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Medication mathematics competency for bachelor of nursing students: Results and challenges of a first year screening test

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Abstract

Getting undergraduate Bachelor of Nursing students to understand and to apply procedures accurately for calculating medication doses in the clinical setting has always been an educational challenge for nursing academics. The experience at Central Queensland University (CQU) appears to reflect that of other universities both in Australia and overseas. In the past, lecturers have reported that students experience difficulties with medication mathematics undertaken in the second and third year of the three year program. Medication calculations require students to have a command of knowledge associated with arithmetic, ratios, fractions, percentages and conversion of units. Students who failed to achieve competence were advised to seek assistance from remedial services such as the Mathematics Learning Centre at CQU. Prerequisites for entry into the program do not include any senior secondary level mathematics. In August 2003, 120 students enrolled in the first year of the Bachelor of Nursing program were invited to complete a mathematics screening test. The test included 25 multiple choice questions. Sections included arithmetic, percentages, fractions, ratios and units. Results showed an average overall score of 15.83/25 (63.32%). The greatest area of weakness was in fractions. Although the findings of this study suggest a level of deficiency in basic mathematics skills in first year undergraduate nursing students, they do not support the introduction of a mathematical prerequisite. Analysis of the findings did not demonstrate any significant correlation between scores and the mathematical entry level of students. The literature suggests a number of strategies that could be incorporated into the undergraduate curriculum; however, further research into the effectiveness of these strategies needs to be undertaken before full-scale adoption is warranted.

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Introduction

This paper presents the findings of the first stage of a three part, ongoing study to determine the best approach to teaching medication calculation to undergraduate nursing students at Central Queensland University (CQU). The current undergraduate curriculum has undergone a major review in 2004, and the results of this study have informed the review about the value of:

1. A mathematics prerequisite for entry into the undergraduate nursing program.
2. A screening test to identify at risk students and the effectiveness of remedial education in basic mathematical skills.
3. Various teaching approaches adopted.

This paper examines the literature and existing practices to proffer new strategies to address this problem.

Literature

Medication administration requires nurses to demonstrate successfully a range of mathematical concepts, including ratios, proportions, fractions, percentages and measurement conversion (Brown, 2002; Hoyles, Noss & Pozzi, 2001; Pozehl, 1996). Errors in medication mathematics may have serious consequences that include harm to the patient, potentially even death, not to mention disciplinary and possible legal consequences for the nurse and the organisation in which he or she is employed (Brown, 2002; Grandell-Niemi, Hulpi, Leino-Kilpi & Puukka, 2003; Hoyles, Noss & Pozzi, 2001; Shore & Shore, 2003). A review of the literature shows that getting undergraduate nursing students to demonstrate a proficient level of medication calculation accuracy remains one of the strongest instructional challenges for nursing academics (Kelly & Colby, 2003).

The use of pre-testing of mathematics skills such as basic arithmetic and algebraic calculations, and the use of the results as a predictor of success in university based nursing courses, are not new. Van Lanen, Lockie and McGannon (2000) examined a university mathematics placement test and other variables that predicted performance in an organic and biochemistry course in an undergraduate nursing program. They sampled 308 undergraduate nursing students. The variables that showed significance in that study were the mathematics placement test score, the grade in the previous principles of chemistry course, the number of supplemental instruction sessions attended and the score on the Nelson–Denny test (which measures reading and comprehension skills and age). Although Van Lanen, Lockie and McGannon acknowledged that these data were dependent on the individual student population, these authors concluded that using predictive values in this way provides a useful profile of students who are at risk.

Similarly, Hutton (1998) pre-tested 231 nursing students with a 50 item test. Results showed 80% (n: 184) of students scored less than 75%. Pozehl (1996) examined the mathematics skills of 112 undergraduate students enrolled in an introductory statistics course; exactly half of these participants were students majoring in nursing. Pozehl's findings indicated that the nursing students were deficient in mathematics skills, particularly algebra, compared to the non-nursing cohort. Pozehl made a number of recommendations, including selective admission requirements that valued pre-existing mathematics skills, early pre-testing of the mathematics skills of nursing students to identify students at risk, ensuring the

availability of early and prompt educational opportunities to the students with a deficiency in these skills and finally the evaluation of mathematics skills throughout the course. Pozehl also tested the level of mathematics anxiety, finding that the nursing students reported higher levels than non-nursing students.

