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# INTRODUCTION

## **Calculators and Controversy**

Calculators are not new. They have been available to the general public for over twenty years. Many people use them every day; some carry a calculator with them wherever they go. Why, then, is their use so problematic with respect to elementary and middle school mathematics teaching?

Educators have advocated using calculators in mathematics teaching for a number of years. In the United States some of the earliest thinking on calculator use in the schools came from the National Council of Teachers of Mathematics (NCTM) in *An Agenda for Action: Recommendations for School Mathematics in the 1980s* (1980), where it was noted that “[m]athematics programs must take full advantage of the power of calculators and computers at all grade levels.” Similar assertions were made in the United Kingdom (Cockcroft 1982) and Australia (Australian Association of Mathematics Teachers 1986).

Yet more than twenty years after the NCTM made its recommendation, calculators continue to have little impact on how mathematics is taught in elementary and middle schools, let alone on the content of that teaching. In fact, many people—parents, educators, and administrators alike—would like to ban calculator use in the classroom, citing fears that children will become reliant on them at the cost of developing proficiency in mathematics. And yet there is little research evidence that supports these fears. In fact, studies point in the opposite direction, by showing that sensible use of calculators in the elementary and middle school classroom leads to improved ability in mathematics.

## **Aims and Purpose of This Book**

Our general aim is to support teachers in developing sensible ways to use

calculators in the classroom and so help children mature as better and more confident mathematicians. Specifically, we attempt to:

- ◆ address issues raised by classroom teachers regarding calculator use
- ◆ provide clear links between calculator use and the elementary and middle school mathematics curriculum
- ◆ address questions raised by parents and others related to calculator use
- ◆ further an understanding of how calculators can engage children in thinking about mathematics and support conceptual understanding
- ◆ offer commentary on and examples of activities designed to incorporate sensible calculator use

### **Why Should We Use Calculators to Teach Math?**

In general terms, we should use calculators in the teaching of math in order to:

- ◆ help children develop number sense
- ◆ help children develop mathematical ideas and understand connections, relationships, and patterns
- ◆ acquaint children with technology
- ◆ respond to national standards
- ◆ put into action the findings of educational research

### ***Helping Children Develop Number Sense***

Number sense is an important idea in mathematics teaching. It is underpinned by the fundamental idea that children (and adults) should and can make sense of numbers. This seems obvious, but for many people numbers do not make sense. Number sense implies that children should deal with numbers in confident and flexible ways. They should have a variety of strategies they can use to approach a problem, and they should be able to select the most appropriate strategy for its completion.

There are two general ways in which a calculator may help children to develop number sense—as a computational tool and as a teaching and learning aid.

*The calculator as a computational tool.* The calculator allows children to work with numbers in ways that they would not be able to do with pencil and paper. In this sense, the calculator allows children to work with messy, real-life data. The calculator here is used as a computational tool, purely for its ability to deal easily and quickly with large numbers and complex data.

Because the calculator enables students to work with such material quickly and accurately, they can focus on the mathematical concept underlying the computational task. An example of how the calculator plays this role is shown in Section 2, in the activity Finding Pi?

*The calculator as a teaching and learning aid.* The calculator can also help children to think about numbers in different ways. In this sense, the calculator is used as a teaching and learning aid, much as students might use manipulatives. Teachers who are just beginning to use calculators in their classrooms often feel most comfortable with this mode of use. Activities reflecting such use are often highly defined and less likely to provoke the criticism that children are relying on calculators rather than thinking for themselves. A typical example of a calculator being used as a teaching aid is the game Wipeout, in which children are instructed to enter into the calculator a four-digit number (e.g., 4761) and then remove one of the digits (e.g., 7) by subtraction. Removing the 7 requires subtraction by 700 and an understanding of numeric face and place value. A fuller description of this activity is offered in Section 2.

### ***Helping Children Develop Mathematical Ideas and Understand Connections, Relationships, and Patterns***

An important aim of mathematics teaching is to help children understand that mathematics concerns relationships and patterns. The calculator can be a useful tool in helping children to develop this insight. The activity Multiplying by 10 in Section 2 is an example of how calculators can support learning important mathematical concepts.

The idea underlying Multiplying by 10 is that whole numbers and decimals follow a consistent pattern when they are multiplied or divided by 10 and powers of 10. Having an understanding of this concept allows children to develop a mental facility for multiplying and dividing numbers by 10, 100, 1,000, and so on. In doing this activity, it is important that children discuss and reflect on how the pattern changes with respect to multiplication and division and from whole numbers to decimals. This observation should help children understand how to quickly multiply or divide by 10 and powers of 10 without having to resort to the quick, but in many cases incorrect, add-a-zero rule often employed with whole numbers but not applicable to decimals.

