Building academic numeracy in a first year nursing course using an evaluative model of program development[1]

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Abstract

Numeracy is a key attribute in nursing. At USQ, a large regional university in Australia, numeracy has been embedded in a course in the first semester nursing program. This chapter identifies the numeracy needs of these nursing students and outlines the model of learning improvement, based on that of Keimig, chosen to target the students' learning within a course. It also describes the method of evaluation and development guiding each of the course design, delivery, and improvement stages. These include both quantitative and qualitative strategies designed to investigate students' and staffs' reflections on curriculum design and assessment. These data collection strategies enabled the design team to incorporate a number of features specifically designed to engage and empower student nurses' numeracy skills in the delivery stage. The program conclusions in the first stage revealed the need for a number of improvements, including more targeted testing and increased flexibility. Three cycles have now been concluded with improvements continuously made as the stages evolve. This chapter includes examples of our evaluation data and it suggests that our approach assists students develop numeracy nursing attributes and allows the design team to respond quickly and effectively to students' needs.

Key words: nursing, numeracy, university, tertiary education, program evaluation

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Introduction

The news line "A mistake over a decimal point caused the death of a Derby baby who was given 10 times the recommended amount of heart medication" (BBC, 2005) highlights the importance of numeracy as a key professional attribute in nursing. The consequences of poor numeracy skills in nursing are well documented world-wide both in the higher education nursing context (Coben et al., 2008; Gillies, 2004; Hansen, 2002; Weeks, Lyne & Torrance, 2000; Wright, 2007) and at the health institutional level (Phillips et al., 2001; Sabin, 2001; Santamaria et al., 1997). Not only can the consequences for patients be devastating, but the psychological trauma for nurses can also be overwhelming (Deans, 2005). Teaching and health institutions usually assess this attribute at multiple levels and are directed, in general terms, by appropriate patient safety centres. However, while there is broad understanding of the key mathematical skills needed, there is a lack of clarity about how to provide support to students to develop these skills in the form of, for example, direct teaching, or through constructive and relevant feedback.

The University of Southern Queensland (USQ) is a regional Australian university enrolling up to 400 first year undergraduate nursing students per year. There is wide diversity in this group with mature age and international students. Initially the university provided various forms of academic skills support through centres outside the Faculties. As Tapper and Gruba (2000) note, there is "a strong tendency for academics to refer students to learning support units rather than addressing students' academic learning skills themselves" (p.56).

Instead of relying on support units alone, the USQ nursing department recognised a better approach was needed. In 2007, academic skills in the undergraduate nursing curriculum were embedded within two new first year first semester courses, CMS1008: Building Professional Nursing Attributes A (conducted through the Faculty of Arts) and MAT1008: Building Professional Nursing Attributes B (Faculty of Sciences and Learning and Teaching Support Unit).

While the aim of CMS1008 is to develop students' academic and information literacies and learning, research and communication skills, MAT1008 develops students' numeracy and Information Technology (IT) skills. These skills are directly linked and highly relevant to the degree and are developed by embedding aspects of other courses taken in the students' first semester while being mindful of courses taken later in the program. The two new courses also take into account a growing discourse on interdisciplinary or 'pluridisciplinary' higher education, which sees value in two or more disciplines combining their expertise to jointly address an area of common concern (Davies & Devlin, 2007), in this case the complexities involved in students' transitions both to university and to future professional nursing practice in an increasingly multifaceted world. The courses were therefore closely linked and offered through the same course website, and shared assessment items across disciplines.

IT features are integrated throughout the two courses' structures. The course material is made available in multi-modal form (i.e. print, CD, and website) through an in-house content creation system. The assessment and all other resources are made available online through the course website. A detailed description of the particular innovative e-assessment approach of the two courses can be found in Lawrence, Loch and Galligan (2008).

The following is a brief literature review of the numeracy needs of nursing students and the model of learning improvement. It then focuses on the design, delivery, evaluation and improvement cycles of the numeracy component of MAT1008. Within these cycles numerous examples are provided to show others the approach taken.

Numeracy Needs

The term academic numeracy, modified from Yasukawa and Johnston (1994), was used by Galligan and Taylor (2005) to clarify the skills necessary for success in the university context. For the nursing context, described in this paper, we have included competence and confidence (Coben et al., 2008) in the definition. Thus, in this context we have defined academic numeracy as:

> *a critical awareness that allows students to become confident and competent in using mathematics and to be able to situate, interpret, critique, use, communicate and even create mathematics within their discipline's setting.*

Academic numeracy is usually based on both the mathematics learnt at school and the mathematics needed in disciplines such as nursing or economics. FitzSimons (2006) makes the distinction by focusing on Bernstein's concepts of vertical and horizontal discourse. While vertical discourse centres mainly on school mathematics, horizontal discourse links closely to numeracy as it is related to on-going practices; is affective; has specific immediate goals and is highly relevant. FitzSimons emphasizes that these discourses are different with different practices and that vertical discourses will not guarantee numerate activity. However parallels can be found to school based mathematics that is needed in the particular context.

