

A calculated risk

Linsey Pitt

School of Health

Background and rationale

The course and module to which this innovation project relates is the Diploma in HE/Registered Nursing: Practice of Nursing 2 Module NH1010. This module sits in term 2 of year 1 of the 3-year Diploma route. One of the key skill outcomes of the module relates to the use of number and one of the subject specific outcomes requires the student to demonstrate knowledge of drug calculations. This is an important area of nursing practice and one that can be problematic.

There is some concern that modern methods of drug delivery have resulted in de-skilling in this area of practice (Duffin, 2000; Coombes, 2000, Hutton 1998) although there is also some evidence from the literature that poor levels of numeracy amongst nurses is not a recent phenomenon (Bayne and Bindler, (1987); Blais and Bath (1991)). In some clinical contexts drug calculations are performed infrequently but when they are performed the calculations may be fairly complex or potentially dangerous if performed incorrectly resulting in a low frequency-high risk situation, particularly in paediatrics. It has been argued that drug calculations do not represent the main source of error in drug administration situations (Hutton, 1998) but others maintain that calculations are a significant source of drug error (Haigh, 2002). Clinical practice colleagues have expressed concern about mathematical competence in qualified staff and are providing remedial programmes of instruction. The literature suggests that this is a significant problem elsewhere, (Lerwill, 1999; Johnson 2002) and not just confined to the UK. The British government has also identified poor numeracy skills amongst the adult population as a concern and have developed various strategies to address this at all levels (Dfes, 2003).

There are four identifiable areas of calculation used to a greater or lesser degree in nursing, depending on the context; calculation of tablets, calculation of volumes of mixtures or injections, flow rate calculations and drip rate calculations. These are tested equally in the School of Health through an examination paper of 1½-hour duration. Questions were set by the module team, who are all experienced nurses, and reflect real drug dosages and volumes. Following discussion with various interested parties it was decided that the students should not be allowed to use calculators and that they would also be required to show their workings in order to obtain a mark. This decision is controversial as some argue that accuracy is enhanced when nurses use hand-held calculators, (Shockley et al. 1989, Kapborg and Rosander 2001). The decision was based on observations by clinical colleagues that a) calculators were often not found in clinical areas and that b) nurses should be able to show the derivation of their answers in case of a difference of opinion between practitioners. It had been noted in a previous test where students were allowed the use of calculators that several students made input errors and arrived at incorrect answers. Shockley et al (1989) note that calculator use is associated with more conceptual errors.

The module markers noted many examples where students have not been able to make sense of the kind of data they would see in practice. The following is but one example taken from a student's paper but which has been also found in other student's work:

A patient is prescribed 10mg of a drug to be administered via a nebuliser mask. The stock dose is 10mg/ml. The volume in the ampoules is 2ml.

How many ampoules will you require?

Student's answer:- $2 \times 10 = 5$

Answer = 5

In the example, there is little evidence that a calculator would have helped this student to avoid a serious overdose, as he did not seem to recognise that the concentration of 10mg/ml would give 20mg of the drug in a 2ml ampoule and that only 1ml of this would be required. One of the key problems the team identified over time was the failure of student to estimate before or after computing to spot the 'obvious error'. Guidelines from the professional governing body the Nursing and Midwifery Council (formerly the UKCC) state that nurses should not rely too heavily on calculators, and that the use of calculators 'should not act as a substitute for arithmetical knowledge and skill.' (UKCC, 2000)

The rationale for asking the students to show how they have arrived at their answer is that by using dosages and volumes that are commonly encountered, the scope for variety of question is limited. This creates the potential for students to 'memorise' answers without understanding how the answers are derived. The drug calculation paper seeks to test the student's application of number to problems, not their ability to blindly memorise. In addition, the student may at some point need to be able to justify their derivation of an answer to a colleague, or understand a colleague's explanation if there is a difference of opinion about the dose required. Processing of the calculation is therefore as important a skill as arriving at the answer.

Results from the first three cohorts of students to sit the paper assessment demonstrated pass rates of approximately 50%, 40% and 35%. The types of errors found in the student's papers suggested problems with both conceptualisation of numerical problems and processing. The ability to calculate drug dosages, as evidenced by testing in a previous version of the nursing curriculum, suggested that drug calculations were generally problematic to students and many students failed to achieve even a 40% accuracy rate. This level of error was felt by many staff to be unacceptable in terms of assuring patient safety. The literature related to the relationship of mathematical paper testing to accuracy in practice is inconclusive with some studies suggesting that written drug calculation tests did not reliably predict which nurses are likely to make subsequent medication errors (Conti and Beare, 1988) whilst others showed that failure rate in written tests was associated with increased likelihood of medication error in practice Calliari (1995).

