Using Electronic Calculators With Third And Fourth Graders
A Feasibility Study

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During the summer of 1974, a sequence of mini-experiments was conducted by the authors, exploring ways to use electronic calculators with children ages 5-7. The results showed that the children responded enthusiastically to the calculator, and that the students who used them showed considerable gains in mathematics achievement.

As a sequel to this sequence of mini-experiments, a small experiment was run using the hand held calculator with children ages 7-9. The experiment was designed to help answer these questions for grades 3 and 4: (1) which standard mathematics topics can be taught most effectively using the hand held calculator? (2) What implications does the hand held calculator have for problem solving situations? (3) What new mathematical topics can be successfully introduced because of the availability of the electronic calculator? For comparative purposes, a standardized mathematics achievement test was administered both before and after the instruction.

Five third and fourth grade children participated in the study during a ten week period in the fall of 1974. Three of the children attended regularly and were given the Metropolitan Achievement Test, both before and after the instruction. The other two attended irregularly, and were not tested. Instruction took place during 32 class meetings during the 10 week period, with each meeting lasting 30 to 60 minutes.

Among the topics which were introduced were the following:
Operation of the calculator.

Using large numbers on the calculator. The children discovered that some large numbers, such as 180 billion, cannot be shown on the calculator.

Writing numbers using only the 1, 0, + and = keys

Negative numbers (introduced using temperature and a number line with spaces to the left of 0); addition of signed numbers.

Internal logic of the hand held calculator; discussed visual appearance and unseen memory of the calculator as a problem is entered.

Estimating: getting "ball park" answers for addition and subtraction problems, then using the calculator to check the estimate.

* This research was supported by Texas Instruments, Inc. working under contract with the MERGE Institute.

** Texas Instruments Model TI 2500 was used throughout the study.
Number tricks (take a number with 3 different digits, reverse the digits, subtract the smaller from the larger, the sum of the difference and the difference with the digits reversed is 1089)

Area
- Decimals (introduction to tenths and hundredths using a square divided to 100 parts; addition, subtraction, and multiplication of decimals)
- Decimal—fraction equivalencies
- Inequalities with decimals
- Unit pricing
- Flow charts for adding and multiplying using the hand held calculator.
- Prime and composite numbers; prime factorization of numbers up to 100.

Throughout the ten week period, a great deal of time was spent reviewing and practicing the arithmetic operations with whole numbers and decimals.

For the three children who attended regularly, the results on the metropolitan achievement test (reported by grade level) were as follows:

<table>
<thead>
<tr>
<th></th>
<th>Before Instruction</th>
<th>After Instruction</th>
<th>Gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Computation</td>
<td>4.3</td>
<td>6.2</td>
</tr>
<tr>
<td></td>
<td>Concepts</td>
<td>7.3</td>
<td>7.7</td>
</tr>
<tr>
<td>(age 9)</td>
<td>Problem Solving</td>
<td>7.0</td>
<td>7.0</td>
</tr>
<tr>
<td>Total</td>
<td>5.6</td>
<td>6.9</td>
<td>+ 1 yr. 3 mo.</td>
</tr>
<tr>
<td>B</td>
<td>Computation</td>
<td>3.8</td>
<td>5.5</td>
</tr>
<tr>
<td></td>
<td>Concepts</td>
<td>3.8</td>
<td>5.6</td>
</tr>
<tr>
<td>(age 7)</td>
<td>Problem Solving</td>
<td>3.7</td>
<td>4.9</td>
</tr>
<tr>
<td>Total</td>
<td>3.6</td>
<td>5.6</td>
<td>+ 2 yr.</td>
</tr>
<tr>
<td>C</td>
<td>Computation</td>
<td>2.4</td>
<td>2.9</td>
</tr>
<tr>
<td></td>
<td>Concepts</td>
<td>3.8</td>
<td>4.9</td>
</tr>
<tr>
<td>(age 9)</td>
<td>Problem Solving</td>
<td>3.4</td>
<td>4.4</td>
</tr>
<tr>
<td>Total</td>
<td>3.0</td>
<td>3.7</td>
<td>+ 7 mo.</td>
</tr>
</tbody>
</table>

While these large gains in mathematical ability are quite impressive, several limitations must be mentioned. Small group, essentially individualized instruction, is not typical of the classroom teaching-learning environment. In a one-to-one situation, a skilled and careful teacher can immediately correct any misconception, and adjust work level to student needs. For example, one child was given a quick review of subtraction of whole numbers when he experienced difficulty in subtracting decimals. So, the metropolitan achievement test relies heavily on accuracy in addition and multiplication tables, and much time was given to practice in tables, albeit with the calculator.

