Should Nurses Carry Calculators?

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Abstract
It has been a widespread tradition of nurse education establishments to forbid the use of hand-held calculators in examinations of mathematical skills (Murphy and Graveley 1990, Hutton 1997). The rationale behind this was that calculators were not freely available in the clinical areas where these mathematical skills would be put to the ultimate test and where accuracy in calculating was obviously vitally important.

This paper describes a study of the use of hand-held calculators in solving nursing mathematics problems. More recent school leavers are compared with mature students in both attitude and use of calculators. Observational data are used to describe the availability and use of calculators in the clinical areas (hospital wards) and recommendations made regarding this issue.

Introduction

As a teacher of student nurses who has a particular interest in nursing mathematics, I wanted to explore the contention of many of my students who had been asked to undertake a mathematics skills test *without using a calculator* that one explanation of their apparent lack of mathematics ability was a learned reliance on a pocket calculator to do all but the most simple addition and subtraction. Although most of these students were recent school leavers, even the mature students who had entered via Further Education Access courses had been taught to compute by using a calculator and attributed their poor performance in the test to the insistence on doing the test without a calculator.

The use of calculators by nurses has been debated over a long period in both this country and the USA. Following a report based on Susan Pirie's thesis (1982), nurse advisors called for all nurses to be issued with pocket calculators to ensure accuracy in nursing calculations. That this suggestion has not been taken up is apparent from my own observations of nurses at work and interviews with both student and qualified nurses. Segatore et al (1994) advocated the availability of calculators or software throughout Canadian hospitals to verify manual computations. I can find no British research into the subject of nurses and calculators, although in general education, concern over calculator dependence has hit the headlines on several occasions recently.

Shockley et al's (1989) investigation of American nurses found that while use of calculators resulted in fewer computational errors, a result consistent with those from general education, the rate of problem conceptualisation errors increased. In contrast to these findings, Murphy and Graveley (1990) found that both fewer calculation errors and fewer set-up errors occurred when nursing students were given the option of using a calculator. Their suggested explanation for the discrepancy between their study and that of Shockley et al, in results from the same

population, was the stage in the course when the studies were undertaken. It was suggested that maturational changes and learning which would be expected to occur during the course could account for the more advanced students in Murphy and Graveley's study making fewer errors related to problem conception. They also admitted that in the faculty concerned, there had been an increased emphasis on nursing mathematics skills at the stage tested which could account for the enhanced performance of their students in problem conceptualisation.

The use of calculators by adult learners was investigated by Koop (1982) and no significant differences between students' performance with and without a calculator were demonstrated. When analysed separately in age groups, there was evidence of a favourable relationship between calculator use and achievement for younger populations. That older students performed better than their younger colleagues when using traditional methods, was a result which suggested to Koop that they might have very good, but latent, computational skills that were awakened by the course. My own research (Hutton 1997) suggests that older students do better than their younger counterparts in mathematics tests which rely on traditional computational methods.

A study by Gujarathi (1987) of accounting students compared two groups of students, one allowed to use calculators for classwork and examinations, the other not. When tested on computational ability at the beginning and end of the course, significant improvement was shown by the non-calculator group. There were no significant differences between the groups in their ability to estimate a reasonable answer or to solve word problems. Therefore, Gujarathi concluded that there was no reason to disallow students' use of calculators. This finding is particularly relevant to nurses, as estimation has been identified as a skill frequently required in nursing work and most calculations involve an element of word problem solving.

The nursing faculty had always maintained that since calculators were not universally available in the clinical areas and that very few nurses carried their own personal hand-held machine, it was imperative that the sort of calculations required in everyday nursing activities could be done accurately without recourse to a calculator. There is no British literature on calculator use among nurses which indicates whether or not they are advantageous in practice and so this study was designed to test the (students') hypothesis that student nurses would perform better in a written test of arithmetic and associated conceptual skills when using a calculator than without. The second part of the study investigated the availability and use of calculators by nurses in the different clinical areas covered by the course.