Professional guidance related to the scope and practice of assessment of drug calculation skill is confined to broad statements and there are no specific curriculum requirements at present. However, our service partners have identified some of the difficulties they face with qualified staff that cannot calculate accurately. Senior clinical colleagues have also commented on the frequency of other types of mathematical error not assessed in this examination such as incorrectly calculating fluid input-output data. This could have serious consequences for the patients as dehydration can lead to serious complications in those with co-existing illness.

The difficulties of assessing the students in this area in ways other than paper test have been discussed within the School. Practical assessment would be preferred but this would need to be regular and consistent and across a variety of contexts and this presents difficulties in two respects: validating the practice of testing in clinical settings and clinical colleagues report poor maths skills in some qualified staff and are undertaking remedial in-house programmes with staff.

As this was a complex area of skill development it was felt necessary to target students who would be likely to have difficulties as early as possible in the course and so the innovation project focused on the development of a diagnostic test which would assess competence in the types of mathematical processing required of the students in the drug calculation test, alert the students to any problem areas and that could be self-administered.

The innovation

The innovation team consisted of a study skills advisor, the project holder and a courseware developer. Clinical staff were consulted to establish current practice in relation to drug calculation. A colleague from the School of Education was also consulted in the early stages to gain insight from a specialist in the development of skills in early-years maths teaching. This contact was made at the initial CELT project workshops. This proved a very interesting and useful experience with the lecturer visiting students who were experiencing severe difficulties for a tutorial class that evaluated well and gave ideas to the project for the type of strategies that could be developed.

Lecturers in nursing considered many of the students' errors to be astonishingly basic, yet the early-years maths lecturer pointed out that some of the 'simple' ratio calculations involved conceptualisation that many of the population find difficult. From these initial meetings it was decided to extend the material produced to instructional material aimed at a more visual representation of drug calculation problems. The diagnostic test was based on the type of skills required for nursing related number tasks and the type of questions devised were designed to be similar in complexity to those used at Key Stage 3 (11-14 years). The areas for assessment were basic arithmetic, measures, estimations, fractions and decimals, ratios and, in addition, working with charts and tables. Questions were mostly free of a nursing context as the diagnostic would be administered early in the course and questions involving drug names could prove distracting to the student. Assessment of mental and written arithmetical processing was thought to be important, as nurses should be able to perform many of their daily numerical tasks mentally in the interests of efficiency. A paper version of the test was administered to a cohort of students and the results analysed. One difficulty with this type of innovation was the timescale. The time between applying the diagnostic test and the students concerned being tested by the drug calculation assessment was too long and so the results of the diagnostic were compared with results of a previous cohort in the drug calculation assessment.

Another aspect to the innovation was to develop the diagnostic test to CD Rom to facilitate self-assessment. This was delivered to a different cohort of students, who were asked to use the CD Rom and then complete an evaluation questionnaire. In addition, the team developed instructional material based around each area of drug calculation with a view to offering eventually a complete package to assist the development of clinically relevant skills. Screenshots of the programme are shown in appendix 1.

The outcomes

It was found that there were fewer students obtaining a mark of 80% in the diagnostic test than were obtaining the pass mark of 80% in the drugs calculation test in the previous cohort. The mostly likely explanation for this is that those undertaking the drug calculation assessment have also had workshops and opportunities such as study skills support and are further on in the course. This is an interesting finding as it suggests that we are able, with the support offered, to raise the level of skill in the students. It also suggests a poor level of entry skills in maths across that student cohort. This finding accords with the module team's perception that the student groups were on the whole low on numeracy skill based on their need for tutorial support.

In addition the test showed where the students' main areas of weakness were mainly ratios, fractions, decimal measures and decimal fractions.

An extra component to the project was the development of a more visual approach to maths problems. An initial search at the start of the project did not reveal any suitable products on the market. One to one sessions with students and an examination of the literature relating to the teaching of difficult maths concepts such as ratios suggested that being able to 'see' the problem was useful. Instructional literature in the journal and in text form tends to be perceived by students as 'dry'. Students with difficulties conceptualising did not find the text form helpful, as working through examples with the use of formulae was presented as abstract concepts, rather than assisting the student to look for patterns in the numbers and grounding the learning in visual and concrete explanations. (Ciancone,1996)

Dreamweaver Course Builder $\dot{\text{O}}$ software was already available in the School and was used to construct the visual materials such as 'drag and drop' images of tablets and syringes. The intention was to allow the user to see and hear tablets dropping into a medicine pot in combination with written feedback. Another example of visualisation of maths involves the use of a 'click and drag' syringe image to allow the student to see the effect of the changing dose-volume relationship of a drug. (See appendix 1)

Benefits

The benefits of the project are:

- The project team have learnt much about creating a visual learning environment and the benefits and limitations of the selected software.
- The project has identified areas for future research. There is a wide variance in perception about the tasks performed by nurses that require competence in handling numbers and not just amongst lecturers but also clinical staff. During the course of the project many opinions were offered about what students and nurses were doing in the 'real world'. In fact this seemed to vary from setting to setting. In some instances nurses were using technology that obviated the need for calculation; in others the same task still required calculation. In some settings there is lack of confidence in the technology and nurses double-check by performing manual calculations. There are dangers in only training nurses with the skills required for one context, as they may work elsewhere when qualified. Of particular interest was a perception from some students and colleagues working in mental health settings that drug calculations were rarely needed. Consultation with an acute mental health unit suggested that in fact quite complex calculations involving titration of dosage could be performed. Research which endeavours to explore the actuality of use of number skills across our partner trusts would be extremely valuable
- A tool for assessment has been devised which has been positively evaluated by students and which should prove useful in directing the students towards early support where necessary
- Useful insights regarding how best to facilitate learning of maths skills have been obtained from communication with colleagues in other schools.

Evaluation

This proved difficult as the only opportunity afforded to trial the CD was just prior to placement at the end of their first term and required therefore a postal return. Students were given stamped addressed envelopes and an incentive of a book token prize draw for those returned within the allotted time. Out of 70 students only 22 questionnaires were returned. The results can be seen in appendices 4 and 5. At this stage in the development of the CD Rom the key areas to explore were functionality, perceived value and readability. The respondents were given the option of adding their name and a phone number for the prize draw but other than that the questionnaires were wholly anonymous. This did not seem to have a bearing on their comments or scores. There was no strong link between the

positivity of their response and previous experience of maths unless noted specifically in appendix 3. Generally the findings are encouraging with the majority of students rating all aspects positively (Appendices 2 and 3). The design team need to review readability as a few students rated this less positively. There needs to be discussion around the time limits given particularly for the mental maths component. This component was trialled on colleagues who were competent but not expert mathematicians and all completed the test within the time limit of 6 minutes. The interactive elements demonstrated in the trial CD Rom were not evaluated as positively as anticipated however only one example of each was offered and the calculations to which they related were not difficult ones.

Future developments

Samples of the CD Rom material were viewed as part of the University Learning and Teaching Projects presentation day at the Main Campus by a range of staff including representatives from other schools as well as finance, personnel and I.T. services staff. Interesting ideas were obtained from some CAD students about the possibilities of alternatives to the software used. Most interest, other than that from students who have used the material has originated from outside of the School of Health. It has been suggested that the development of the CD Rom instructional material continue using alternative software with a view to providing a useful learning aid that could be used for nursing students and possibly as refresher material for qualified staff. The students' comments suggest that it would be useful to distribute the CD Rom diagnostic test at the start of term 1 to supplement the input on number skills given in the key skills module.

Acknowledgements

Sincere thanks are extended to: Dawn Gray and Alan Smith of the project team; Bob Davies of the School of Education; the students of cohorts April 2002 and October 2002 at New Cross Hospital for their contribution to the evaluation of this project and to teaching colleagues and clinical staff in our partner NHS Trusts who have provided professional advice regarding the content of the CD ROM.

References

- Bayne T and Bindler R. (1997) Effectiveness of medication calculation enhancement methods with nurses. *Journal of Nursing Staff Development* 13:6 293-301
- Blais K. and Bath J.B. (1992) Drug calculation errors of baccalaureate nursing students. *Nurse Educator* 17:1,12-15
- Ciancone T. (1996) Numeracy in the Adult ESL Classroom, *ERIC Digest*, Feb 1996
- Calliari D. (1995) The relationship between a calculation test given in nursing orientation and medication errors. *Journal of Continuing Education in Nursing* 26:1 11-14
- Conti A., Beare P.G. (1988) Performance on a mathematics/drug calculations test: relationship to subsequent reported medication errors. *Journal of Nursing Staff Development* 4:54-58
- Department for Education and Skills (2003) The National standards for adult literacy and numeracy: adult numeracy core curriculum http://www.dfes.gov.uk/curriculum_numeracy/intro/ns/ last accessed 10.9.03
- Duffin C. (2000) Poor standard of maths put patients' lives at risk. *Nursing Times* 96:34, 23
- Hutton B.M. (1998a) Do school qualifications predict competence in nursing calculations? *Nurse Education Today* 18: 25-31
- Haigh S. (2002) How to calculate drug dosage accurately: advice for nurses, *Professional Nurse* 18:1 54-56

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

Johnson S.A. (2002) The 4 Cs: a model for teaching dosage calculation. *Nurse Educator* 27: 2, 79-83

