SO YOU WANT TO BUY A CALCULATOR

Daniel T. Dolan
Columbus High School
Columbus, Montana

Mathematics educators throughout the country are faced with a new crisis in the classroom, the hand calculator. Prices have decreased dramatically in the face of widespread inflation, and continued lower cost coupled with increased sophistication is predicted. It is now possible to find a simple calculator at the same or lower cost than that of a mathematics textbook.

If teachers intend to begin this work with students, the choice of machinery becomes a fundamental problem. Selection today is varied, and prices fluctuate almost daily. Thus far, teacher input has not been significant with respect to the machine features most desirable in the classroom, so we must take what the manufacturers produce.

During the summer of 1975, 11 junior high teachers from Montana were involved in writing and developing materials for a junior high school curriculum. A segment of this program includes materials and activities utilizing the hand calculator. As the program was to purchase 100 calculators for pilot schools, several firms made calculators available to the team for analysis and testing. Wallace Judd, who has published a number of curricular materials for hand calculators, worked for three days as a consultant with the writers. He was extremely helpful in directing careful analysis of each calculator. As members of the team worked with a variety of available machines, it was obvious that features varied widely, even where keys were identical.

After careful analysis, the teachers involved concurred that anyone considering purchase of calculators for schools should spend considerable time in studying each machine and its functions. The following features were found to be most desirable for use with junior high students.

1. <u>ALGEBRAIC LOGIC</u>. Most calculators today are being produced in this mode as opposed to arithmetic or adding machine mode. Algebraic logic allows the problem to be entered as it is written. For example, $5 \times 2 + 6 = 16$ can be solved by pressing the keys in exactly that order, similarly $14 - 3 = 11$ or $24 \div 6 \times 2 \div 5 = 1.6$. Laws of operation must be considered in problems such as $6 + (2 \times 5) =$ __. It must be entered as $5 \; \textcircled{x} \; 2 \; \textcircled{+} \; 6 \; \textcircled{=}$ __.

A machine with arithmetic logic is immediately distinguished by the $\textcircled{\pm} \; \textcircled{=}$ keys. An addition problem such as $5 + 3 + 7 =$ __ must be entered as $5 \; \textcircled{\pm} \; 3 \; \textcircled{\pm}$

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7 ⊕ __ . A subtraction problem such as 17 - 5 = __ is entered as 17 ⊖ 5 ⊜ __ ; however, it can be entered as 5 ⊜ 17 ⊖ __ . The latter may possibly lead to the suggestion that subtraction is commutative.

The algebraic logic is most consistent with the natural way that a student thinks and does mathematics. Thus, it would seem more appropriate for increasing understanding, rather than introducing a new mode of operation along with the calculating tool.

2. <u>FULL FLOATING DECIMAL</u>. Most of the newer calculators are being constructed with this capability. One can check this feature quickly by entering 17 ÷ 3 = __ . If the answer is displayed as 5.6666666 on an eight-digit display, then the machine has a full floating decimal. If, however, 5.6666667 is displayed, the machine is rounding off in the last place.

Calculators which contain a selector switch with F, 0, 2, 4, allow both floating and fixed output. One should check these outputs with the selector at each position to find out if the calculator is rounding off the answers.

The capability of selecting the output mode can be very desirable in the junior high school classroom. In many situations it may be desirable to use an integer output along with a decimal input. For business or monetary problems, the round-off at two decimal places can also be useful. Analysis of repeating patterns in conversions of fractions to decimals necessitates the full floating decimal.

A caution is necessary here concerning the calculators that claim 12- or 16-digit display with the use of special key ⬆ . On one such machine, any problem such as 17 ÷ 3 = __ results in a terminating decimal. The answer displayed is 5.33333 (lower register), 330000 (upper register). The final six digits are displayed by pressing the ⬆ key. Thus, *all* rational numbers result in terminating decimal in the eighth place.

3. <u>A SEPARATE CLEAR ENTRY AND CLEAR KEY</u>. We found that some machines have only a Ⓒ key and if a mistake is made with a single digit entry, the entire problem must be cleared and one must start over. The clear entry key CE allows one to clear only that which is on the display, without destroying other data which has

been entered into the machine. This can be of great value to students that have not yet mastered the keyboard.