The research

The study involved a single entry cohort of 117 student nurses who commenced the Project 2000/ Dip H.E. Nursing course in 1996. In order to test the effectiveness of having the option to use hand-held calculators for the types of calculations required in nursing, an experiment was designed as a double cross-over in which same subjects were tested on identically constructed but numerically different tests, both with and without access to a calculator. Order effect was allowed for by randomly allocating the subjects to four groups, two of which did different tests using calculators first time round and two of which used them in their second test.

Subjects

The participants in the study ranged in age from 17 to 47 with a mean age of 25 and represented all four branches of nursing. The proportion of males to females, mean age of the group and school mathematics qualifications on entry were comparable with previous groups and so this cohort was taken to be a representative sample of Project 2000 students at this particular college.

The tool

I had designed the mathematics papers to test the skills commonly used in all branches of nursing. The questions were made such that computation without a calculator would be straightforward. The formula for calculating drip rates and information regarding metric units was supplied within the test. For example:

Given that there are 1000 micrograms in a milligram and 1000 milligrams in a gram, express the following in gram.....

Half the test consisted of straightforward numerical calculations and conversions within the metric system, while the second half was made up of word problems, such as

If 85% of the recommended daily allowance of Folic acid is 170 microgram, what is the full recommended allowance?

Students did one test straight after the other with just a short break between to allow the collection of papers and the changeover of calculators where necessary.

Results

Overall results showed a significant difference between the test scores achieved by those students using a calculator and the non-calculator group. When the test was broken down into sections to allow separate analysis of computational skills and problem-solving skills, there was a significant difference in scores in all sections. The greatest difference was seen in the section requiring straightforward numerical calculation, with less difference in the metric conversion and word problem sections (see table 1).

Total students n =117	Without calculator mean score (SD)	Using calculator mean score (SD)
Computation section (maximum possible = 6)	3.03 (1.31)	3.93* (1.17)
Metric conversions (maximum possible = 4)	2.57 (1.28)	3.02* (1.24)
Word problems (maximum possible = 10)	3.73 (2.04)	4.47* (2.19)
Total score (maximum possible =20)	9.34 (3.71)	11.4* (3.83)

Table 1 : Effect of Calculators on test scores * $p<0.005$

Results by time since leaving school

The results were analysed further in relation to how recently the students had left school, since the literature suggests that calculator use in schools has been routine within the last ten years. (Shuard et al 1991).

The results of those students who had left school over ten years ago (n= 41) were compared with those leaving within the last ten years (n=76). Within the group who had left school more than ten years previously, there was a significant difference in the *overall* increase in mean scores when calculators were used. However, in the more detailed analysis, only the section requiring straightforward number computation showed a significant difference between calculator users and non-users. No difference was demonstrated in either of the other two sections. In contrast, the group who had left school within the last ten years showed significant differences between the scores of calculator users and non-calculator users in every section of the test (see Table 2).

Section of Test	Students who left school 1987 onwards (n=76)		Students who left school before 1987 (n = 41)	
	No calculator Mean (SD)	With calculator Mean (SD)	No calculator Mean (SD)	With calculator Mean (SD)
Numerical computation (max.poss = 6)	3.03 (1.19)	4.08* (1.06)	3.05 (1.53)	3.66* (1.33)
Metric conversions (max.poss = 4)	2.67 (1.19)	3.22* (1.11)	2.39 (1.42)	2.63 (1.43)
Word problems (max.poss = 10)	3.83 (1.96)	4.62* (2.1)	3.56 (2.25)	4.20 (2.36)
Total score (max.poss = 20)	9.53 (3.31)	11.92* (3.5)	9.00 4.39)	10.49* (4.28)

Table 2 : Results of students by time of leaving school *p<0.005

Discussion of test results

These results suggested that the most benefit from access to a calculator was to students who had left school from 1987 onwards. From what these students had said, they were used to having a calculator for all mathematical work and had apparently forgotten how to do operations such as division in the traditional manner

There may be an argument that greater familiarity with a calculator accounted for the significant difference between the results achieved with and without a calculator among the more recent school leavers which was not seen in the older group. In other words, it could be suggested that proficiency with a calculator was a definite advantage in this test. However, it might then be expected that the more recent school leavers would perform better overall than their older colleagues and this was not the case, there was no significant difference between the collated results of both tests (with and without calculators) between the two groups.