However, these facts are not enough to entirely discount the very real gains that were shown. Several of the children were in the upper range of the scale originally, and the retest did not necessarily represent a real power test for them. Gains in areas such as understanding of negative numbers, comprehension of flow charts, real world problem solving skills, and actual ability to compute with the hand held calculator were not measured at all. Nor will they be measured in other standardized tests generally in use.

**Summary**

As a result of this study, we would like to offer these tentative answers to the three questions asked about third and fourth grade mathematics.

**Question 1:** Which standard mathematical topics can be taught most effectively using the hand held calculator?

a) The hand held calculator is especially useful for testing and practicing place value skills with whole numbers and decimals. Quick, non-tiring practice (as contrasted with written practice) can be given.

b) Negative numbers are discovered through just "playing" with the hand held calculator. Formulas such as $A < B \implies A - B = -C$ can be tried with many numbers so the child can see the pattern.

c) Decimal and metric measures, including area and volume, can easily be taught.

d) Prime and composite numbers can be more easily identified because of the capability of quickly and accurately checking factors.

e) The calculator is especially good for going from fractions to decimals, but difficult the other way.

f) In general, a guided discovery method can be used because the children can quickly try many examples and detect patterns and algorithms.

**Question 2:** What implications does the calculator hold for problem solving situations?

a) The students are able to obtain much more practice with "real world" verbal problems (which are closer to real life than typical verbal problems are). The children do not have to write the equation, which can be tiring, nor do they have to remember the numbers and operations mentally.

b) One surprising benefit of using the hand held calculator in a verbal problem solving situation was a test of how quickly different children process oral information. A teacher can readily detect children with weak listening skills and weak short-term memories by taking note of children who continually need the problems repeated. In fact, practice with this type of problem and increasingly longer and more difficult examples seemed to help the children gain speed in listening skills.

c) The children enjoyed and were highly motivated to try fairly com
plex real world problems involving several operations. Teachers used the calculator to explore large number problems that occurred in other subject areas such as social studies and language arts. Students made up their own problems and tried solutions, often discovering a need for operations or algorithms which hadn't yet been taught.

d) Because the computation is done easily, the emphasis in teaching can be placed on problem definition, delineation of relevant and irrelevant information, operations involved, formula and equation writing, pattern recognition, and algorithm formulation.

*Question 3:* What new mathematics topics can be successfully introduced because of the availability of the electronic calculator?

a) In general, from the brief experience in this study (grades 3-4) and discussion with teachers, the standard mathematics curriculum can be expanded in computation to include use of numbers of greater magnitude. A shift of emphasis occurs, so that estimating skills, the use of negative numbers, and decimals occur at a much earlier time than normally taught in the standard mathematics curriculum. In other areas, such as pre-computer skills, the use of flow charts and discovery of "debugging" techniques become an intrinsic part of the curriculum.

b) The teacher has an opportunity to spend more time on concrete representations of concepts since she can check instantly for student understanding by having the children show answers on the calculator. Patterns can be more easily detected and explored. The children are not tied to a writing surface when they explore mathematics.

c) The teachers expressed a desire for problems using large numbers. As one teacher said, "a book of 'fantastic' large number word problems is needed. Things kids can relate to, such as large number attendance figures as parades, fairs, or numbers of hamburgers or pizzas eaten at a restaurant."

Finally, we should comment on one concern expressed to us by teachers: How will students who have used the calculator do on standardized tests? Our strong, but tentative results should help in this regard. In this study we incorporated many activities using the calculator to "drill" the children in addition combinations and times tables. These activities could easily be incorporated into any calculator curriculum.

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