Nursing students need to be numerate in order to become successful in their careers. While there are no global benchmark numeracy standards for nurses, there are similar standards evident in most countries. The UK provides a good example of this. Here, there is a move to develop a national framework for learning, teaching and assessment in nursing education (Sabin, 2001) and more specifically a benchmark for nurses at registry (Coben et al., 2008). Coben and her colleagues suggest that teaching and assessment in the nursing degree must be able to generate in students: 'independence; good critical judgement…; proficiency in practice; and accountability to relevant stakeholders […]'. They identify key numeracy areas of: *Drug administration and prescribing; fluid balance calculation; support for patients' nutritional needs; calculation of intravenous fluid requirements/rates; calculation related to weight and body mass index (BMI); nursing administration; plotting and recording data; and understanding the research evidence.*

Johnson and Johnson (2002) identified four component processes – computation; conversion, conceptualisation and critical evaluation. These processes, they say, need to be scaffolded, building on previously learned material. Hilton (1999) using the work of Pirie (1987) identified critical mathematics components essential to becoming a numerate nurse:

- Addition of three digit integers
- Subtraction involving three digit integers
- Multiplication involving two digit integers
- Division by an integer between 1 and 9
- Multiplication of two decimal fractions
- Multiplication of two fractions
- Division of two fractions
- Conversion of fractions to decimals
- Conversion of decimals to percentages
- Calculating percentages of integers
- Conversion between SI units
- Multiplication of integers and decimals by 10, 100 and 1000
- Evaluation of expressions of the form ($A \times B$ divided by $C \times D$).

In Australia, Pierce and her colleagues (2008) highlighted a fundamental problem in decimals for a significant minority of nursing students, but there has been little other research at this depth to identify the underlying mathematical conceptual difficulties of nursing students.
The four components identified above, i.e. the different discourses, the numeracy areas, the mathematics skills, and the processes, are all regarded as important and consequently incorporated in the numeracy course material for MAT1008. However, further contextualization to the local context and discipline was needed and an approach was required to allow students to develop these concepts. This approach of learning improvement is outlined next.

The model of learning improvement

Ruth Keimig's model of learning improvements (Keimig, 1983) presents a guide for effective programs and includes a hierarchy of learning improvement programs that describes and ranks four types of programs ranging from broad generic remedial courses to focussed comprehensive learning systems (Figure 1).

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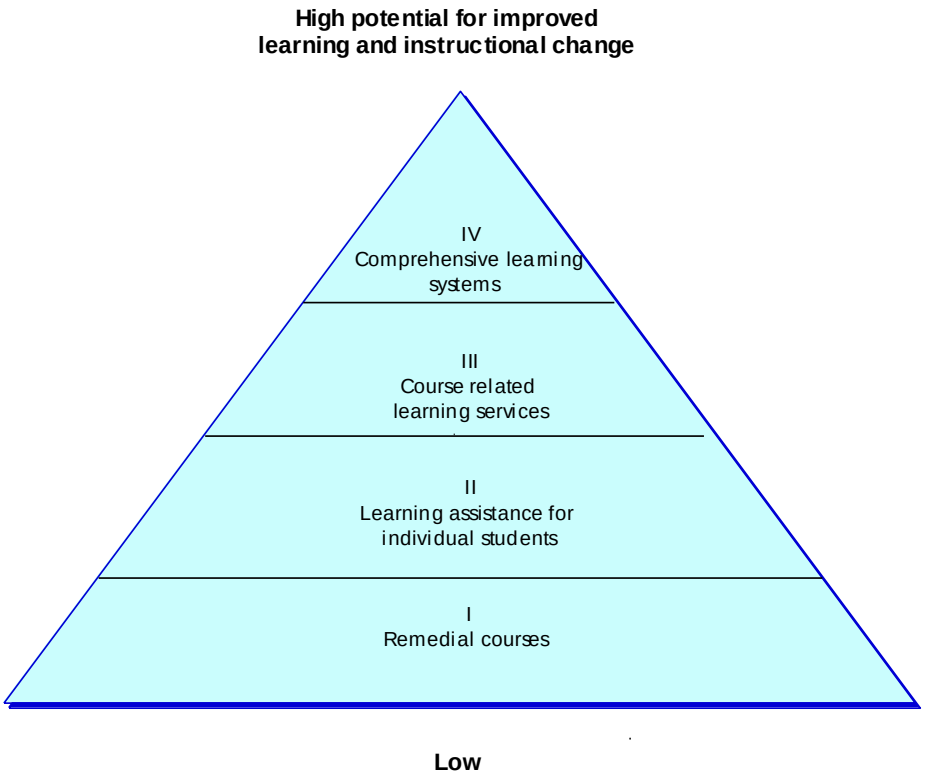


Figure 1: The Hierarchy of learning improvement programs (Keimig, 1983, p. 21)

In universities, according to Keimig, support that is 'targeted at specific aspects of learning within academic courses' (p. 21) is more likely to succeed in improving students' learning. USQ already has programs similar to Level I, II and III in the Keimig hierarchy to improve academic numeracy through preparation programs (Level 1) and a Learning Centre (Level 2) and, front end numeracy workshops (Level III). Keimig's comprehensive learning system (Level IV) was used successfully to solve the issue of uneven preparedness of 1st year students in a core mathematics course (Taylor & Mander, 2003), but not in other non-mathematics based courses.
There are clear parallels between the general English for Specific Purposes (ESP) model from Second Language Learning and embedding numeracy. In particular the Content Based Instruction (CBI) model from the work of Brinton and her colleagues in the US (Brinton, Snow

& Wesche, 2003) included theme-based instruction, where the themes create the organising principle for the course syllabus. In the context of academic numeracy, Mathematics for Specific Purposes (instead of ESP) programs were proposed with the themes emerging from both the disciplines (e.g. nursing or economics) and mathematics.
In relation to the nursing context, students were able to access both Keimig's Level I and II programs and until 2007 were able to enrol in an optional two-day front-end context-specific workshop (Level III). In 2007, instead of a front-end program, an integrated approach (Level IV) was proposed. Keimigs' general approach was to target learning **within** a course. This resulted in the proposal of the specific theme-based numeracy course MAT1008 in the 1st semester program,
A one semester half credit point course, was created based around seven modules which focused on: Why maths for nursing; basic arithmetic and formula; graphs & charts; ratio & proportion; percentages & averages; measurements; and drug calculations. Students attended 2 hour tutorials (interactive "mini-lectures") once a week with a limit of 20 students per class, rather than follow the more traditional lecture approach.
This next section describes the methods used to design, develop and evaluate the course and includes examples of the course and evaluation in each of the stages.