### ***Acquainting Children with Technology***

Although critics often cite the use of calculators in elementary and middle

schools as one reason for low math aptitude among schoolchildren, according to research, calculator use in elementary and middle schools is limited. In fact, many eleven-year-old children in Britain were unable to cope with the requirements of a national test that demanded explicit use of calculators. They ignored the calculator options and resorted to standard pencil-and-paper methods for calculating. In the United States, one group of sixth graders reportedly rejected calculators in situations in which their use would be appropriate, because they were unable to understand the decimal display on the machine. Since their knowledge of division was limited to whole numbers and remainders, they were unable to interpret the decimal notation shown on the calculator. For many children (and adults), many of the keys on even the simplest of calculators (for example, the memory functions) are not used, because they never learned how to use them. Mathematics instruction that does not acknowledge the presence and power of calculators and that does not teach children how to use the calculator effectively and efficiently will continue to produce members of society who are “calculator ignorant.”

Therefore, another reason for using the calculator in elementary and middle schools is to help children understand how and when its use is appropriate. It is the job of the teacher to help children become “calculator-aware.” A calculator-aware child is able to make an informed choice about using, or not using, a calculator for a given computation. Effective teaching with calculators involves preventing children from becoming overreliant on these tools to the extent that they are used for even simple calculations.

### ***Responding to National Standards***

*The Principles and Standards for School Mathematics* (NCTM 2000) recently added to the points made earlier in *An Agenda for Action*; the “technology principle” of this document states that “[t]echnology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students’ learning” (24).

In fact, curriculum documents in the United States, the United Kingdom, and Australia widely recommend that calculators be used to:

- ◆ support and extend students’ mathematics-learning experiences
- ◆ develop mathematics proficiency within a technologically rich learning environment

- ◆ help children understand and use the features of a basic calculator, interpreting the display in the context of the problem and using the constant function, memory, and brackets to plan a calculation and evaluate expressions

### ***Putting Research Findings into Action***

Although research into calculator use at the elementary and middle school levels is limited, findings offer a positive view of such use. Major reports have come from the Calculators in Primary Mathematics (CPM) project in Australia, the Calculator Aware Number (CAN) and Calculator as a Cognitive Tool (CCT) projects in the United Kingdom, and two research meta-analyses in the United States (Hembree and Dessart 1986; 1992).

Used correctly, the calculator can be a powerful agent for change in the classroom. Reports from the CAN and CPM projects indicate that children made many gains in mathematics as a result of the introduction of calculators, which changed the way mathematics was taught in the project schools. The use of calculators caused teachers to reexamine their methods, assumptions, and philosophy of mathematics teaching. This served to highlight the calculator's role in

- ◆ enabling both teachers and children to focus on the development of number sense
- ◆ fostering positive attitudes and persistence with respect to mathematics
- ◆ furthering children's strategies when faced with a calculation
- ◆ increasing students' ability to solve problems in their heads and with pencil and paper
- ◆ eliminating the need for strict conformity to fixed sets of procedures in solving equations

The calculator is one of the best tools for developing computational choice, if it is used to further children's thinking about numbers. Results from the CPM project (Groves and Stacey 1998) indicated that children "made more appropriate choices of calculating devices" and that "there was no evidence that children became reliant on calculators at the expense of their ability to use other methods of computation" (128). Hembree and Dessart (1986; 1992) reported similar findings in the research studies they looked at in the United States, and noted that children's mathematical aptitude improved with the introduction of calculators into the classroom.

## Using This Book

We do not intend for this book to be read from beginning to end. A suggested method of use is to look through the questions in Section 1, read those that are of particular interest to you or most relevant to your classroom practice, and try out with your students the activities presented in Section 2. The math goal of each activity is identified based on the conceptual understanding or ability the activity is intended to support. The activities are particularly aimed at children in grades three through eight. Each activity is marked with a grade range of three to five or six to eight, but this is only a suggestion. You may want to adapt the examples to match more closely the needs of your students. Activities are typically generic in format; you should be able to modify them to meet the needs of different ages and abilities. You can try them with a small group or the whole class. Once an activity is completed, evaluate its effectiveness in developing children's mathematical understanding, always bearing in mind the responses of your students, especially those new to calculator use.

As you and your students become more confident in working with calculators, you may wish to integrate the calculator into your everyday mathematics teaching. Work with calculators should form part of normal classroom activity rather than being a special reward or mode of busywork for children who have completed their regular assignments.

Be prepared to learn along with your students, as together you explore the use of the calculator as a powerful tool in your mathematics classroom.