Some calculators with eight-digit display will indicate an error if the number entered, or the result of an operation, exceeds eight digits. Others will display the answer with the decimal point in the correct place, and indicate that the number must be multiplied by 10^8 or some other power of ten. The latter machine is certainly more appropriate. In both cases, most machines which were investigated are then frozen; that is, no further calculation can be done until the machine is cleared with the Ⓒ key, thus, clearing the entire problem.

On one machine, however, it was possible to press the Ⓒ Ⓔ key in order to cause the overflow indicator to vanish; then one could continue with the operations. It must be remembered, however, that the displayed number is still a number multiplied by 10^8. One might think that this feature has little or no value, but several instances were investigated where it became a definite advantage.

4. <u>CONSTANT FACTORS</u>. Be careful of this one. Some older models have a Ⓚ key for this purpose. Thus, the student must remember to set it. He may also find that the constant is stored in the memory and this will affect his use of both the memory and a constant. Again, one must be careful as machines were found where the first factor became a constant for one operation and the second for another.

This is easily checked by doing the following:

Press   6 ⓧ 5 ⓐ 30   5, the second factor, is constant for
Press   7 ⓐ 35   multiplication
Press   1 ⓐ 5

Press   15 ⓓ 5 ⓐ 3   5 is constant for division
Press   20 ⓐ 4
Press   30 ⓐ 6

Any machine used in the classroom should be consistent using the same factor as a constant for all operations. It seemed most appropriate to us that the second factor should be the constant. This alleviates possible confusion with respect to the commutative property for subtraction and division.

5. <u>CHANGE OF SIGN KEY</u> ⊕/⊖ . This is most desirable if one wishes to use calculators with integers. Care should be taken to note the location of the minus

sign on the display. Some models place it to the right; others have a small light indicator. Our consensus was that it is most desirable for students to have it placed to the left of the display just as it would be written on paper.

One calculator with upper and lower registers indicated the minus sign to the left, sometimes. However, the result of multiplying a large number (five digits or more) by a negative number was displayed as a positive number. The minus sign was displayed only if the (↑) key was depressed, and then it was indicated on the upper register to the right. A student using this machine might easily get the idea that the product of a positive integer and a negative integer is positive, especially if you use very large positive or very small negative numbers.

6. <u>MEMORY</u>. While this feature is not an absolute necessity for junior high or elementary school students, it can certainly save a great deal of time in more complicated problems. Some machines have a simple store (STO) and recall (RM) key, whereas others have an accumulating memory (M±) (M=) . The latter will add or subtract the displayed number to the contents of the memory with the (M±) key or (M=) key.

Once again, be careful in analyzing calculators with the memory feature. We found one machine with a functioning memory, (M±) and (M=) , that added the answer obtained, when using the equal key, automatically to the memory. If the (M±) key was then used, the result was added a second time. Thus, if one pressed 3 x 2 = 6, six was entered into memory. If (M±) key was then pressed, 12 would be the result in memory.

This particular method of memory usage could be most confusing to young students. They would certainly wish to see the results of each step in a problem and then enter it into the memory. It can also cause trouble if one forgets, and presses the equal key before the (M±) key.

If a memory machine is to be purchased, be sure that it contains a separate clear memory (CM) key. Some calculators we analyzed had one key to clear the machine and the memory (C/CM) . One press cleared the machine and a second cleared the memory. We found this to be a definite disadvantage. If a problem involved several calculations which were to be placed in memory, one had to be sure that

the memory was clear before starting. At various times, we found ourselves clear-
ing the problem and the memory because of lack of foresight. Students would cer-
tainly have this same problem.

Another feature important on a memory machine is the memory indicator. Stu-
dents may forget from one problem to the next that data has been stored. Thus,
a light or display indicator of some kind is most beneficial.

Each of the teachers involved in this writing project had previous experience
with calculators. Some had machines in their classrooms, while others had inves-
tigated various models for purchase in their district. Since then, each of us
who looks at a new model calculator will carefully scrutinize each feature claimed
by the manufacturer. We will also make certain that those capabilities are con-
sistent with the mathematics being taught and the level of understanding of the
students who will use the machines. Teachers and administrators desiring to pur-
chase calculators will serve themselves and their students well to take ample time
in the same type of analysis.