Program design, development and evaluation: methodology

Throughout the design, delivery and evaluation of the numeracy component, an adaptation of Guba & Stufflebeam's method of evaluation and program development was used (Guba & Stufflebeam, 1970; Taylor & Mohr, 2001, see Figure 2). This model incorporates evaluation priorities in each cycle and in each stage of the cycle.

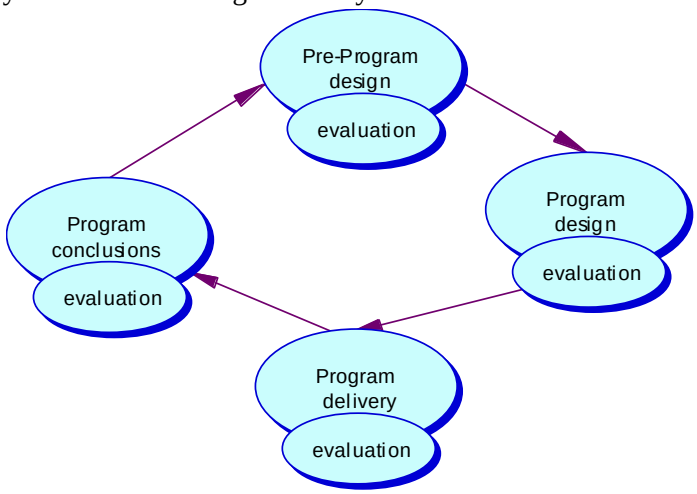


Figure 2: Model of program development (Taylor & Mohr, 2001, p. 33)

The evaluation included quantitative and qualitative strategies with students and academic staff reflecting on curriculum design and assessment. Data were obtained from pre-and post tests, electronic discussion groups on the bulletin board, reflections in assignments, emails and the standard university student evaluation form as well as an online end of semester survey of students, focusing on the specific features of the numeracy component. More detailed explanation of the e-assessment and the evaluation in relation to this can be found in Lawrence et al. (2008). Table 1 outlines the various evaluation strategies used and their relation to the stages in the design of the course.

Table 1: Relationship between the evaluation stages and strategies in the nursing program

Item	Evaluation Strategy	Pre-program Design	Program Design	Program Delivery	Program Conclusions
1	Numeracy audit	✓	✓		✓
2	Weekly then monthly discussions with 1st year nursing lecturers (and as needed)	✓	✓	✓	✓
3	Debrief with 1st year nursing lecturers				✓
4	Use of feedback from previous student surveys of courses including those that were replaced by current courses	✓	✓		✓
5	Examination of assignments			✓	✓
6	Student surveys			✓	✓
7	Official student evaluation of teaching				✓
8	Online discussion groups				✓
9	2009 second and third year student cohort survey				✓
10	One-on-one sessions with students to investigate student learning		✓	✓	

Two independent formal student evaluations were carried out at the conclusion of each cycle. One was designed by the team to address program specific issues (Item 6, n = 94 in 2008), and the other is the standard university course quality survey (Item 7, n = 23 in 2007). In 2009, second and third year nursing students were also surveyed to investigate the impact of the first year, first semester program on the three years of their studies and to ascertain any lasting impacts on their future professional careers (Item 9, n = 66). The following section will describe and exemplify the four stages in this model.

Pre-Program Design Stage

The pre-program design stage included an academic numeracy audit (Item 1). As well, weekly and then monthly sessions with nursing staff were undertaken (Item 2) as the program design evolved to ensure the design reflects, and continues to reflect, the needs of the staff and students. One comment from an interview with a Nursing lecturer involved in course pre-design, shows the importance of collaboration:

> … it certainly gave focus to the first year of the program, because part of the goal was to target the first year experience and to deal with things like retention. If nothing else, the strengthening of the teaching teams would have been a benefit. And having that level of communication. It must translate down to the students, because the students are then able to talk about different courses across that semester and know that they are linked together.

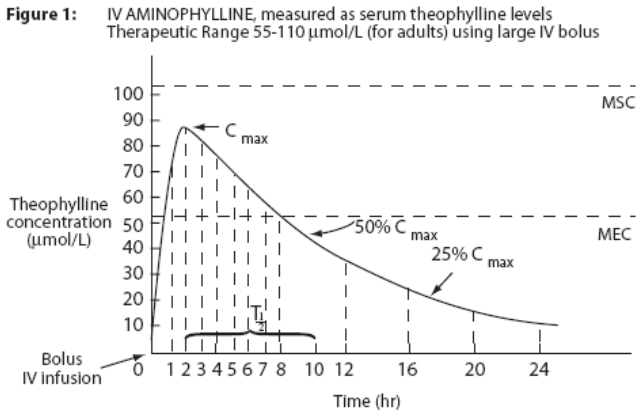
Additionally, student evaluations and tests from previous nursing support programs (see appendix for some results of these tests) are used to inform the content and approach. In the pre-program design and development stages (Item 4), it is possible to draw on experience and research of over 17 years of academic numeracy support particularly in nursing (Galligan, 2001, 2002; Galligan & Pigozzo, 2002; Galligan & Taylor, 2005).

Academic numeracy audit (Item 1)

As part of the initial numeracy audit, a literature and program review were undertaken to benchmark the content of this course with others in Australia and elsewhere. Additionally, in

2006 an audit of the current course/s and interviews with staff provided an overview of what needed to be included and emphasised. Table 2 summarizes the seven skills identified and some in-context examples. Where possible actual examples involving numeracy from other nursing courses were used and photographs were taken of drug containers showing typical drug concentrations that they would use in subsequent semesters. Many of the mathematics skills identified in Table 2 (skills 2 to 7) relate back to the arithmetic skills (1).

