



## A whole-of-curriculum approach to improving nursing students' applied numeracy skills



Thea F. van de Mortel\*, Leeann P. Whitehair, Pauletta M. Irwin

Southern Cross University, PO Box 157, Lismore 2480, NSW, Australia

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### SUMMARY

*Background:* Nursing students often perform poorly on numeracy tests. Whilst one-off interventions have been trialled with limited success, a whole-of-curriculum approach may provide a better means of improving applied numeracy skills.

*Objective:* The objective of the study is to assess the efficacy of a whole-of-curriculum approach in improving nursing students' applied numeracy skills.

*Design:* Two cycles of assessment, implementation and evaluation of strategies were conducted following a high fail rate in the final applied numeracy examination in a Bachelor of Nursing (BN) programme. Strategies included an early diagnostic assessment followed by referral to remediation, setting the pass mark at 100% for each of six applied numeracy examinations across the programme, and employing a specialist mathematics teacher to provide consistent numeracy teaching.

*Setting:* The setting of the study is one Australian university.

*Participants:* 1035 second and third year nursing students enrolled in four clinical nursing courses (CNC III, CNC IV, CNC V and CNC VI) were included.

*Methods:* Data on the percentage of students who obtained 100% in their applied numeracy examination in up to two attempts were collected from CNCs III, IV, V and VI between 2008 and 2011. A four by two  $\chi^2$  contingency table was used to determine if the differences in the proportion of students achieving 100% across two examination attempts in each CNC were significantly different between 2008 and 2011.

*Results:* The percentage of students who obtained 100% correct answers on the applied numeracy examinations was significantly higher in 2011 than in 2008 in CNC III ( $\chi^2 = 272, 3; p < 0.001$ ), IV ( $\chi^2 = 94.7, 3; p < 0.001$ ) and VI ( $\chi^2 = 76.3, 3; p < 0.001$ ).

*Conclusions:* A whole-of-curriculum approach to developing applied numeracy skills in BN students resulted in a substantial improvement in these skills over four years.

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### Introduction

To date, there is no widespread consensus on how to define numeracy within nursing. In this paper we have adopted the definition of Coben (2000, p. 35), who suggests that a numerate person knows in which situations mathematics should be used, what type of mathematics to use and how to do the calculation, how accurate the calculation needs to be, and how to interpret the answer in relation to the context. To be numerate in nursing therefore necessitates more than the ability to perform accurate drug calculations, instead requiring declarative knowledge (the what), procedural knowledge (the how to), and conditional knowledge (when, where and why it should be applied) (Glaister, 2005). Throughout this paper we have used the term 'applied numeracy skills' to encapsulate our understanding of what being numerate in nursing entails.

Unfortunately, students are increasingly entering tertiary education programmes with inadequate numeracy skills (Sabin, 2001; Taylor and Galligan, 2006), creating problems when graduates require these skills, which are vital to ensure competent and safe practice by health professionals. Medication-related incidents are the second most common incident reported in Australian hospitals (Roughead and Semple, 2009), and the most prevalent medical/nursing error worldwide (Weeks et al., 2012). Medication calculation errors may decrease the clinical effectiveness of a drug, and increase the incidence of adverse drug events, morbidity, mortality and health care costs (Classen et al., 1997; Eastwood et al., 2011; Hussain and Kao, 2005; Runciman et al., 2003; Tissot et al., 1999). Additionally, errors in calculation and medication administration can threaten a nursing career (Coben, 2010).

However, nurses often perform poorly on numeracy tests (Oldridge et al., 2004). Experience does not necessarily improve applied numeracy skills, as qualified nurses as well as nursing students often struggle with such skills (Dilles et al., 2011; Eastwood et al., 2011; Grandell-Niemi et al., 2006; McMullan et al., 2010; Wright,

\* Corresponding author. Tel.: +61 266203305; fax: +61 266815722.  
E-mail addresses: [tvandemo@scu.edu.au](mailto:tvandemo@scu.edu.au), [theav@ncgpt.org.au](mailto:theav@ncgpt.org.au) (T.F. van de Mortel).

2006). To address this issue some nursing accrediting authorities have determined that 100% mastery of medication-related calculations and administration is required of nursing students upon registration in order to ensure patient safety (M. Cleary, 2008 pers. comm.; Nursing and Midwifery Council, 2007). Hubball et al. (2007, p. 94) suggest '[w]hen learning outcomes are externally mandated (or strongly encouraged), it is important that institutions have effective road maps for their implementation.' This paper will examine relevant national and international attempts to address this global concern and will present the results of longitudinal research that examined the efficacy of a whole-of-curriculum approach to improving Bachelor of Nursing (BN) students' applied numeracy skills.

