Research

Evaluating the Effectiveness of Calculator Use in Drug Dosage Calculation among Italian Nursing Students: A Comparative Study

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ABSTRACT

Background

Patient safety, including safe drug administration, is an essential component of the nursing profession. Mathematical competence is considered an essential skill for nurses. Drug administration is among the principle duties of nurses, therefore it is essential that nurses are able to carry out, drug dosage calculations, to assure patient safety. Nursing research indicates that a poor medication calculation skill is an international issue for the nursing profession.

Aim

To verify if calculator use in the written Maths Skill Test (MST) reduces errors in the test and improves undergraduate nursing students' performance.

Methods

This study compares the test results of the second year nursing students randomized into two groups: an experimental and a control group, respectively with and without a calculator, to understand if the calculator helps students to reduce mathematical errors.

Results

The range of the scores was different between the two groups. The experimental group had scores ranging from 16.15 to 29.25 out of a possible 30, the average score was 24.30 (SD 3.34) and the control group had scores ranging from 12.80 to 27.25, the average was 22.73 (SD 4.38).

Conclusions

Our study shows mathematical deficiencies in both groups, despite the use of a calculator.

Implications for practice

An integrated approach of several strategies will improve drug calculation skills of nursing students and ensure patient safety.

Keywords

Drug calculation, Nursing education, Nurses students, Calculator, Patient safety

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Introduction

Patient Safety includes the safe, accurate and correct drug administration; precise drug dosage calculations are an essential skill for nurses. Weaknesses in calculation skills may result in the administration of incorrect drug doses to patients, causing damage or endangering their lives [1].

Drug administration is among the principle duties of nurses, therefore it is essential that nurses are able to carry out, drug dosage calculations, to ensure patient safety [2,3]. Computing skills are core competencies that nursing students must develop in order to graduate. Nursing research indicates that a poor medication calculation skill is an international issue for the nursing profession [4-6]. Several studies since the 1980s have found that significant proportions of students were unable to pass math tests [7-9].

Errors in the drug dosage calculation is predominantly attributable to conceptual errors, followed by errors of calculation and by conversion errors [3,5,6,10-14].

Blays and Bath [8] identified three areas of drug calculation errors: conceptual, mathematical and measurement. Conceptual errors involving difficulty setting up the problems correctly or how to construct a calculation; mathematical errors demonstrated students' difficulties in performing basic functions such as additions, subtractions, multiplication, division of whole numbers, decimals and fractions; measurement errors indicated an inability to solve the maths calculation, for example students' difficulties in performing long division or multiplication, involving also the conversion between metric and apothecary units of measurement. They found, in their study with 66 nursing students, that 68% of errors made were due to conceptual errors (the most common type of error).

Mathematical errors indicated that nurses did not understand basic maths principles [3,4,6,8,13,15].

Brown [9] showed that students had difficulty in carrying out calculations essential for the management of drugs, which are: addition, subtraction and division of fractions, decimals, percentages and conversion. Most of the students are able to correctly perform calculations involving multiplication, subtraction and division of whole numbers, but when they had to deal with calculations involving fractions, decimals and percentages, the average rate of correct answers ranged from 38% to 92% in 1988 and from 42% to 97% in 2003.

One area of the nursing practice to receive special attention in recent years, in many Countries (UK, Finland, USA, Canada, Australia, and New Zealand) regards the standards in drug dosages calculations skills of nurses and student nurses. In education, the teaching of these skills should be included in programs and assessed by Universities. In university curricula, for students to learn how to perform basic mathematical and drug calculation and, as programs tend to be assessment-led, to strengthen these skills through summative assessment before the students begin their clinical placement [16]. Several international research studies that examined drug calculation skills of nurses and student nurses showed that the evaluation methods of these competencies are not standardized [1,3,17]. An important factor to consider is the use of the calculator and the effects it could have on the calculation ability of nursing students. In international literature there is an important debate on this topic.