Table 2: Mathematical skills needed by nursing students and examples from the nursing context

Mathematical skills needed	Examples from the nursing context
1. Arithmetic: × and ÷ decimals (especially with powers of 10), and concepts; fractions (what they are); divisor dividend misunderstanding; cancelling fractions (especially multiple including mixed numbers).	(2500mg of drug required with 25 mg per 3 mL of the liquid to be given) $\frac{2500}{25}\times 3$
2. Using Formulas.	$BMI = \frac{w}{h^2}$ (BMI = body mass index; w = weight in grams; h = height in metres)
3. Ratio and Proportion.	Drug calculations including volume and tablet medications including discussion on why the formula works $\frac{\text{Dose Required}}{\text{Dose in Stock}} \times \text{Stock Volume}$ 
4. Graphs and charts: reading them carefully including units and scale.	Patient charts; drug concentration over time; reading graphs, tables and charts within research articles 
5. Rates and Percentages: (what to do with the 100);. (cancelling; decimals and understanding fractions).	Intravenous infusions, e.g.: You have to run an infusion of 500 ml Dextrose/Saline over the next 3 hrs. How many ml per hour will you be infusing at? How many drops per minutes will the infusion be set to if you are using a giving set of 20 drops/ml.
6. Measurement: conversion; confusing volume (mL) and mass (mg).	Drugs in milligrams or grams; volumes of liquids in mLs or L.
7. Problem solving (including critical	Drug calculations: reading the problem, identifying the elements and

evaluation).	reflecting on answers: e.g.: The doctors have ordered an infusion of 1500mL of 5% Dextrose to be given at the rate of 50 drops per minute. Assuming a drop factor of 20 drops per mL, how many hours will it take for this infusion to complete?

The seven skill areas formed the basis of seven modules of study in the course. The modules also included all the features identified earlier in the literature review.

Student Tests (one part of Item 5)

Since 1992 nursing students have been tested for their mathematics skills at USQ. Data from the previous 1999-2002 pre-test (see Appendix) indicated some areas students consistently found difficult:

- Estimation
- Order convention
- Converting decimal hours to minutes
- Converting grams to milligrams
- Solving equations with the unknown on the denominator
- Reading syringes

Most of the above areas were not highlighted by Hilton (1999) as critical, but were seen by nursing staff as necessary for some component of the nursing program. These concepts were then targeted in the learning material and assessment for MAT1008. This test became an integral part of the program and used a self-test mechanism developed to identify what was known by the student. This was completed, marked and checked by the students themselves and included confidence levels. This self-audit approach has been used by the university in a number of other courses (Taylor, 1998; Taylor & Mander, 2003).

Other design elements

Today's students approach studying at university very differently from 20 years ago (Lawrence, 2005). Students often do not attend lectures and tutorials due to work and family commitments. Delivery needs to be flexible and has to be developed within a current curriculum, scaffolded without the lecturer, but have a mechanism where students may elect to access extra support.
There is a strong move to more computer mediated environments, thus the ability to incorporate alternative avenues for students to follow is becoming easier to develop. The material in this course was prepared to be delivered in multi-modal format (CD, Web and Print) and had particular characteristics to suit the learner, much of which had been developed in previous material, either for nursing students in other support programs or for other adult learning contexts. The characteristics included:

- Cartoons for humour;
- Social presence in the online format so students knew they were not alone and could get feedback from tutors and fellow students;
- Videos of a nursing practitioner explaining the importance of each mathematics concept;
- Video clips of adults (re)learning various maths concepts in the context of everyday life;
- Photos of drug labels for authenticity;
- Extra material to explain concepts in more detail if needed with fully worked solutions.

Together, the numeracy audit, the information from the students tests and workshops and other pre-design elements, formed the basis of the course design. Meetings with key nursing staff then

informally evaluated and approved the approach. A delicate balance had to be found. For example, it was essential that students' numeracy skills improved without teaching a medical calculations course (this was done by nursing staff the next semester).

Program Design Stage

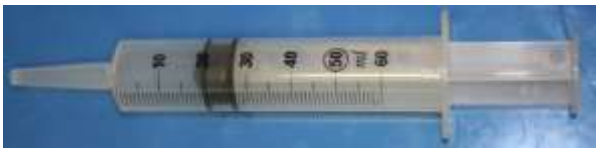
The course is offered in first year first semester and based on seven modules. The first module investigates students' existing levels of mathematics understanding and competency and to discuss why mathematics is important to the nurse. This module also sets the scene for the remaining modules which were developed around the design mentioned above. Each module commences with a video of a nursing practitioner followed by a series of exercises in mathematics related to nursing. The online material allows students to unfold further material if needed (for further explanation or examples). A characteristic of the student self-audit in the first module is a curriculum approach related to each type of student readiness. 'Already learned' mathematics content knowledge can quickly be refreshed in the new nursing context. For those whose mathematics skills are incomplete a different approach is taken by addressing context and affect. Moreover this approach assists the students to identify what they found difficult in the past. Seven features focus on content:

(1) for simple revision,
(2) for development,
(3) for anxiety,
(4) for overcoming barriers to understanding,
(5) is highly relevant and contextualized,
(6) has rewards built in to boost students' confidence, and
(7) has a variety of explanations and modes of delivery.

In MAT1008, this takes a number of forms: written material; visual material; pre-recorded teacher talk; interactive marking, peer marking etc. The content of the course is linked directly to the audit mentioned earlier, and the seven modules reflect these skills in context. Table 3 shows examples of features of the content.

Table 3: Features of content that attends to numeracy needs.

