Developing Children's Number Sense Using Calculators

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Abstract: In the past, most people believed that calculators were useful only for obtaining or checking answers to computation problems. Therefore, in many ways they have often been ignored as a teaching resource. Based on the lack of interest, some parents and teachers have shied away from calculator's use, especially in primary mathematics. Many researchers have also found that using calculators as a teaching aid is most useful and effective in developing number sense and mental computation. The *Calculator-Aware Number* (CAN) project in Britain found that children develop their own strategies for carrying out calculations and achieve a high level of numeracy when using calculators

Key words: teaching aids, computational tools, motivators, number sense.

Of the three available methods of computation, i.e. mental, paper-and-pencil, and calculator, mental and calculator computations are the ones most frequently used in everyday life. However, in schools, paper-and-pencil methods still receive the most emphasis (Department of Employment, Education, and Training, 1989). Calculators used to be considered appropriate for older students, e.g. secondary students, who have already mastered basic numeracy skills. Now, it is realized that the calculator can be used in teaching even very young children as well. Indeed, computational alter-

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natives are very important issue facing mathematics educators in preparing young children in the era of high technology.

These computational alternatives -calculators, paper-and-pencil, mental computation, estimation and computers- need to be developed in order to allow children to make wise choices in the selection and use of these alternatives for solving their mathematical problems. To do so, people who are in charge of mathematics education, i.e. lecturers, researchers and teachers, have to think how to create an instructional balance using these alternatives in schools.

Shuard et al (1991) state that, in the past, calculators were regarded as having two major functions. Firstly, children used calculators to check their mental calculations and, secondly, they used calculators for calculations, which they needed to do, but which were too complex for their heads to do or using paper-and-pencil method. Since the mid of 1980's it has been recognized that the calculator has a third use. It can be a resource for generating, introducing and developing mathematical ideas and processes. In other words, the calculator should be used as a teaching aid in mathematics. Finally, calculators can be used to explore the calculator's keys and operations.

The widespread availability and use of calculators and computers in primary schools have challenged teachers to rethink how mathematics should be taught. Some topics in primary mathematics may be easier to develop using calculators -for example, number patterns. The use of calculators in primary schools can increase children's performances in dealing with numbers. Sometimes calculators can extend children's skills in mental computations (Shuard et al, 1991).

WHY INTRODUCING CALCULATORS IN PRIMARY MATHEMATICS?

The calculator is one of the most effective and efficient computational tools because it can be taken anywhere and has many functions. Moreover, the calculator can be used to motivate young children to learn mathematics as well as to reduce the burden of difficult calculations.

Blane and Willis (1986:55) give the following reasons why teachers should introduce the calculator in primary mathematics as a teaching aid, as a computational tool and as a great motivator. Very few companies use paper-pencil calculations in preference to the calculator. Calculators

are with us now. They will never go away. Children should learn their strengths, their place in mathematics, and also their limitations. Calculators can be a teaching aid, providing a constructive tool for developing understanding. They are great motivator for the mathematics lesson. Calculators provide many opportunities for mathematics creativity. They assist a child in overcoming specific 'danger areas' or calculation barriers to solving problems that are otherwise within the cognitive range of the child. The calculator is a vital aid when introducing and working with decimals, place value, sequences, problem solving, the inverse properties of the operations x & + *and* + &, and also in estimation.

The Calculator as a Teaching Aid

One of the most important functions of calculators in primary mathematics is as a teaching aid to develop number concepts.

The calculator is one of the most effective tools that can be used to develop number concepts (Manalu, 1994; Hanbury, 1994; Williams, 1987). Fanning (1989) argues that using calculators helps to develop place value concepts and teach counting in primary mathematics. An example of how calculators can be used to develop place value concepts is to ask children to enter number 567 on the calculator, then ask them to wipe out 6. In these case, children should know that the value of 6 in 567 is 60. So, they should take away 60 from 567. By creating a lot of examples, especially using large numbers, children will develop their understanding about place value and their number concepts in general.

Howard (1992) points out that the calculators can be used to generate many examples in a short time, e.g. to develop number patterns, from which children can see the patterns before making generalizations. The calculators can also play an important role for young children's number development, especially if they use them to explore numbers freely.

Calculators are an excellent teaching aid for generating counting sequences by using constant addition (Fanning, 1989; Cheeseman, 1994). Children can use calculators to count by given number. For example, to count by 3's the instruction is 3 + = ...

The calculator will show the sequence as follows: 3, 6, 9, 12, 15, Teachers can then ask the children, "What is the next number?", or, "If you press = ten times, what number will appear?" Such exercises are good for practicing mental computation, developing conceptual under-

standing of number, and improving critical thinking, because children will investigate and maybe analyze some patterns before giving a generalization or an answer.

