Let's Bring Calculators Out of the Closet

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Technology is having a strong influence on elementary school mathematics programs, as indeed it should. It is no longer futuristic to talk of a technological revolution, or of a computerized society. They are here. We see evidence of calculator and computer use every day--at home, at the supermarket, at the bank, and at other commercial establishments. It has been reported that more than 75 percent of nine-year-olds either have a calculator of their own or access to a calculator at home. (Carpenter, Corbitt, Kepner, Lindquist, and Reys, 1981). To ensure that children will be able to function effectively once their formal education is completed, our instruction in school should be aimed at equipping students to cope not only with their present environment but with a changing world.

Instruction about and with calculators has been advocated for several years. In the late 1970s, numerous articles were published both in professional and popular journals and in books dealing with the pros and cons of using calculators in the elementary school. In the early 1980s, while some resistance to the use of calculators in elementary schools was still apparent, awareness of the potential instructional uses and benefits of calculators was slowly increasing as people accepted the existence of calculators in their lives and in their children's lives (Suydam, 1980).

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In April 1980, the National Council of Teachers of Mathematics (NCTM) released An Agenda for Action: Recommendations for School Mathematics of the 1980s. One of the eight recommendations dealt with computing technology: "Mathematics programs must take full advantage of the power of calculators and computers at all grade levels"(p. 8). One recommended action to accomplish this goal was as follows:

> Calculators should be available for appropriate use in all mathematics classrooms, and instructional objectives should include the ability to determine sensible and appropriate uses. (p. 9)

In this province, Guidelines for the Use of Calculators Grades 1-12 was published by Alberta Education in 1981, encouraging the utilization of calculators as instructional and computational aids in all Alberta classrooms.

Given the wide accessibility and strong support for their use, what has happened in the past few years to integrate calculators into the mathematics curriculum? Not much! Calculators are not being used to advantage in many classrooms (Williams, 1983). They are, in effect, in the closet.

Factors Influencing Non-Use

What happened to slow down, if not stop, the acceptance of calculators as an important instructional aid in mathematics? Probably the most important factor was the arrival of the microcomputer. The energies of mathematics teachers seem to have been diverted to the acquisition and use of microcomputers. In what are genuine (and laudable) efforts to further the use of technology in schools, the instructional value of calculators appears to have been forgotten or dismissed. Williams makes an interesting point when he says:

> It is curious that many who questioned the educational value of the role of calculators in the mathematics education of elementary school students have no reservations about putting microcomputers in every elementary school classroom. (1983, p. 4)

Another factor contributing to the inertia in using calculators is that some of our earlier fears about them still exist. These fears which are "founded on hearsay, half-truths, and innuendos," ignore evidence from research on achievement and learning, yet form the basis of many people's beliefs and attitudes about the use of calculators (Reys, Suydam, and Lindquist, 1984, p. 11). Erroneous beliefs created by these fears need to be dispelled.

Belief 1: Students will not learn "the basics" and mathematics achievement will decline.

Over 150 studies on the effects of the use of calculators have been conducted in the last 10 years. Few other topics have received so much attention during this century. Consistently the results have indicated that "No, the calculator does not appear to affect achievement adversely" (Suydam, 1980, p. 3). In nearly all instances (97 percent), achievement scores are as high or higher when calculators are used for mathematics instruction than when they are not used for instruction, even though use of the calculator is not allowed on the tests (Suydam, 1980). In fact, not only are there no measurable detrimental effects, there is evidence "that children in the primary grades benefit from using calculators in the study of mathematics" (Wheatley, Shumway, Coburn, Reys, Schoen, Wheatley, and White, 1979, p. 20), and "research is showing the calculator to be a powerful teaching and learning tool" (Driscoll, 1980, p. 1).

Belief 2: Students will become dependent upon calculators.

The response to this belief could be "Yes, students might become dependent upon calculators <u>if</u> we do not teach how to use the calculator intelligently."

Calculators are instructional tools which have certain capabilities, but which also have certain limitations. Teachers must accept the responsibility for teaching students how and when to use calculators, and thus what their limitations are. This must be done in elementary school, before attitudes and habits become ingrained. In a calculator and problem solving study, it was noted that "there was no evidence that the students became calculator dependent" (Suydam, 1979, p. 2).

Belief 3: Using calculators does not require thinking.

In a study involving 50 elementary school classrooms, Grades 2 through 6, researchers observed that "Children soon learn (much to their surprise) that the calculator does not think for them" (Wheatley et al., 1979, p. 20). Of course calculators do not think--they only follow instructions. It is the person operating the calculator who decides which keys to punch, what order to punch them in, and how to interpret the result. In the study mentioned above, both teachers and students reported that students tried difficult mathematics problems that they would not have tackled without a calculator. In fact, a very strong argument can be made that using calculators actually increases student thinking (Reys, Suydam, and Lindquist, 1984, p. 11). Mathematics is more than computation, and using the calculator frees students from laborious and tedious computation, and forces them to dwell on the thinking that usually precedes computation.