	Content:	Course examples
1	for simple revision	Recommendations from the Self Test results, with worked solutions linked to other material as needed Final Results for student 123456789 for Readiness test You need to study the following sections: SIMN 3.4-Divide by powers of 10 SIMN 6.4-Volume concentrations SIMN 7.6 Average Rates TPPA 2.2.1-Addition TPPA 2.2.2-Subtraction TPPA 2.2.3-Multiplication TPPA 2.2.4-Multiplication TPPA 7.2-Rearranging equations
2	for development	Optional examples and exercises with worked solutions and linked to extra explanation

		Exercises (a) Evaluate the following **without** a calculator. Check your results on the calculator. (i) $7 \times 5 + 4$ (ii) $10 - 6 \times 7$ **Solutions** (a) (i) $7 \times 5 + 4$ $= 35 + 4$ $= 39$ (ii) $10 - 6 \times 7$ $= 10 - 42$ $= -32$  This animation describes order convention
3	for anxiety	• Early and late assessment for planning and reflection only; • quick response to assignments through peer assessment and online computer marked assessment CMA's • videos of everyday numerate experiences linked to nursing numeracy;
4	for overcoming barriers to understanding	• Extra support through The Learning Centre; • Reflections on their tests to stimulate metacognition • Pre-recorded teacher talk going over how to do certain skills
5	that is highly relevant and contextualised	• All skills are related to nursing and to their other courses e.g. using: o SI units and measurement in *Biophysical Nursing Foundations*; o reading graphs from articles in *Social Determinants of Health*; o includes videos and photos related to nursing, for instance: Exercise 10.2.1 Look carefully at the syringe below and read, as accurately as you can, the volume of fluid contained. 
6	which has rewards built in to boost confidence	• Early assessment that doesn't penalise not remembering the maths; full marks are possible for every student • flexible online testing
7	with variety of explanations and modes of delivery	• Written: Material is on a CD online or in a book form; • teacher talk recorded: Students come to class and some concepts have been recorded and placed online; • visual material added: In-context material added to material • flexibility: Material online is linked to extra material if they want further explanation

Many of the features identified in Table 3 had been evaluated previously in non-nursing contexts. For example self-test (Taylor, 1998); extra material from a suite of materials designed

for adults returning to study (Taylor & Galligan, 2002); and Peer marking (de Raadt et al., 2005).

Program Delivery Stage

Once the program was designed, continued evaluation could still take place during the delivery stage, with staff and students and some improvements could be made immediately due to the online and interactive nature of the course delivery. For example, student comments about content on the discussion forum (Item 8) were responded to with screencasts which were added

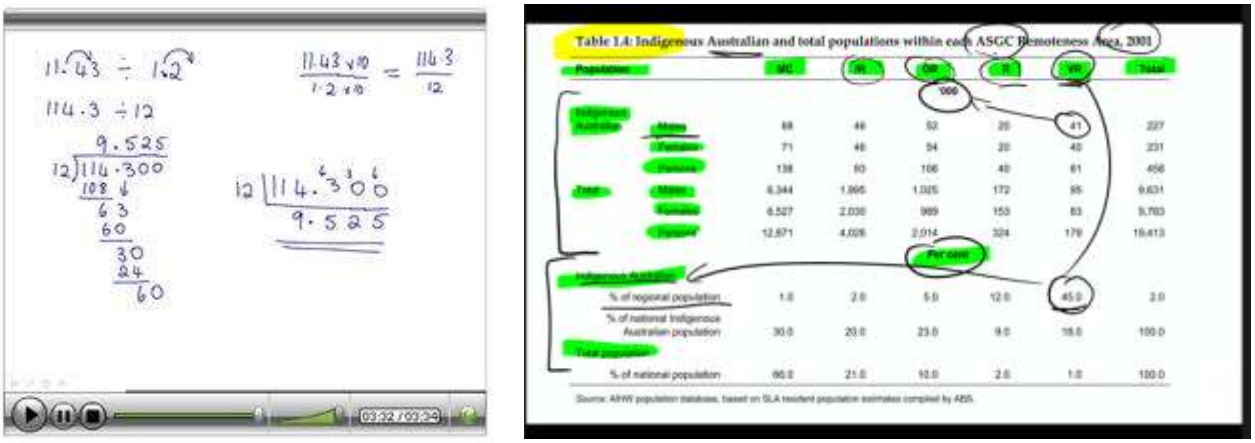


Figure 3: Screencasts developed to aid understanding

to the material via links from the course site. The screen cast on the left in Figure 3 shows students how to divide by a decimal and the one on the right explains how to read tables and graphs for a particular assignment. Students did appreciate them:

> I really liked the videos, exercises and links available either in the book or on study desk [the online management system] to assist with understanding the content. (student survey, 2008)

Program Conclusions Stage

At the completion of both the 2007 and 2008 offers of the course, reviews were undertaken, taking into account staff comments (Item 3), student comments from the standard course review questionnaire (Item 7), an online questionnaire developed by the team (Item 6), and pre-and post test comparisons (Item 5). These confirmed the team was going in the right direction. For example one student commented:

> the actual content is not something that I find particularly interesting, but the way it was taught to me made me realise how I would use it in my nursing career and that is what made it interesting. Also as I am a 'visual' learner I found the pictures used on the MAT course site helpful.

From the feedback, a number of improvements were discussed by the team. Two of these are Self Test and flexibility and are described below.

Self Test

This pre-test provided an avenue to understanding both students' errors and students' approaches to the questions. For example, Figure 4 shows various correct strategies students used in one question of the self-test. The one on the left shows multiplying 1.2 by 60 minutes; the student in the middle converted the 0.2 into a fraction and then added; the third student on the right used a ratio strategy, and deduced from the fact that one hour is 60 minutes that 0.1 of an hour must be 6 minutes, so 0.2 must be 6 + 6 minutes.