In most of the studies that have used the written test for the assessment of nursing students' drug calculation skills, the use of a calculator was not allowed because the authors believed that students should think and reason over the calculation that they had to do, arguing that the main difficulties demonstrated by the students were related to the inability to conceptualize the problem and therefore the calculator would not be of any help [4,5,18].

Some studies show that students in this age group have always made use of a calculator in their education; therefore they may fail to achieve satisfactory results without its use [2,19-21].

In addition, the inability to use the calculator during an assessment test may increase anxiety in students, preventing them from performing well in an examination [22]. Some authors argue that calculators are used by nurses in the drug dosage calculation, in a clinical setting and this can reduce computational errors [2,22-25].

Shockley [20] found that the use of calculators in a written test reduced computational errors, usually made by students performing calculations, but increased conceptual errors. This is probably due to the fact that some students erroneously believed that using the calculator did not require them to understand how to perform the calculation required, or what the problem asked them or extract the information to correctly set up the calculation.

Tarnow and Werst [22] showed, in their study of 83 students, that calculator use did not make a significant difference between two groups of students with and without a calculator. Pentin and Smith [26] found that nurse's ability to calculate drug dosages without a calculator remains contentious and many nursing programmes test their students but allow them to use a calculator or do not assess the process of the calculation when a calculator is used. Moreover they support that the issues for healthcare practice in relation to drug dosages calculation requires further investigation, including establishing if there is any difference in drug calculation error between nurses who use a calculator only and those who perform maths calculation with and without a calculator.

As shown by all this literature, the use of a calculator for drug dosage calculation is controversial and for this reason further studies are needed.

Aim

The aim of this study is to verify if calculator use in the written Maths Skill Test (MST) reduces errors in the test and improves undergraduate nursing students' performance.

Methods

■ Study design

A comparative design was selected for this study.

■ Participants and setting

The Curriculum includes modules of pharmacology distributed over three years, with teaching of calculations, and nursing sessions in all semesters of the three year course that provide different training strategies: theoretical calculation of drug dosages, maths tutorials, drug calculation teaching, especially in the second year; in the third year these educational strategies are oriented towards critical and intensive care.

■ Sample

A convenience sample of 78 second year nursing undergraduates attending a Northern Italian University were used for this Study, students were divided randomly into two groups: an experimental group (n=39) and a control group (n= 39) that had carried out the test respectively with and without the use of a calculator.

■ Instrument

The instrument used in this study consisted of 2 sections: the first section collected some general demographical data: age, gender, ethnic background and educational qualifications. The second section contained a mathematical and drug calculation test. The original instrument was designed by Wright [3]. Before being used, the test was validated by experts in nursing training so that it was adequate for Italian students. This MST consisted of 32 exercises divided into six parts: percentages, ratios, fractions, and place value, multiplication of fractions and interpretation of information. The first five sections each comprised of five exercises and the sixth section (interpretation of information) comprised of seven exercises covering all areas of difficulty identified in literature. Figure 1 shows some example of the questions.

■ Data collection process

This quasi-experimental study was carried out in March 2014, at the end of the first semester. Students had followed the pharmacology and nursing lectures in which they were taught exercises of drug dosage calculations; furthermore, they carried out clinical training provided in their program that included the preparation and administration of drugs with the preceptor supervision. Student of both groups had 30 minutes to complete the test. Students were told that they would not be allowed to communicate with each other, during the test. The test was performed with the supervision of the researcher.

■ Ethical considerations

This study was carried out after written approval from the University Academic Committee. All participants were given written information about the study and written consent to participate was obtained. Students were also reminded that the results were confidential and would not affect their studies at the University.

■ Data analysis

All tests were analyzed anonymously. Each was assigned a code, before entering the data into the database. The tests were corrected and the answers were coded as correct or incorrect, before inserting them into the database for analysis. In the first four sections, one point was awarded for each correct answer; in section five, the score could range between 0-1, depending on the level of calculation performed. The correct answers in section six were given a score of 0.71. The answers not given were considered wrong. Scores could range from 0 to 30. Descriptive analysis of frequency, percentages, mean and standard

Part 1: Percentages

Calculate 40% of 4000

Part 2: Ratios

Resolve this problem: you have a bottle of 1000 ml containing 1g of Adrenaline and you have to administer 0.0001g of Adrenaline. How many millilitres will you administer?