Exposing these three beliefs as erroneous provides the most compelling reasons for using calculators with elementary school children.

Effective Uses of the Calculator

Calculators can be used as efficient and effective instructional aids in developing and practising major areas of the elementary mathematics curriculum.

Basic Facts

Clearly, a significant proportion of instruction in the early grades must continue to be based on the use of manipulative materials, which are essential for initial concept development. Equally clearly, the rapid recall of the basic facts of arithmetic must remain an important instructional goal in elementary grades. Use of a calculator has been shown to actually enhance the learning of basic facts in the primary grades (Channell, 1980).

Strong evidence also exists that students are enthusiastic about using calculators, that greater motivation for learning is accompanied by a more positive attitude toward mathematics, and that greater persistence is shown resulting in more time on task. It seems foolish not to take advantage of these "intangibles" to help all children master the basic facts of arithmetic.

Many ways of using calculators in the development and mastery of basic facts exist and can be found in the sources named in the "Student Materials" list at the end of this article. Two illustrations follow.

Beat the Calculator. One calculator with two children can provide effective practice. One child enters a basic fact in the calculator, for example, 6 x 9 or 5 x 8, and at the same time says the fact aloud to the other child, who tries to write the answer before the first child can get the answer displayed on the calculator.

Hidden Facts. A calculator with an automatic constant addend or multiplier can provide individual practice. For example, to practise multiplying by 7, the child enters 7 x = which the calculator "remembers." Any number now entered will be multiplied by 7 when = is pressed. The child enters a number, for example 8, mentally does the multiplying, presses = and 56 is displayed. This "hidden facts" technique can be used with any operation and any set of numbers.

Understanding and Concept Development: Operations and Place Value

Calculators emphasize when to use a certain operation and what operation to use, rather than how to perform algorithms. This emphasis can increase students' understanding of the four basic operations and of the relationships between them. The meaning and importance of place value can also be illustrated. Many examples similar to those below are contained in the sources listed in the "Student Materials" list.

Make it Big!

Put 4, 5, 6, 7 in the squares to make the the largest number possible.

☐ ☐ x ☐ ☐

Which Operation?

8 ☐ 5 ☐ 2 = 26

Switch it!

Change one + to a - to get an answer of 44:

20 + 22 + 24 + 26

Wipe Out: Remove the 7

from 876543
from 0.567891

Estimation Skills

Estimation skills can be developed using a calculator, and indeed are needed in order to use a calculator effectively. Students must become alert to the reasonableness of results rather than merely accepting whatever answer the machine produces. Skill at estimation is an essential and practical daily life skill and also promotes a sense of "friendliness with numbers." Consider these examples.

Find the Number One student enters a number and pushes + then = several times. For example, enter 12 and push + then = three times. Calculator displays 48. Give the calculator to another student who is to identify the mystery number by pushing = as many times as needed. Each time = is pushed the first player gets one point. Students exchange and play again, then add their scores. The one with the highest score wins.

Target Multiplication Students are given a target area and an entry number, for example, target area 680-710, entry number 25. One student enters 25, pushes x, enters a number to try to get in the target area and pushes x again. If in the target area, that student wins. If not, the calculator is given to another student who enters a number and pushes x to get the new number in the target area. Play continues until one student "hits the target." Some experience multiplying with decimals is necessary. A similar target game may be played using divisions. For addition and subtraction target games, students are given several numbers and a target, and asked to choose two numbers whose sum or difference is closest to the target.

Pattern Searching, Exploring, and Discovering

The study of mathematics is often defined as a search for patterns. Recognizing a pattern requires a student to analyze and reflect, to notice similarities and differences, and to become aware of the distinction between essential and nonessential elements--all of which involve important aspects of problem solving. The experience of exploring and discovering patterns and relationships is enhanced by the use of the calculator because its display is easily erased and students are not discouraged by mistakes. The calculator also frees the student from the drudgery of computation where the underlying pattern can be lost in the length of the computations. The calculator only does the calculating; the student must do the thinking, observing, and testing to arrive at generalizations and discover the pattern. Pattern searching activities can also awaken in students a fascination with numbers which helps develop a friendliness for numbers far beyond that attained by students who are merely competent "symbol manipulators." Following are examples of such activities. Again, the reader is referred to the "Student Materials" list for additional sources of activities.

Counting A calculator with a constant addend/multiplier is necessary for most counting activities. Students begin by counting by ones which should emphasize the physical link between the display and pressing the keys. Usually pushing 1 + = = = will make the calculator count by ones starting with 1. To begin from any other number, say 50, enter 50 + 1 = = =. Practice in counting helps students relate the size of the number to the amount of time needed to push the buttons to count to the number. Counting both on and back by ones, twos, threes, fours, and so on, can lead to many patterns, an awareness of sequence, and preparation for all the operations. Counting on or back by tens and hundreds places an emphasis on place value, as does counting by tenths and hundredths.