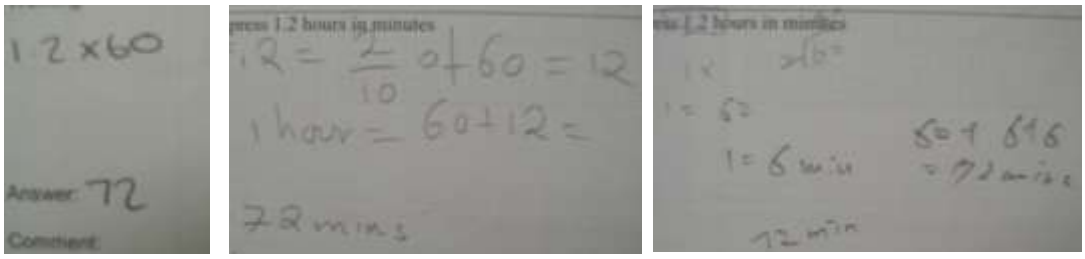


Figure 4: Students answers to a time conversion question

Some students made multiple errors in a question e.g. in converting from grams to milligrams. This student's work (seen in Figure 5) showed her using the wrong conversion factor, then while correctly suggesting to multiply, divided by moving the decimal point to the left.

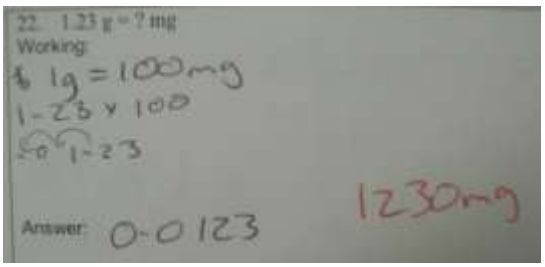


Figure 5: Student answer to a conversion question

Data from 2008 pre and post tests are included in the Appendix. It appears there is some improvement in aspects of students' mathematics skills, particularly those marked with an asterisk. For example in question 22, in the pre-tests only 51% of students answered correctly to a question on measurement conversion, but in the post-test, 91% of students were correct. Some of the concept gaps found from the pre-and post-tests were used to improve the course. From completed evaluation of these errors, material was developed to help overcome the conceptual errors, and incorporate different approaches to solving the problem. In 2008 Computer Marked Assessments (10 questions each) were included after each mathematics module. Students commented that they liked this aspect of the course, as one student commented: *The CMA's were easy enough and not stressful. This class was pretty easy to do.*

In 2009, some screen casts with handwritten explanations and an online student forum to discuss the use of the calculator in nursing practice was added.

Another addition to the Self Test was a reflective section. It is important to investigate why students don't know certain concepts, for instance because they have forgotten, are anxious about it, get confused, or have had missed schooling. A reflection mechanism to find out more about the student was included in the self-audit via students emailing their responses to a tutor together with their Self Test results. For example if they had forgotten a particular concept then they would take a different strategy to revise than if they had learnt it but never understood. Samples of students' reflective comments are included below.

> Student 34: as a general rule I understand what the question is asking and I don't know how to properly answerer the question or I make silly mistakes in my working.

> Student 89: Before attempting the questions I will read the questions thoroughly and if the answer does not look right I will attempt the question more than once until the question looks correct.

> Student 94: I do agree with the study plan [the computer automatically generated a study plan], except for the volume concentrations, I do understand volume concentrations but I just read the scale wrong, whereas not knowing how to do it. I feel that I do not have to put a lot of time into the studying of the maths; I am one of those people that can be shown something once and will remember it for a while. I enjoy maths on a scale of 1 - 10 around 8. I enjoy maths as long as I can see the purpose for doing the maths, algebra I always struggled in due to I could not find a purpose for the equations and so on.

In the examples above, reading appears to be an issue, so in the tutorial or in the instructions for Computer Marked Tests, emphasis is further placed on reading carefully and correctly.

Flexibility

In the 2007 evaluation, some students said they wanted more flexibility in how they approached the course. In 2008 changes were made to provide a mechanism for them to self-select flexible curriculum alternatives. After week 1 and completion of the Self Test, a parallel set of tutorial classes were made available which allowed students, confident in mathematics and IT skills, to complete the course in half the time. For students who were not confident in both areas, extra classes were made available through The Learning Centre. Students responded positively to this flexible approach. A typical comment from students surveyed*: I am glad I did the fast track and to have that option is fantastic.* Some students thought they could have followed the fast track, but chose to stay in the normal track as a student commented: *I didn't want to get overconfident and was happy to mosey along at a steady pace. I viewed this course as getting all students up to the same benchmark to go forward for the rest of the course* (student survey 2008).

Additional findings

Generally the evaluations were positive. For example the student survey (Item 6) revealed positive perceptions about the course. When asked the question "One of the objectives of these two first year courses was to help you master the skills you need to succeed at university. How satisfied are you that the courses helped you to become competent and confident using the following skills?" over 90% of the students were satisfied or very satisfied that the maths, computing, e-learning, writing, referencing, communication and learning how to succeed skills helped them. A comment from one mature aged student summaried many of the sentiments from students starting out at university: … *being terrified, not knowing anyone or how uni works, I found that [the course] extremely helpful.*

There was a group of comments about growth in understanding, confidence and reflection, which are essential skills across university disciplines:

- *Not everybody is good at maths. But at the same time I'm beginning to realise when something looks wrong*. (Interview with Student October 2008)
- *The peer reviews were a way to reassess your own work and acknowledge where you may have gone wrong. Giving helpful and positive remarks to others students also helped to give them feedback for future assignments.*

In the 2009 survey of second and third year students who had completed CMS/MAT (Item 9) their responses to the question "How have the skills learnt in CMS/MAT1008 helped you to succeed in clinical placement situations?" included:

- *Certainly without those don't think I will still be at university right now.*
- *The maths components as I hate maths but understand the strong need for it……*

Conclusions

The evaluation data received to date suggest that our approach assists students to develop numeracy nursing attributes. The instant return of most of the assessment items which were computer based and electronically submitted had a direct impact on our teaching, allowing the course team to respond to student queries and to trouble shoot more effectively. The feedback

from 2007 and 2008 suggests that students are extremely supportive of the courses. The pre and post tests in mathematics and pre and post reflective comments by students are evidence of increased confidence and competence in numeracy. Teamwork, study and reflective and evidence-building capabilities related to university and discipline requirements were also favourably mentioned in the feedback.