The Learning and Development Centre at the London South Bank University (LSBU) in the United Kingdom found that some of their undergraduate nursing students did require corrective classes to remedy their lack of knowledge in the mathematics that was required by their courses (Starkings, n.d.). The staff of the Centre identified that setting up mechanisms of support for the LSBU undergraduate nursing students required a number of steps. Firstly, diagnostic tests were performed to ascertain the students' levels of mathematics knowledge and their strengths and weaknesses. The diagnostic test undertaken by the LSBU undergraduate nursing students examined basic number skills, manipulation, fractions, decimals, percentages and powers. 32 per cent of students were required (if the score was <40%) or recommended (if scores were between 40–49%) to attend remedial classes. The retest following the remedial classes showed a 25% rise from the initial scores. These staff members concluded that the extra classes provided were advantageous and this strategy was applied in future cohorts (Starkings, n.d.).

Brown (2002) administered a computational mathematics test to 868 undergraduate associate degree nursing students from across the United States of America. The mean score was 75% and these students demonstrated that they were under-prepared in skills essential to medication calculation mathematics, such as fractions, decimals and percentages (Brown, 2002). Brown's (2002) conclusions echo the recommendations provided previously by Starkings (n.d) and Pozehl (1996): that pre-testing upon admission is critical; that remedial mathematics courses should be mandatory if the pre-test results indicate deficiencies; and finally that testing should be ongoing throughout the program.

The findings of Hoyles, Noss and Pozzi's (2001) ethnographic study into the practices of paediatric nurses strongly suggest that the mathematics utilised in undergraduate nurse education is not visible in practice. Instead, they found that the participant nurses, who had practised longer than three years, employed a more holistic approach. Their success in medication calculation was related to "situated abstraction" (Hoyles, Noss & Pozzi, 2001). This notion is based upon the assumption that context is an inseparable component of medication mathematics, as nurses will choose actions that seem relevant to them in their situation (Hershkowitz, Schwarz & Dreyfus, 2001). The three factors that were situational were: the packaging of the drugs; the specific social routines (such as checking with two nurses); and the clinical effects of the drug itself.
Kelly and Colby (2003) identified a similar phenomenon with their students and argued that a constructivist approach to teaching medication mathematics was the key. No formulas were provided to their students; instead the students were encouraged to answer the following questions: "What are the givens? What are you looking for? What information must be transformed in some way?" At the end of this process, one important step was performed and the students were asked to justify their answers. This process allowed the students to identify irregularities in dose rate, volume or concentration (Kelly & Colby, 2003). Although the constructivist approach may enhance students' ability to learn medication calculations, we argue that students still require basic understanding of mathematical concepts.

This review of the literature has shown that a large proportion of undergraduate nursing students are unable to demonstrate an appropriate level of mathematical knowledge on entry into the program. This study seeks to determine the level of mathematical knowledge of the CQU nursing students.

Methodology

All 120 first year, on-campus undergraduate nursing students at CQU in 2003 completed a supervised mathematics screening test. The test consisted of 25 questions. There were five sections in the test. They assessed knowledge of arithmetic, percentages, fractions, ratios and units of measurement. Each section of the test consisted of five questions. Each question was worth one mark, giving a possible total of 25 marks for the five sections together. Demographic data and test scores were analysed using the SPSS software. Data were presented using descriptive statistics (counts, percentages, standard deviations). Pearson's correlation tested significant relationships among variables.

Results

The majority of students (80%) had senior mathematics or equivalent (postsecondary mathematics or preparatory mathematics). This was higher than expected. There was no significant correlation between the level of entry mathematics and the students' test scores.