The section which benefited most from access to a calculator was that of straightforward numerical computation where 'sums' could be directly transferred from the written test to the calculator and answers transcribed from the calculator onto the answer sheet. There was less effect on conceptual skills demonstrated by calculator access. The small increase in scores in this section shown by the more recent school leavers might be explained by the additional time available to them to deal with the word problems. Having spent less time on the earlier questions as a direct result of having access to a calculator, more time would be available to tackle the word problems. They may also have gained confidence from having access to a calculator and therefore have been less affected by maths anxiety.

Increased confidence from having access to a calculator was illustrated from the analysis of a random sample of twenty answer papers. While there was a significant increase in the number of questions attempted when a calculator was available, the difference in the number of accurate answers was less pronounced, the ratio between number attempted and number of correct answers being unchanged. An increase in confidence does not mean an increase in accuracy (see Table 3).

Students n=117	With calculator access	Without calculator
Mean number of questions attempted (SD)	17.75 (2.4)	15.5 (3.0)
Mean number of correct answers (SD)	10.65 (2.6)	8.65 (3.2)

Table 3: Effect of access to calculator on number of questions attempted (out of 20) and number of correct answers

The findings overall suggest that although calculator use is associated with increased accuracy in arithmetic, its effect on conceptualisation of a mathematics problem is minimal. Mistakes were made even when the calculator was available and so, while the availability of a calculator reduced arithmetic errors, it should not be assumed that it ensures accuracy. Calculators are used so widely by school students following the National Curriculum that it is possibly unwise to ban them from use in the nursing calculations classroom. However they should not be viewed as infallible and alternative methods should be taught in addition. Estimation of a sensible answer should be encouraged to avoid acceptance of a calculator generated answer from a wrongly set up problem.

Use of calculators in the clinical areas

Having found that most beginner student nurses performed marginally better in a test of mathematical skills when given access to a hand-held calculator, I wanted to know how widespread their use was in the clinical areas and therefore whether it was realistic to encourage their use during the nursing course, rather than traditional paper and pencil methods. If calculators were being used in all ward areas then we should be encouraging their

use in the classroom, but if they were not, then the nurses needed to be able to perform the relevant calculations without them.

I analysed data which I had gathered through interviews with both trained staff and students. This suggested that there was little or no calculator use in the mental health sector, even in units where patients with eating disorders were treated and calorie calculation was important. The nurses from the learning difficulties sector denied the need for calculators in their dealings with figures, the most common use of mathematics being in keeping track of the petty cash.. So I concentrated on the areas of general adult nursing and children's nursing and 'shadowed' trained nurses as a participant observer and picked out incidences when calculators were used.

Adult nursing

There were some contradictions in the data collected from interviews with staff and more senior students in general adult nursing. The students told me that calculators were not always available on the wards and so condoned the college's earlier insistence on non-usage. At the same time they claimed that for the sort of calculations which they were required to do, they did not need a calculator. When asked for what mathematics they *would* want access to a calculator, they thought that it would be useful in paediatrics and intensive care.

My observations on the general adult wards supported the students' views in several ways. The every day calculations did not require a calculator. For example, if a dose of 12.5 mg was prescribed by injection and the drug was available in !ml ampoules containing 25 mg, there was no evidence of a calculation being made. The nurses 'knew' that 12.5 was half of 25 and so the correct dose would be ½ ml. None of the nurses I observed on a general adult ward produced a calculator from her pocket and, although there was one available in the ward office, I did not observe it being used at any point.

The adult intensive care unit (ITU) was a different matter. I had interviewed one of the senior staff who felt that errors were made through unintelligent use of the calculator, although she was generally in favour of them being available to ITU nurses. When I observed on this Unit, there was an identified calculator for every bed-space. They were used constantly for virtually all calculations whether simple, as in the case of adding up fluid intake from a variety of intravenous infusions, or highly complex as in working out the settings for the next hour's dialysate to maintain a slightly negative fluid balance as illustrated in the box below

INTAKE is calculated by adding all columns (except HAEMO)		= 505
OUTPUT: all columns added (including Haemo)		= 1146
as balance is to be -50, this becomes	1146 - 50	= 1096
Sub total input is then subtracted from output to give 1096 - 505 = 591		
This is therefore the amount of haemofiltration fluid to be entered on the chart (in effect it runs through over the next hour).		
Totals are then finalised as:	INTAKE 505 + 591 =	1096
	OUTPUT	1146
	BALANCE	-50

Although the actual arithmetic is straightforward, using a calculator speeded up the process and seemed to give the nurse confidence in her calculations. When she did make an error, simply by pressing the wrong button, she immediately noticed that her answer 'cannot be right, because we've got more than that through', and recalculated correctly.