The management systems assist the course team's effectiveness in design and delivery. The content and authoring management system, for example, allowed the authors to easily incorporate multi-media features to support learning, address anxiety, flexibility of learning, contextualize learning and allow for a variety of explanations. The learning management system was highly praised by the students as being easy to use and helped them to connect with their assessments, material, fellow students and the instructors.

The success of the course relies on the many features embedded in the course and its close linkage to other courses in the semester and beyond. The academic numeracy audit, while not necessarily producing new insights into the mathematics skills needed, provided direct links to expert academic nursing staff and most appropriate in-context examples. For example, since USQ is a regional university and many students are from rural areas, graphs and statistics linking to this context were used to emphasise the importance of rural nursing issues. The student self-audit and reflections move away from the unhelpful remedial approach to diagnosing skills and provide insight into student error and approaches which can feed into further curriculum development. The flexible approaches to curriculum, student readiness and delivery provide students with maximum opportunity for learning. We realise this approach to building professional nursing attributes is only one step. The next is to map the development of numeracy over three years of the degree and into their profession. This will allow the students to develop their competence and confidence in numeracy to prepare for the demands of the nursing profession.

References

BBC News. (2005). Baby died after 'decimal' error. Retrieved June 01, 2008,from http://news.bbc.co.uk/1/hi/england/leicestershire/4566427.stm

Brinton, D. M., Snow, M. A., & Wesche, M. B. (2003*). Content-based second language instruction* – Michigan Classics Edition. Ann Arbor, MI: University of Michigan Press.

Coben, D., Hall, C., Hutton, B. M., Hall, D., Sabin, M., & Weeks, K. (2008). Numeracy for nursing: The case for a benchmark. In T.Maguuire, N. Colleran, O. Gill & J. O'Donoghue (Ed.), *The Changing Face of Adults Mathematics Education: Learning from the past, planning for the future. Proceedings of ALM-14, the 14th International Conference of Adults Learning Mathematics - A Research Forum (ALM), held at the University of Limerick, Ireland, 26-29 June, 2007*. (pp.88-102) Limerick: University of Limerick in association with ALM.

de Raadt, M, Toleman, M & Watson, R 2005, 'Electronic peer review: a large cohort teaching themselves? *Proceedings of the 22nd Annual Conference of the Australasian Society for Computers in Learning in Tertiary Education (ASCILITE'05*), QUT, Brisbane.

Davies, M., & Devlin, M. (2007). *Interdisciplinary Higher Education: Implications for Teaching and Learning. Centre for the Study of Higher Education*, The University of Melbourne. Retrieved 30 April, 2009, from http://www.cshe.unimelb.edu.au/pdfs/InterdisciplinaryHEd.pdf

Deans, C. (2005). Medication errors and professional practice of registered nurses. *Collegin 12*(1), 29-33.

FitzSimmons, G. E. (2006). Adult numeracy: Crossing boarders of discourse. In M. Horne & B. Marr (Eds.), *Connecting voices: Practitioners, researchers & learners in adult mathematics and numeracy* (proceedings of the 12th International Conference of Adult Learning Mathematics (ALM). Melbourne: ACU National.

Galligan, L. (2001). Analysing nursing students' drug calculation errors. In J. Bobbis et al (Eds.), *Numeracy and Beyond*: (Proceedings of the 24th Annual Conference of the Mathematics Education Group of Australasia Inc. Vol. 1, pp. 241-248). Sydney: MERGA.

Galligan, L. (2002). I can only do it with Aspirin. In G. Crosling & G. Webb (Eds*.), Supporting Student Learning: Case Studies, Experience and Practice from Higher Education*. London: Kogan Page.

Galligan, L., & Pigozzo, R. (2002). Assisting Nursing Students Solve Drug Calculation Problems Using Metacognition and Error Analysis. *Literacy & Numeracy Studies*, *12*(1), 45-62.

Galligan, L., & Taylor, J A. (2005). Investigating academic numeracy in non-mathematics courses at university, "Building" and/or training: *Proceedings of the 11th International Conference on Adults Learning Mathematics* in Kungälv, Sweden. 29 June-2 July 2004. Göteborg, Sweden: Göteborgs Universitet. (ISSN 1404-0646).

Gillies, R. (2004). Numeracy for nurses: The case for traditional verses non-traditional methods for teaching drug calculation. In I. Putt, R. Faragher & M. McLean (Eds.), *Mathematics education for the third millennium: Towards 2010 (Proceeding of the 27th annual conference of the Mathematics Education Group of Australasia* Vol. 1, pp. 255-262). Townsville: MERGA.

Guba, E & Stufflebeam, D 1970, *Evaluation: The process of stimulating, aiding and abetting insightful action*, Monograph series, Measurement and Evaluation Center in Reading Education Bloomington, Indiana University.

Hansen (Maag), M. (2002). *The Effectiveness of an Interactive Multimedia Learning Explanation on Baccalaureate Nursing Students' Mathematical Achievement and Self-Efficacy*. (Doctoral dissertation, University of San Francisco, 2002).