Part 3: Fractions

Calculate ½ of ¼

Part 4: Place value

Calculate 0.0125 x 100

Part 5: Multiplication of fractions

$$\frac{500}{4} \times \frac{15}{60} =$$

Part 6: Interpreting information

Wilfred requires 500ml blood over 4 hours. The giving set delivers 15 drops per ml. How many drops per minute would the infusion be set at?

Figure 1: Some questions of the Maths Skills Test [3].

deviation were used for the data. Independent t test was used to compare the test scores between the two groups. SPSS 15.0 statistics software version (Statistical Package of Social Sciences Inc. Chicago, IL, USA) was used to analyze data.

Results

▪ Demographical Data

The response rate of the test was 100% (n. 78). The participants were predominantly female in both groups (71.8%), The age range of the sample was between 20-35 (mean 23.97, SD 3.7) in the experimental group, and between 20-40 (mean 26.71, SD 6.4) in the control group. The percentage of foreign students was 7.7% in the experimental group and 17.9% in the control group. In the experimental group 23.1% had a scientific background, 20.5% had a humanities background; in the control group 15.4% had a scientific background, 28.2 % had a humanities background. In both groups, 5.1% already had another degree, 46.2% had a miscellaneous background and 5.1% did not provide any information.

▪ Test Results

The range of the scores was different between the two groups. The experimental group had scores ranging from 16.15 to 29.25 out of a possible 30, the average score was 24.30 (SD 3.34) and the control group had scores ranging from 12.80 to 27.25, the average was 22.73 (SD 4.38). The highest score achieved by students in the experimental group was 29.25 (only one student who made only one mistake about the calculation on conversion) and in the control group was 27.25 (seven students that made three errors). One student (2.6%) in the experimental group and five students (12.8%) in the control group were able to resolve less than 50% of calculations in the test.

The results showed a difference of borderline significance between the two groups ($t = 1.78$, $p = 0{,}078$, IC al 95% 0.18-3.33). We did not find significant links between the level of competence and qualification, neither between the students' skills and ethnic background. The average scores in each area of both groups are shown in **Table 1.**

Students in the experimental group displayed better performance in the sections relating to "Place value" and "Multiplication of fractions", than students in the control group, while students in the control group performed better in the "Fractions" and "Percentages" sections, than students in the experimental group. In the "Ratios" section, the results obtained by the students of both groups were similar.

In the interpretation of information section, the main difficulties for students were in the conversion of mcg into mg. in the infusion rate and in the drip calculation. Most of the students in both groups, n. 31 (79.5%) in the

Table 1: Comparison of range and mean scores between two groups.

Skills	Experimental group Students N. 39 Range	Mean (SD)	Control group Students N. 39 Range	Mean (SD)	P value
Percentages	0-5	4.00(1.39)	0-5	4.08(1.30)	N.S.
Ratios	1-5	4.08(1.08)	1-5	4.05(1.25)	N.S.
Fractions	2-5	4.05(0.97)	2-5	4.36(0.81)	N.S.
Place Value	3-5	4.35(0.74)	1-5	3.87(0.97)	0.016
Multiplication Fractions	2-5	4.07(0.87)	0-5	2.98(1.32)	0.001
Interpreting. Information	2.13-5	3.86(0.71)	0-5	3.38(1.11)	0.026
Total score	16.15-29.25	24.30(3.34)	12.80-27.25	22.73(4.38)	N.S.

experimental group and n. 34 (87.2%) in the control group were not able to convert mcg into mg; n. 21 students (54%) in the experimental group and n. 25 (64%) in the control group were unable to calculate drip and infusion rates.