Various studies have examined methods of improving student nurses' applied numeracy skills (Glaister, 2005; Greenfeild et al., 2006; Kohtz and Gowda, 2010; Koohestani and Baghcheghi, 2010; Rice and Bell, 2005). For example, Glaister (2005) found that computerised learning was significantly more effective at transferring procedural knowledge than either integrative learning, or a combination of the two, although there were no significant differences between scores on other types of knowledge acquisition. However, following a review of two randomised controlled trials of the online learning programme "Authentic World", Ainsworth et al. (2012) reported that use of this computer programme created a small negative effect on numeracy that was statistically significant in one of the trials. Another approach included the use of revision sessions (Hutton et al., 2010). Whilst these did improve post-intervention numeracy scores, the differences were statistically significant in only three sections of the test, and post-intervention scores were relatively poor.

There have been several attempts to assess the effectiveness of dimensional analysis teaching methods on numeracy skills, with conflicting results. For example, Kohtz and Gowda (2010) found no significant difference between the scores of nursing students allocated to dimensional analysis and conventional teaching methods over a 2-year period. Conversely, Koohestani and Baghcheghi (2010) found that students taught using dimensional analysis had significantly higher post-intervention scores than those taught using conventional methods three months following the intervention, although the number of participating students was small ( $n = 42$ ) and the statistical analysis did not take cluster randomisation into account. Rice and Bell (2005) also investigated the efficacy of dimensional analysis with a small sample and the comparison group differed in their baseline characteristics, receiving less tutoring than the intervention group, which confounded the results. Thus the relative effectiveness of the two teaching methods is unclear.

Vincent (2004), in her discussion of numeracy projects in Australia aimed at primary and secondary school settings, suggested that a scaffolded, whole-of-school approach was needed to lift the nation's numeracy performance. Keimig (1983) also rated comprehensive learning systems more highly as a means of improving learning than standalone preparation programmes or isolated interventions. Several attempts have been made to take a more holistic approach to numeracy development in nursing students. For example, Galligan et al. (2010) developed a unit of study covering numeracy and information technology skills that was embedded in the nursing programme. The project was evaluated via pre- and post-intervention data for 2008 plus aggregate post-test data from previous years, however, the direction of the change post-intervention differed between questions, and no statistical tests of significance were applied to determine which results differed significantly. Thus there is little data to demonstrate that the intervention was successful in its aims.

Only one paper has reported on a whole-of-curriculum approach to the development of numeracy skills in nursing students (Elliott and Joyce, 2005). This approach included a:

- basic calculation test in the first year with an 'informal' 75% pass mark to establish a skill baseline, followed by feedback to encourage students with difficulties to seek help.
- medication calculation examination in the second year with an 85% pass mark. Students were allowed three attempts, and were offered remedial work to improve their skills.
- medication calculation examination in the third year with a 100% pass mark. Students were allowed three attempts.

The authors reported on the proportion of students who failed those tests by year of the degree, but did not provide historical data on fail rates prior to the implementation of their intervention; therefore it is not possible to determine if their new approach influenced numeracy skills in their students. To date no longitudinal study of a whole-of-curriculum approach to the development of applied numeracy skills in nursing students has been conducted that incorporates pre- and post-intervention data for comparison.

## Background

The large failure rate in a final year undergraduate nursing applied numeracy examination in 2008, as well as dissatisfaction by academics with the effort required to assist students to gain competency in numeracy skills, led a nursing department in one Australian regional university to review its approach to the teaching and assessment of numeracy in a three-year Bachelor of Nursing (BN) programme. Teaching and assessment of numeracy skills at this time was situated within six on-campus clinical nursing courses (CNCs). A course for the purposes of this document refers to a requisite component of study delivered over one university semester. Students who were enrolled full time had to complete two CNCs per year. Table 1 outlines numeracy content and assessment across the programme. Resources such as online practice exam papers and answers were provided in all clinical courses to enable students to revise their numeracy skills. In addition, students enrolled in CNCs I–IV could attend non-compulsory numeracy tutorials. Failure to gain mastery in the final numeracy re-sit exam meant that students failed the course. With the exception of the CNC V examination in 2008, which was a practical test applied whilst students were on their clinical placement, the applied numeracy exams were administered as paper-based contextualised in-class tests that included questions on basic numeracy, drug and intravenous fluid calculations, and medication administration. The students were required to demonstrate a combination of declarative, procedural and conditional knowledge.

## Issues and Actions for Change

As part of a wider initiative to enhance curriculum quality through a whole-of-curriculum approach to embedding key skills in the BN (van de Mortel and Bird, 2010), a review of numeracy teaching was

**Table 1**  
Numeracy content and assessment in the clinical nursing courses (CNC) of the Bachelor of Nursing, 2008.

Year/semester	Course	Content taught	Pass mark	No. of attempts
1/1	CNC I	Basic numeracy skills	80%	2
1/2	CNC II	Medication foundational skills Principles of safe medication administration Calculations for parenteral routes, excluding intravenous (IV) calculations	80%	2
2/1	CNC III	IV medication and fluid calculations and administration	85%	2
2/2	CNC IV	Complex calculations applicable to acutely ill clients	90%	2
3/1	CNC V	Paediatric calculations	No exam <sup>a</sup>	
3/2	CNC VI	Revision of CNC I–V content	100%	3

<sup>a</sup> Medication administration skills were assessed during the clinical placement. Calculators were permitted in all examinations.

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