The mean total score was 63.32%; however, closer inspections of means of individual sections show particularly poor results in fractions and percentages. The mean fraction score was 47.2% and the mean percentage score was 58.2%. The greatest variation occurred in these two sections, as was evidenced by a larger standard deviation (as shown in Table 1).

Table 1: Means and standard deviations for scores

Section of test	Mean mark awarded	Standard deviation of marks awarded
Arithmetic section (maximum 5 marks)	4.01	1.033
Percentages section (maximum 5 marks)	2.91	1.432
Fractions section (maximum 5 marks)	2.36	1.576
Ratios section (maximum 5 marks)	3.08	1.086
Measurement units section (maximum 5 marks)	3.44	1.222
TOTAL SCORE (maximum 25 marks)	**15.83**	**4.456**

While 25.83% achieved 80% in the total score (as shown in Table 2), only 8.3% achieved the expected level in each section. The other 91.7% were recommended to undertake the self-directed remedial learning activities made available online by

the CQU Mathematics Learning Centre prior to enrolling in clinical practice courses in the second year of the program.

Table 2: Percentage of students achieving a pass (80%)

Section of test	Percentage of students scoring more than 80% in each section and in the whole test
Arithmetic	68.83
Percentages	35.83
Fractions	26.66
Ratios	35.00
Measurement Units	54.16
TOTAL SCORE	**25.83**

Post-testing of students entering clinical practice courses in 2004 has been undertaken to determine the effectiveness of remedial self-directed learning. The results of this post-testing will inform the further development of mathematical support in the future curriculum. Preliminary results do not support prerequisites but do suggest that screening and remedial work may be beneficial in improving basic mathematics skills in nursing students.

Discussion

The deficiencies in basic mathematics skills highlighted in this study were suspected by the researchers and lecturers involved in the Bachelor of Nursing program at CQU. Even so, the percentage of students who could not demonstrate proficiency was surprising. Assumptions had been made by the lecturing staff that the majority of students had a foundational level knowledge in areas of fractions, decimals, ratios and percentages. Activities related to, and assessment of, medication mathematics were then based on this assumption. In practice, there was always a number of students who could not apply what the lecturers previously considered to be mathematics foundational knowledge. For example, during a medication calculation tutorial for third year nursing students in 2003, a number of students did not recognise even the most common of mathematical principles. Some students could not identify that

$\frac{3}{4}$ was in fact $3 \div 4$.

Similarly, some students did not appreciate the fraction of an hour when applying it in a formula, for example:

To calculate drip rate drops/min:

$$\frac{\text{drops/mL of giving set} \times \text{volume of infusion (mL)}}{\text{Number of hours the infusion is to run} \times 60}$$

The accurate substitution of number, if infusion was to be run over 30 minutes, was as follows:

$$\frac{\text{drops/mL of giving set} \times \text{volume of infusion (mL)}}{0.5 \times 60}$$

However, some students attempted to substitute the number without considering the fraction of an hour that 30 minutes required, that is:

$$\frac{\text{drops/mL of giving set} \times \text{volume of infusion (mL)}}{30 \times 60}$$

Needless to say, these students did not accurately calculate the drip rate.
Many universities across the United States of America have examined this problem and have attempted to pre-test their students to identify mathematics competency (Bindler & Bayne, 1984; Brown, 2002; Hutton, 1998). The results of this study, showing a lack of proficiency in areas of fractions, decimals and percentages, support previous pre-testing results reported in those previous American studies. The lack of proficiency in what we considered foundational mathematics will alter our current curriculum strategies.

Deficiencies of these kinds led Pozehl (1996) to the assumption that mathematical prerequisites may alleviate this issue. This was the original predisposition by the researchers in this study. Although this assumption is easily made, comparisons of the data related to entry level mathematics and current levels of mathematics proficiency did not support this premise. Although the majority of nursing students had senior mathematics or equivalent, there was no significant correlation between entry level mathematics and results on the pre-screening test. When critically examining the recommendations of other researchers who performed mathematics pre-testing, the authors noted that they did not include a comparison of entry level mathematics in their test scores (Pozehl, 1996).