Hilton, D. (1999). Considering Academic Qualification in mathematics as an entry requirement for a diploma in nursing programme. *Nurse Education Today, 19*, 543-547.

Johnson S. & Johnson, L. J. (2002). The 4 Cs. A model for teaching dosage calculation, *Nurse Educator 27*(2), pp. 79–83.

Keimig, R.T. (1983). *Raising academic standard: A guide to learning improvement*. ASHE-ERIC Higher Education Report No. 4. Association for the Study of Higher Education, Washington, D.C, USA. (ED233669)

Lawrence, J. (2005). Reconceptualising attrition and retention: integrating theoretical, research and student perspectives, *Studies in Learning, Evaluation and Development*, 2(3), 16-33, Retrieved 25 March 2008 from http://sleid.cqu.edu.au

Lawrence, J., Loch, B. and Galligan, L. (2008). Building professional nursing and academic attributes in a first year nursing course. Special issue: Reframing e-assessment: adopting new media and adapting old frameworks. *Learning, Media and Technology, 33*(3) 169-189.

Phillips, J., Beam, S., Brinker, A., Holquist, C. Honig, P., Lee, LY, & Parmer, C. (2001). Retrospective analysis of mortalities associated with medication errors. *American Journal of Health-System Pharmacy 58*, 1835-1841.

Pierce, R., Steinle, V. A., Stacey, K. C., & Widjaja, W. (2008). Understanding decimals: A foundation for correct calculations. *International Journal of Nursing Education and Scholarship, 5*(1), Art. 7. Retrieved 4 March 2008 from http:www.bepress.com/ijnes/vol5/iss1/art7.

Pirie, S. (1987). *Nursing and Mathematics: Deficiencies in Basic Mathematical Skills among Nurses*. London: Royal College of Nursing.

Santamaria, N., Norris, H., Clayton, L.,& Scott, D. (1997). Drug calculation competencies of graduate nurses. *Collegian*, 4(3), 18-21.

Sabin, M. (2001). *Competence in practice-based calculation: Issues for nursing education*. Edinburgh: School of Acute and Continuing Care Nursing, Faculty of Health and Life Sciences, Napier University.

Tapper, J. & Gruba, P. (2000). Using a 'conference' model to teach communication skills in a communication across the curriculum program. *Language and Learning Across the Disciplines. 4* (1), 55-65.

Taylor, J. A. (1998). Self Test: a flexible self assessment package for distance and other learners. *Computers and Education 31*, 319-328.

Taylor, J. A. and Mohr, J. (2001). Mathematics for math anxious students: development, design and evaluation of a distance education course. *Journal of Developmental Education* 25 (1), 30-41.

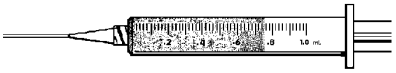
Taylor, J. A., & Mander, D. (2003). Developing study skills in a first year mathematics course. *New Zealand Journal of Mathematics, 32 (Supplementary Issue)*, 217-225.

Weeks, K. W., Lyne, P., & Torrance, C. (2000). Written dosage errors made by students: The threat to clinical effectiveness and the need for a new approach. *Clinical Effectiveness in Nursing, 4*, 20-29.

Wright, K. (2007). Student nurses need more than maths to improve their drug calculating skills. *Nurse Education Today, 27*(4), 278-285.

Yasukawa, K., & Johnston, B. (1994). A numeracy manifesto for engineers, primary teachers, historians… .a civil society - can we call it theory? *Proceedings of the Australian Bridging Mathematics Network Conference* (pp. 191-199). Sydney: University of Sydney.

Appendix A

Question	Pre 99-02	2008 Pre	2008 Post
1. Write the following number in numerals: *Twenty thousand two hundred and six*	87	83	81
2. 102 - 36 =	95	97	99
3. 1 048 + 21 376 =	94	96	94
4. 23 × 145 =	87	92	99
5. 168 ÷ 12	95	96	99
6. Estimate 512 × 174	36	23*	51
7. Round 495 to the nearest 10	88	79	89
8. 7 + 2 × 3 =	58	76*	88
9. 3/4 = 15/?	93	88	94
10. Find the average (mean) of the following list of numbers: 21.3, 22, 24.7, 20.4, 19.	78	31**	82
11. 15.8 x 0.2	76	83	97
12. Express 3/4 as a decimal	93	94	87
13. Express 80/480 as a fraction in simplest form	80	78*	92
14. 7.42 ÷ 100	88	84	97
15. Find 30% of 25.	83	86	94
16. Express 0.5 as a fraction in simplest form	90	91	95
17. Calculate: 2 mL -1.34 mL	91	78	96
18. Calculate: √81	93	95	99
19. Express 7 hours 20 minutes in minutes	93	88	96
20. Express 1.2 hours in minutes	50	50*	74
21. 360 mL = ?L	86	73	81
22. 1.23 g = ?mg	50	51*	91
23. The chart represents a patient's temp. When was his temperature the highest? What was his temperature the last time it was taken?	Not asked	 88 66	 97 97
24. If $b = \frac{w}{h^2}$ find b if w = 2, and h = 4.	Not asked	48	74
25. $\frac{10}{4} = \frac{8}{x}$: x=	35	44*	77
26.The diagram represents a syringe with fluid. How much fluid is in  the syringe?	48	48*	82
27 Energy is measured in Kilojoules (kJ). Margarine contains 32.2	83	75	94

kJ/gram. How much energy is in 500g tub of margarine?		86	97
28 A clock gains 15 seconds in a day. How long does it take to gain 2 minutes?	78	85	90
29 A Paediatric patient weighing 25 kg is ordered Augmentin 10mg/kg. If Augmentin is supplied as a syrup containing 125mg/mL, how much syrup is to be measured out	68	57 73	80 90