The Calculator as a Computational Tool

Another function of the calculator in primary mathematics is as a computational tool. Children can use them for checking and finding answers, especially for complex mathematical problems which are difficult to do in their heads. Moreover, using a calculator to check and find answers is very fast.

As technological tools in doing mathematics in primary school, calculators can increase children's confidence (Howard, 1992:325). For answers which are found mentally, children can check and see the real answers on the calculator. They may think carefully about the answers if the answers found mentally and those found on the calculator are different. Hopefully, they can try again to find the answer mentally in order to have the same answer as the calculator (if the calculator buttons were pressed correctly). For simple computations, teachers should convince children to find the right answers using other computational alternatives (e.g. paper-and-pencil methods) before using calculators as a computational tool to find or check their answers. The purpose of this method is to avoid children's depending too much on the calculator.

Calculators free children from the burden of difficult calculations and let them concentrate on the question and on what might be a reasonable answer (Bennett & Cheeseman, 1990:256).

The Calculator as a Motivator in Learning Mathematics

The calculator can be a motivator in mathematics and is very important to reduce the burden of calculations in terms of time when attention should be focused elsewhere. Calculators can do this in at least three ways: by providing the correct answers, by enabling attention to remain on the problem, and by giving confidence to try specific cases. Calculators can also provide a rapid picture of what is happening through their visual display (Open University, 1982).

Children who have free access to calculators will begin to use them to try out ideas, experiment and explore numbers. Children might feel

more comfortable doing the exploration of numbers with calculators than with their teacher or even by committing their ideas to paper (Bennett & Cheeseman, 1990). By using free investigations of finding, and understanding from the observation or investigation, children can improve their understanding about numbers. Calculators provide an excellent opportunity for discussion because every child has different interests and can choose different numbers and keys to press.

THE CALCULATOR AS AN AGENT FOR CHANGE IN THE CURRICULUM

One of the recommendations of the National Council of Teachers of Mathematics (NTCM, 1980) is that "Mathematical program must take full advantage of the power of calculators and computers at all grade levels' (NTCM, 1980:8). The calculator is one of the tools that the children should know and use in this technological era. Fusin (1992) suggests that school mathematics needs to undergo a shift from teaching children to be calculators for known adult problem situations to helping children learn to use calculator -and other future tools- to solve problem situations not yet imagined by adults. Her suggestion reflects the changes in mathematics education in the United States of America, which are summarized in Curriculum and Evaluation Standards for School Mathematics (NTCM, 1989:15-16, 65-69).

Children themselves should understand the various mathematical problems that can be solved using calculators. Calculators have the potential to transform school mathematics from a procedure dominated to the exciting study of numbers and their relationship.

In summary, there are many benefits that can be offered by calculators in the primary classroom. The calculator can also be used as a means of solving problems in faster, more effective and more efficient ways. Moreover, the calculator is a very good motivator that may lessen the burden of the children in learning mathematics because they can use it while playing, enjoying, and even just freely exploring its arithmetic functions. Finally, the calculator is a device, which provides plenty of opportunities for trying to solve problems of greater challenge.

THE SUPPORT OF THE CURRICULUM

The Curriculum and Standards Framework for Mathematics (Board of Studies, 1995) supports the use of the calculators in primary mathematics.

In the section on the Availability of Technology (p. 14), the Curriculum and Standards Framework: Mathematics (CSF) clearly mentions that recent improvement in the availability of calculator and computer software has forced a major reevaluation of school mathematics curricula in terms of content and strategies of teaching and learning mathematics. It further supports the use of the calculators and computers in primary mathematics by placing clear emphasis upon the sensible use of the technology in concept development, as well as in technology-assisted approaches to problem solving, modeling, and investigative activities. The document also states that at all times the choice of the appropriate technology and the extent to which it is employed should be guided by the degree to which these tools assist students to learn and do mathematics. Furthermore, the CSF includes a strand called Mathematical Tool and Procedures at every grade level. There is a clear evidence that tools, including calculators, are very important in doing mathematical problems.

In the section on Mathematical Tools: Curriculum Focus of the CSF, it is clearly indicated that calculators are an important tool that should be used by children in learning mathematics. The curriculum provides plenty of opportunities for every grade level to use calculators as teaching aids with different emphasis. For example, in grade one, children are asked to use a four-function calculator to represent and explore numbers. In grade two children are asked to use them for calculations with numbers and to develop place value concepts. In grade three and four, children are asked to use a four-function calculator to investigate patterns and to perform operations on whole numbers, money and other measurements, while grade five and six children are asked to use calculators to carry out sequences of operations on whole numbers and decimal numbers.