Discussion

The main objective of this study was to evaluate whether the use of a calculator improves students' performance in drug calculations. Our study has highlighted gaps in mathematical competence in all areas, in both student groups, despite the use of a calculator. We found that the use of the calculator slightly improved student performance, but it did not help them to solve conceptual problems [4,5,18].

The main difficulties expressed by students were related to interpreting information and multiplying fractions, (core competencies in drug administration). The results of our study concord with previous studies [3,6,9].

The answers given by students in some areas of the test clearly show that students did not understand the mathematical concept that was required; for example in the section on percentages most of the students in both groups (89.7% in the experimental group and 84.6% in the control group) were able to calculate 2.5% of 100, but the following question asking to calculate 40% of 4,000, 35.9% of students in the experimental group and 43.6% in the control group responded incorrectly. The answers given to this question (same in both groups: 40, 400, 4) indicated that these students had difficulty in understanding the underlying mathematical concept of percentages.

In the Ratios section, requiring students to understand the concept of proportion, students in the control group showed better performance (56% of students correctly answered all the questions in this section) compared to students in the experimental group, where only 46.2% were able to correctly answered all the questions.

This suggests that the calculator is not useful in a situation where students are required to not only fully understand the information provided but to also successfully carry out the calculation to achieve the correct dosage to administer; some students even used the wrong symbol, g instead of ml, highlighting an inability to comprehend the question [4,5,18]. The results obtained in this section suggest that those students not using a calculator took longer to reach an answer compared with those allowed to use calculators, who were probably confident that the calculator would have prevented them from making mistakes [20].

Also in the section on fractions, which required reasoning skills, many students in the control group (53.8%) displayed superior competence, correctly answering 5 questions, compared to the experimental group where only 43.6% were able to successfully answer 5 questions.

In the Place Value section, the experimental group achieved better results than the control group: 20 students (51.3%) of the experimental group and 10 (25.6%) of the control group were able to correctly answer to all the questions. The results of this section showed a significant difference between the two groups (p=0.016), but the errors made by students of both groups were the same. Questions that required multiplication or division by 10, 100 or 1,000 were incorrectly answered. In this section the students in the experimental group shouldn't have made any mistakes, thereby achieving full marks. However, the use of a calculator probably led the students to feel overly confident and consequently to have a lack of attention to detail, making the mistake of using the wrong symbol, dividing rather than multiplying and vice versa, or keying a number in with the too many or too few zeros.

The calculator provides the students with a false sense of security and therefore they are more likely to make mistakes [20].

Also in the section concerning the multiplying of fractions, the difference between the 2 groups is significant (p=0.001). The students in the experimental group achieved higher scores than those in the control group: 14 students (35.9%) in the experimental group and 4 students (10.3%) in the control group correctly answered all the questions in this section. 14 students (35.9%) in the experimental group and 11 students (28.2%) in the control group arrived at the penultimate step, but were unable to successfully achieve the correct result. It must also be noted that 2 students (15.4%) in the control group were unable to answer any question correctly and this obviously influenced the overall average mark of the group.

Many students in the control group (n. 17 = 43.6%) arrived at the penultimate step without achieving the correct result; we may suppose that these students felt unable to achieve the result without the use of a calculator and therefore gave up; surprisingly many students in the experimental group (n. 13 = 33.3%) also gave up at the same stage. We expected that the students using a calculator would not have made this kind of mistake. From the students mistakes we can understand that they were unable to carry out long calculations, but above all they were unable to apply a logical process and have displayed a lack of understanding of the link between clinical practice and mathematical calculation; the calculator was only of use to those students possessing a clear understanding of mathematical principles and the ability to conceptualise and reason.

