SPECIFICATIONS FOR ELECTRONIC CALCULATORS

David Jesson
University of Sheffield
Sheffield, England

Frank Kurley
Rowlinson School
Sheffield, England

This article, which appeared in Mathematics Teaching No. 70 (March 1975), the journal of the Association of Teachers of Mathematics (ATM), has been reprinted with the permission of Editor David S. Fielker.

The day of the £10 calculator has arrived. Maybe even this remark will seem to express unwonted surprise if the downward spiral in prices continues. But, whatever the future holds, there is no doubt that many teachers in schools of all types are beginning to consider buying one or more of these machines. With this in mind a group of interested teachers at the 1974 ATM Conference set out to provide some guidelines which would specify what to look for in a basic machine. This is a machine which could be used almost universally in the classroom, with age groups of at least five to 16.

Perhaps a word of explanation is necessary here because this article is concerned with machines without memories and without scientific function keys like LOG, SIN, COS, and so on. It is not that these machines are unimportant, but that with limited funds available a basic machine which meets nearly all the calculation requirements of children up to 16 would appear to have an overwhelming priority. The basic machine's price already matches that of the cheap transistor radio, and there are numbers of cases on record where these have been bought for children by fond relatives. There are many apparently similar machines on the market and it was felt that some guidelines would be useful to get best value combined with maximum applicability from the money spent.

A basic machine should have the following, in order of preference:

1. natural order arithmetic;
2. floating point;
3. underflow;
4. constant key to operate on all four operations;
5. eight-digit display;
6. not too small, fingertip sized keys;
7. rechargeable batteries, with alternative mains operation; and
8. CLEAR ENTRY key.

These items can be checked by using the following tests:

1. *Does it use natural order arithmetic?*

   (a) Key in: 7 - 2 = __ (5)

Look for a separate "=" key. Beware of machines that have "+=" or "-=" keys since these often demand an 'unnatural' arithmetic in the sense that calculations on the machine do not follow the written order even with simple binary operations.

(b) Key in: 8 - 5 x 13 ÷ 7 = __ (5.5714285)

Each operator is a binary operator, working sequentially from the left. This calculation should be evaluated as though bracketed from the left; that is, (((8 - 5) x 13) ÷ 7).

2. *Does it have full floating point arithmetic?*

(a) Key in: 123 ÷ 456 x 789 = __ (212.82236)

This will indicate whether the intermediate calculation result (0.2697368) is carrying maximum decimal places. This should be so, and even if a fixed decimal place setting is provided, the intermediate calculation should still be carried out to the limit of the machine's capability. A severe fault in the decimal handling is evident if this chain calculation is not carried out satisfactorily.

Some machines demand that each part of a chain calculation be completed with an "=" key, and this may lose significant figures in the final result, because the displayed digits are only part of those used in a calculation. Depression of the "=" key may destroy the non-displayed digits.

(b) Key in: 1 ÷ 81 = (0.0123456)
and 1 ÷ 81 x 100 = (1.2345679)

If the machine has the capacity for doing arithmetic to more than eight digits, the last operation will give the maximum set of significant digits that can be displayed on the eight-digit calculator. Clearly, if the machine has this facility, it will be more accurate, in the sense of avoiding rounding errors more successfully.

3. *Does it indicate when figures have been dropped?*

Key in: 88888888 x 2 = __

The full answer is 177777776, one digit too many for the eight-digit calculator. Observe how the machine handles this.

Some machines give 1.7777777, with the decimal point indicating one place dropped, associated sometimes with a flashing display. Other machines indicate this condition by the absence of a decimal point. This is less satisfactory because it appears to give an authentic result, whereas it is only a partially appropriate result. Normally all calculation should be termintated when overflow appears.

4. *How does the constant key operate?*

Almost all of the latest calculators have a constant facility, most usually indicated by a 'K' key, which allows entry of a given value to a store. The basic machine should allow this constant to operate on all four operations.

(a) Key in: CLEAR 2.3917 = K
Then 5.56 = x
should produce 13.560939.

(b) Key in: CLEAR 2.3918 = K
Then 5.67 = +
should produce 8.0617(000).

(c) Key in: CLEAR 2.3917 = K
Then 5.67 = -
should produce 3.2783(000).

(d) Key in: CLEAR 2.3917 = K
Then 5.67 = ÷
should produce 2.3706986.

The clear key on many machines clears not only the display but also the contents of the 'constant' store. This store is best considered as holding a constant and an operator. On the same machines the operator needs to precede the constant. This is best checked using the multiplication example, 4(a).

5. *How many digits does the calculator display?*

There are a number of machines which can give more than the eight figures we feel sufficient. The important point to note is that eight figures is the maximum likely to be of use, so that more figures either cost more or alternatively are displayed in two parts. There seems no advantage in this. However, the apparent capacity of the machine may be limited to its displayed digits, in which case rounding errors may occur. The test at 2(b) is useful for deciding this.

6. *Is it large enough?*

If too small, it can easily be knocked on the floor, or slipped into a pocket or briefcase. Keys need to be tested to see that fingers don't touch more than one key (inadvertently) at a time. The display should be clearly visible from a wide angle of view, clearly readable in daylight conditions.

7. *Can it be easily used in a classroom?*

This implies rechargeable batteries and a mains unit for recharging. The time between charges is also important. In general, machines that keep all eight digits' positions lighted will drain the batteries more quickly. Light emitting diodes (leds) are more efficient than other forms of display. If a mains unit is bought for recharging, check that it is rated at 240v AC. A number of those inspected are rated at 220v AC, and will have a diminished life on the mains supply in U.K.

8. *Does it have a 'clear entry' (CE) key?*

As already noted, the CLEAR key will clear both the display and the constant store, which may be undesirable in the middle of a calculation if a mistake has been made in entering a figure. A CLEAR ENTRY key allows the re-entering of a corrected number if the mistake is noted before the next operation key is pressed. This can be very frustrating in a sequential calculation if no CE key is available.

These eight questions and checks can be put in the form of a matrix, and individual machines assessed comparatively. There is an order of priority here, although there may be rather less agreement over the order of items 6 to 8.

During this study, it emerged that a number of machines already on the market came near to meeting the 'basic' specification. This is either because we (luckily) agree with some manufacturers, or that we have not been far-sighted enough. It does, however, lead one to ask whether we should leave it to chance in the future. If the educational market is one of the large growth areas, then when are manufacturers going to take seriously the need to produce an adequate basic calculator at the right price? We have heard a figure of £5 quoted. Who will take up the challenge?