From the discussion above it is clear that, in order to achieve the curriculum core, schools should ensure that calculators are available for mathematics lessons and are consistent with the outcomes at each level. While children would be expected to own four function or scientific calculator, it may still be necessary for a school to provide some graphing calculators for work at level six and seven. In order to respond to this statement and enhance children's learning, Curriculum Development Centre and the Australian Association of Mathematics Teachers encourage: teachers to become aware of the potentials of calculators by reading, discussing with colleagues and exploring the use of calculators in their classroom

and by becoming proficient calculators; schools to develop and implement their own policy on the use of calculators in cooperation with other schools and be consistent with the recommendations made in this document; examination boards to incorporate the calculator into their assessment procedures at all levels to reflect the increasing extent and range of calculator use in schools; parents to support and liaise with the implementation of local policy regarding the use of calculators by their children; publishers to integrate the appropriate uses of calculators into all their publications in mathematics at all levels (Curriculum Development Centre and the Australian Association of Mathematics Teachers, 1987:5).

NUMBER SENSE

The term *number sense* refers to several important but elusive capabilities, including flexible mental computations, numerical estimation, and quantitative judgement. Number sense is a term that requires theoretical analysis, rather than a definition (Greeno, 1991). In the Curriculum and Evaluation Standards for School Mathematics (NCTM, 1980), number sense is defined as an intuition about number that is drawn from all the varied meanings of number. Markovist and Sowder (1994) use the same term of number sense as an intuitive feel for number.

Children's number sense allows them to understand numbers and their multiple relationship, e.g. operation, relative magnitude of numbers and reference for quantities and measures. Number sense also refers to a well-organised conceptual network that enables one to relate numbers and their operation properties and to solve number problems in flexible and creative ways. Greeno (1991:185) likens mathematics to a conceptual environment, stating that the methapor of a subject-matter domain as an ability to find and use concepts and principles in the environment as resources seems to apply well to domain of number and quantities particularly in its suggestions regarding number sense. He further states that people with number sense know where they are in the environment, which things are nearby, which things are easy to reach from where they are, and how routes can be combined flexibly to reach other places efficiently.

Since textbooks are limited to paper-and-pencil orientation, they can only suggest ideas to be investigated, they cannot replace the 'doing of mathematics' that is essential for developing number sense. At all grade

levels, no subtitutes exist for a skillful teacher and an environment that fosters curiosity and exploration.

THE ADVANTAGES AND DISADVANTAGES OF USING CALCULATORS

Some advantages and disadvantages of using calculators in learning mathematics in the rural areas in Indonesia can be presented below.

Advantages: introducing new technology in the rural areas; improving students' self-confidence when checking answers; facilitating students when facing complex computations; motivating teachers in creating new methods in teaching mathematics; facilitating teachers and students in facing new era in learning mathematics; reducing any burden in learning mathematics.

Disadvantages: improving students' dependence to computational tools; reducing students' attention when teachers explaining lessons; students may use calculators to find answers to computational, problems if teachers do not controll them seriously; students may use calculators to find answers, if teachers cannot create teaching method related to calculator use.

The following are examples of using calculators to develop children's number sense.

Counting by ...'s

Sense of numbers can be developed using the method of counting by a certain number. For example, counting by 2's. Input number 2, + and = signs. So the formulation is 2 + = . Press = sign repetitiously according to students' needs. Then, the calculators will show the sequence as follows 2, 4, 6, 8,... After pressing = sign 9 times (example), then ask students, 'What next number will appear?'

Place Value

Ask children to enter number 234 (example) on the calculator. Then, ask them to wipe out 3. In that case, students should know that the value of 3 in 234 is 30. So they should take away 30 from 234. By creating a lot of examples, especially using large numbers, children will increase their understanding about place value of numerals in numbers.

Number Lines

Ask children to enter certain numbers followed by + and = signs. Press = sign step by step. Then, the calculator will show number line. For example, 3, 6, 9, 12, 15, ... To develop children's number sense, ask them to close their eyes when pressing = sign, then ask them how many times = sign should be pressed if the sequence is, like 3, 6, 9, 12, 15, 18.

CONCLUSION

The availability and the use of calculators in primary mathematics can help children to develop place value, number patterns and relationships, and mental computation. However, calculators have not been widely used in primary school mathematics to explore numbers. Calculator provides a rich mathematical environment. Finally, the calculator is convenient computational tool that can be used to encourage children to check their answers found mentally or using other computational alternatives.

Even though most of the research findings support the use of calculators in primary mathematics and policy statements on the use of calculator support their use, wider use of calculators in primary mathematics is still debated by some people in terms of their role in teaching mathematics. On the one hand, many teachers, especially in developed countries use calculators as a teaching aid to develop number sense. On the other hand, plenty of teachers just use calculators to check or find answers.

Number sense is an intuition about numbers that allows children to develop a well developed sense of meaning for numbers and their relationships and the ways in which numbers are embodied, including symbols and operations on numbers. Number sense needs to be developed effectively and efficiently by using computational tools that provide the opportunity to explore mathematics.

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