Nifty Nines Students multiply each of the numbers 1 through 9 by 9, in their heads, and write the products. Then the calculator is used to multiply each of the numbers 1 through 9, by 99, by 999, and by 9999. The pattern which emerges can be tested by multiplying 99,999 without the calculator.

Seeing Double Students are told to multiply their favorite two-digit number by 101, then multiply other two-digit numbers by 101. After noting the pattern, students are to predict whether this will happen with any two-digit number, and tell why or why not.

Problem Solving

Learning to solve problems is the main reason for the study of mathematics. The NCTM Agenda for Action (1980) recommends that "problem solving be the focus of school mathematics in the 1980s" (p. 1). The development of problem solving skills is one of the major goals listed in the Elementary Mathematics Curriculum Guide for Alberta (Alberta Education, 1982). In addition, Alberta Education has recently published a monograph entitled Let Problem Solving Be the Focus for the 1980s.

The calculator may have its greatest impact on students' problem solving abilities. Often students' principal difficulty in solving problems has been the inability to compute, and the calculator eliminates this problem. Calculators thus shift attention from the drudgery of tedious computation to strategies for problem solving. Students must be able to determine what strategies and operations to use--how to solve a problem--before they can use the calculator to get a solution.

Research indicates that students solve more problems and employ a wider variety of strategies when calculators are used (Wheatley, 1980). Utilizing a calculator as a problem solving aid allows students to deal with more realistic data than only numbers that come out evenly and decreases anxiety about computational errors. In short, calculators appear to extend students' abilities to solve problems.

Again, the "Student Materials" list at the end of this article contains many sources of problem solving activities using the calculator.

Concluding Observations

Support for the use of calculators in elementary school would seem overwhelming. We have everything to gain and nothing to lose in adopting calculators as instructional tools. Related curriculum changes are inevitable--as they should be. Even now, curriculum committees and textbook authors are including calculator activities as part of the regular program. The near future will undoubtedly see a drastic reduction in the amount of time and energy devoted to insisting that students become highly proficient in performing paper-and-pencil calculations with numbers of more than two digits. Instructional time is a precious commodity, and students who are forced to spend this time learning to behave like relatively inexpensive machines are learning the skills most subject to obsolescence! Students' time should be devoted to learning skills more likely to be needed by humans in a technological world. The near future should also see the development of tests which measure more than computational facility and which allow the use of calculators.

But significant and enduring curriculum change does not depend solely on textbooks and tests. Real curriculum change begins and ends with the classroom teacher, because only the teacher can change what actually happens in the classroom. The situation is reminiscent of a story about a small boy and a wise man:

> The wise man came to the village once a year to share his wisdom. The small boy, as small boys will, decided to show the village that the wise man wasn't always right. He captured a small bird and held it in his hands. He planned to ask the wise man if the bird was alive. If the wise man said, "Yes," he would squeeze the bird and the wise man would be wrong. If the wise man said "No," he would open his hands and the bird would fly away. When the boy finally got to the front of the line and asked the wise man if the bird was alive, the wise man responded, "It's in your hands." (Immerzeel, 1976, p. 493)

And that is the situation with calculators today--only the classroom teacher can bring calculators out of the closet. It's in your hands.

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Williams, D.E. "Remember the Calculator?" Arithmetic Teacher 30, no. 7 (1983):4.

Selected Student Materials

1. Arithmetic Teacher
   November 1976 (Vol. 23 No.7)
   Special Calculator Issue
   1906 Association Drive
   Reston, Virginia 22091

2. Beginning Calculator Math
   Gerardus Vervoort and Dale Mason
   Fearon Pitman Publishers
   c/o Canon Canada Inc.
   3245 American Drive
   Mississauga, Ontario L4V 1N4

3. Calculator Activities for the Classroom Book 1
   George Immerzeel and Earl Ockenga
   Creative Publications, Inc.
   c/o Setsco Educational Ltd.
   567 Clarke Road,
   Coquitlam, B.C. V3J 3X4

4. How to Develop Problem Solving Using a Calculator
   Janet Morris
   National Council of Teachers of Mathematics
   1906 Association Drive
   Reston, Virginia 22091

5. Keystrokes: Calculator Activities for Young Students—
   Book 1: Addition and Subtraction
   Book 2: Multiplication and Division
   Book 3: Counting and Place Value
   Book 4: Exploring New Topics
   Robert Reys et al.
   Creative Publications, Inc.
   c/o Setsco Educational Ltd.
   567 Clarke Road
   Coquitlam, B.C. V3J 3X4