The remedial session applied in Hutton's (1998) study consisted of self-directed study booklets covering fractions, decimals, ratios and percentages. The post-testing following this strategy did show statistical improvements in all sections of the test applied; however, test scores for areas such as decimals, fractions, conversions and word problem solving remained under 50%.

One solution proffered in the literature was adopting a teaching and assessment style that included situational abstraction (Hoyles, Noss & Pozzi, 2001). In this approach, the students do not substitute figures into recommended formulae without being immersed in the clinical environment. Cues from the clinical environment such as the packaging of the medication and titration tools such as medicine cups or intravenous fluid bags will influence practical decision making. In the past, we have not used the concept of situational abstraction when assessing students' proficiency in medication calculation; instead we have relied on written assessment methods. In doing this, we have not allowed students to draw on the cues from the clinical environment in the calculation process. For example, one student proposed an answer that would be easily recognisable as incorrect in the clinical setting. The student provided an answer that required giving a six month old baby 30 ml of liquid medication when the medication was dispensed only from a 10 ml container. In practice, a six month old baby would have difficulty in taking 30 ml instead of the correct amount of 3 ml.

Conclusion

Regardless of the strategies (formula based, situational abstraction or the constructivist approach) applied to the Bachelor of Nursing curriculum teaching medication mathematics at CQU, it is important that students are proficient in foundational mathematics calculation. There are some fundamental mathematics rules that are applied to medication mathematics regardless of the method by which the student works out the answer. This study demonstrates that many of our students lack foundational understanding of these mathematical rules in the areas of ratios, conversions, fractions and percentages.

This study has highlighted that further research is required to determine:

1. the best method to achieve proficiency in basic mathematical skills; and
2. the best method to teach and assess medication calculation skills.

References

Bindler, R., & Bayne, T. (1984). Do baccalaureate students possess basic mathematics proficiency? *Journal of Nursing Education, 23*, 192–197.

Brown, D. L. (2002). Does 1 + 1 still equal 2? A study of the mathematic competencies of associate degree nursing students. *Nurse Educator, 27*(3), 132–135.

Grandell-Niemi, H., Hulpi, M., Leino-Kilpi, H., & Puukka, P. (2003). Medication calculation skills of nurses in Finland. *Journal of Clinical Nursing, 12*, 519–528.

Hershkowitz, R. Schwarz, B. B., & Dreyfus, T. (2001). Abstraction in context: Epistemic actions. *Journal for Research in Mathematics Education, 32*(2), 195–222. Retrieved January 5, 2004, from the Proquest database.

Hoyles, C., Noss, R., & Pozzi, S. (2001). Proportional reasoning in nursing practice. *Journal for Research in Mathematics Education, 32*(1), 4–27. Retrieved December 18, 2003, from the Proquest database.

Hutton, B. M. (1998). Nursing mathematics: The importance of application. *Nursing Standard, 13*(11), 35–38.

Kelly, L. E., & Colby, N. (2003, October). Teaching medication calculation for conceptual understanding. *Journal of Nursing Education, 42*(10), 431–432. Retrieved December 18, 2003, from the Proquest database.

Pozehl, B. J. (1996). Mathematical calculation ability and mathematical anxiety of baccalaureate nursing students. *Journal of Nursing Education, 35*(91), 37–39.

Shore, M. A., & Shore, J. A. (2003). An integrative curriculum approach to developmental mathematics and the health professions using problem based learning. *Mathematics and Computer Education, 37*(1), 29–38.

Starkings, S. (n.d.). *Drug calculation and the mathematics required for nursing.* Learning & Development Centre, London South Bank University. Retrieved December 18, 2003, from www.ltsnhsap.kcl.ac.uk/resources/articles/sstarkings

Van Lanen, R. J., Lockie, N. M., & McGannon, T. (2000). Predictors of nursing students' performance in a one-semester organic and biochemistry course. *Journal of Chemical Education, 77*(6), 767–770.