annual conference of the Mathematics Education Research Group of Australasia Inc., Melbourne.

Coleman, T. & Snape, T. (1999) Calculator use in the primary school. *Teachers and Curriculum,* Vol.3. University of Waikato: Leaders' Press.

Groves, S, & Cheeseman, J. (1995). Beyond expectations: Using calculators with young children. *SET (Research Information for Teachers), No.1, Item 3.*

Hepburn, Barbara. (1996). Calculators and parents. *Teaching and learning mathematics.* The Association of Teachers of Mathematics. Great Britain.

Lindale, C. & Biddulph, F. (1991) Introducing calculators to junior children. SAMEpapers 1991. Hamilton: Centre for Science and Mathematics Education Research, University of Waikato.

McChesney, J. (1995) The difficult road ahead for the simple calculator. In J. Neyland (Ed.) *Mathematics education: A handbook for teachers. Vol.2.* Wellington: Wellington College of Education.

Storey, B. (1994) Introducing the calculator. In In J. Neyland (Ed.) *Mathematics education: A handbook for teachers. Vol.1.* Wellington: Wellington College of Education.

Thompson, C. & Walker, V. (1996). Connecting decimals and other mathematical content. *Teaching Children Mathematics, 2, 8, 496-502.*

Usiskin, Z. (Ed.) (1999) Groping and hoping for a consensus on calculator use. *Mathematics Education Dialogues, Vol.2, Issue 3.* Reston, Virginia: National Council of Teachers of Mathematics.