I also observed a more general ITU in one of the other hospitals used for clinical placement of our students. Here, although there was not a calculator actually allocated for every bed, there were several around the Unit and in addition, the permanent staff all carried one in their pocket. They were used frequently for a similar range of mathematical calculations as those described above. An algorithm was used within this unit to estimate the fluid lost from a patient due to insensible causes and a calculator was recommended when this calculation was being made. The algorithm below is applied to a 70 Kg patient with a temperature of 38.6 °C

	Algorithm	Mathematics required	Result
i)	0.5 mls/kg/hr	0.5 x 70 = 35	= 35
ii)	subtract half if patient on heated humidifier	35 ÷ 2 = 17.5 35 - 17.5	= 17.5
iii)	add 25% of result per °C body temp>37° (*or* subtract for temp<37°)	38.6 - 37 = 1.6 25% = ¼ 1.6 x 17.5 x ¼ = 7 7 + 17.5	=24.5ml/hr

Again, although the arithmetic involved is not particularly difficult, the nurses would not attempt this calculation without the calculator.

Children's nursing

The extent to which calculators were used in children's nursing varied, but their use was much more widespread here than in any other branch of nursing.

My observations on a children's ward confirmed that children's nurses carried their own calculators which were used for most arithmetic, even the straightforward adding up of fluid-balance charts. During preparation of injections and intravenous fluids, I observed no cross-checking of calculator calculations using any other method. A student nurse was observed using a calculator but writing down the answer that she got at each stage, even though the calculator had a memory facility. She then checked her answer with the trained mentor, but admitted to having no idea of an approximate answer. The mentor, who had also used a calculator, reassured her that this would come with experience!

Experience was very apparent in the staff nurse whom I shadowed in the neonatal ward. Although she used a calculator for everything, she was aware of what the answer should be, usually extraordinarily accurately. The work of the neonatal unit staff required more diverse calculations than those I had observed on the ward. The size of the babies meant that drugs

and fluids all had to be carefully calculated according to weight, which, because these were new-born babies, changed every week, if not daily. Many of the babies had been born with gut problems which further complicated fluid balance calculations since intake was often a mixture of intravenous fluid, parenteral nutrition and restricted oral feeding. While prescriptions for drugs and feed additives were officially the domain of the medical staff, the experienced nurses on this ward checked them themselves. I noticed that the doctor responsible for prescribing the parenteral feed regimes would borrow a calculator from a nurse in order to do his own calculations.

Discussion of observational data

The use of calculators in the clinical learning environment is widespread in areas such as Paediatrics and Intensive Care. The calculations required in these areas are both more frequent and more complicated than in other areas of nursing. Since calculators are not available in many of the less technical areas, student nurses need to know how to do the calculations involved in straightforward administration of fluids and drugs without recourse to a calculator.

Nurses on the child branch and those working in high tech areas of adult nursing, need to be able to use a calculator intelligently. It must be recognised that without a rough estimate being made, or a knowledge of what is reasonable to expect, reliance on the calculator for the right answer could be dangerous. Making use of a hand-held calculator in the clinical areas should be combined with use of estimation and a recognition of what constitutes a sensible answer.

Conclusions

This study has shown how an experiment on the effect of using a hand-held calculator in a mathematics test indicated that its use was most beneficial to more recent school leavers. Data gathered from interviews with more experienced students and staff, together with observational data, showed that calculators were considered largely unnecessary for the mathematics required in mental health nursing, learning disabilities or general adult wards. The areas where calculators were used extensively were children's nursing and high tech areas within adult nursing. Therefore, nurses within these areas need to be able to use calculators accurately and to have an idea of what the correct answer should be, as a checking mechanism.

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