Students in both groups displayed a great level of difficulty in the sections concerning “interpretation of information” which required the successful interpretation of information relating to specific clinical cases and the knowledge to carry out those type of calculations pertinent to clinical practice. Very few students, 7 (17.9%) e 8 (20.5%) in the experimental group and 1 (2.6%) e 15 (38.4) in the control group respectively knew how to solve all the problems or didn’t know how to answer even one problem within that particular section. We find it useful to point out that 2 students (5.1%) in the control group were unable to answer any question in this section. The most common error among students of both groups where found in calculations concerning drops or the conversion of units of measurement. The answers show that students have a lack of knowledge of conversions and therefore would not be helped by the use of a calculator. One student from the control group provided a answer of 4 mcg. The calculation was successfully carried out but the mistake lay in the fact that it regarded tablets and not mcg, therefore the answer was wrong. While the student had no difficulty with the conversion, they displayed a lack of careful consideration of the problem. It is difficult to determine if this error was due to a problem in conceptual comprehension or merely a distraction on the part of the student.

The results of this study confirm that where there is a clear lacking in the understanding of mathematical concepts the use of a calculator does not help the student achieve the correct answer, nor does it help in achieving the correct answer when a specific situation must be successfully interpreted by the student [3,4,7,17].

We believe that the calculator could provide the student with a valid instrument of support in basic mathematics and arithmetic calculation, with a decrease in computational errors. However, it is of no use whatsoever in the analysis of data and information, neither in the calculation or interpretation of the results. This concords with other published studies [2,5,22]. First and foremost the student must learn to carry out calculations, to understand the information provided and to reflect on the results obtained; the calculator can be only be useful to verify/confirm the results obtained. We found that the calculator slightly improved student performance, but it did not help them in solving conceptual problems. Using the calculator serves only to improve a deficiency in numbers, but does not help to achieve the correct result where it is required to understand the meaning of the problem.

Our study has highlighted the mathematical deficiencies in both groups of students, despite the use of the calculator. The calculator slightly improved student performance, but it did not help them in solving conceptual problems.

On the basis of these findings, we believe it could be useful to implement practical sessions of maths calculations without the use of a calculator in the skills laboratories.

We recognise that the sample is rather small and the data were collected from a single University, therefore the results must be interpreted with caution. Further studies are required to assess the competences acquired over time, as well as participants' retention of drug-calculation skills.

Conclusions

This study indicates that many students in both groups demonstrated an obvious lack of knowledge of calculation. The calculator slightly improved student performance, but it did not help them in solving conceptual problems. In clinical practice there is no acceptable margin of error for drug dosage calculation; 100% is the only acceptable score for a drug calculation test. In order to perform accurate drug calculations student nurses need to have basic mathematical skills in order to calculate mathematical problems, moreover they need to be able to conceptualise clinical information presented to them to formulate a maths calculation to be solved [4,5,14]. However, integrated strategies to improve drug calculation skills in nursing students need to be implemented.

There is a need for new approaches to teaching and assessing drug administration; the cooperative learning's methodology helpful in the training of adults is in fact a method little used in Italy, especially in hospital care settings, in particular on security and prevention of risk [27].

Implications for clinical practice

An integrated approach which embraces a variety of strategies to improve drug calculation skills of nursing students ensure they are able to safely and effectively carry out drug calculations.

We need to find suitable training strategies to help students understand conceptual mathematics and we need to understand how to contextualize these training strategies and how to evaluate learning outcome in clinical practice. We believe that the clinical skills laboratory is extremely important and must provide simulated practical sessions without the use of a calculator. We suggest that Drug calculation workshops should be an integral part of the nursing curriculum with summative assessments at the end of each academic year and during clinical placements. This learning should be further reinforced through regular practice and assessment in clinical practice.

Contribution to the Manuscript

- Anna Maria Grugnetti, Annamaria Bagnasco, Loredana Sasso were responsible for the study conception and design;
- Anna Maria Grugnetti & Giuseppina Grugnetti performed the data collection;
- Stefania Menoni performed the data analysis;
- Maeve Casey was responsible of the Supervision of English Language;
- Anna Maria Grugnetti, Annamaria Bagnasco, Cristina Arrigoni, Giuseppina Grugnetti, were responsible for the drafting of the manuscript;
- Anna Maria Grugnetti & Cristina Arrigoni made critical revisions to the paper for important intellectual content;
- Loredana Sasso supervised the study.

Conflict of interest

None

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