Kapborg I., Rosander R. (2001) Swedish student nurses solving mathematical items with or without help of a hand-held calculator – a comparison of results. *Nurse Education in Practice* 1, 80-84

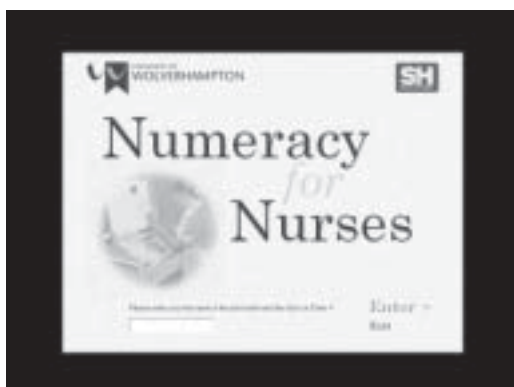
Lerwill C.J. (1999) Ability and attitudes to mathematics of post-registration health-care professionals. *Nurse Education Today*, 19, 319-322

Shockley J, McGurn W, Gunning C, Gravely E, Tillotson D (1989) Effects of calculator use on arithmetic and conceptual skills of nursing students. *Journal of Nursing Education* 28: 9, 402-405

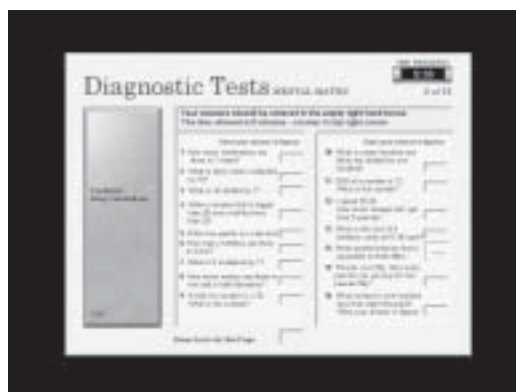
UKCC (2000) *Guidelines for the administration of medicines*

A Calculated Risk: Appendix 1

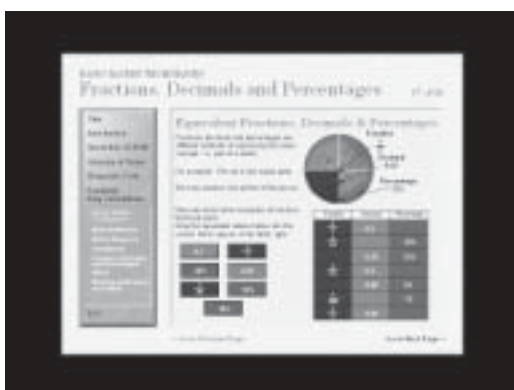
Screenshots of the 'Numeracy for Nurses CD Rom



1. Title Screen



2. Mental Maths Diagnostic Test



3. Fractions, decimals and percentages activity screen



4. 'Click and drag' activity example

Appendix 2

A Calculated Risk: Evaluation Questionnaire Results: Quantitative Data Questions

Number of responses in each category

1. Evaluating the introduction to the CD ROM

- a) The introduction was clear
- b) The introduction was easy to read
- c) I knew what the purpose of the test was after reading the instructions
- d) I was reassured that the test was for my benefit

Strongly agree					Strongly disagree
1	2	3	4	5	6
14	6	2			
14	5	2			
15	4	3			
14	5	3			

4. Following the tests you should have been given a score and some feedback based on your score. Please rate the feedback in the items below

- a) My test score was what I expected
- b) I found the feedback useful
- c) Knowing my score will help me to plan for future study
- d) I know whom I need to see to get further help if I need it
- e) I am aware of what I need to do now in relation to my numeracy skills
- f) I am likely to follow the advice offered in the feedback

Strongly agree					Strongly disagree
1	2	3	4	5	6
8	8	5			
11	8	2	1		
14	3	4	1		
13	4	4			1
15	2	5			
15	2	4			

5. At what point in the course do you think it would be most useful to have the CD ROM

- a) Before starting the course as part of a pre-course information pack
- b) At the beginning of the key skills module in term 1 year 1
- c) After the key skills module
- d) At the start of term 2
- e) I would not find it useful

Strongly agree					Strongly disagree
1	2	3	4	5	6
5					
15					
3					
1					

6. Evaluation of the other materials

On the CD ROM there were some other materials. These are not yet completed but we would be pleased to have your feedback on the following

- a) The materials were generally interesting
- b) The click and drag activities helped me to relate to the learning task
- c) The function which allowed me to fill a syringe on screen helped me to work out the answer to the problem
- d) The content in the tutorial areas was the right level for my needs
- e) I could easily understand the language used in the tutorial material
- f) The size of the words was readable

Strongly agree					Strongly disagree
1	2	3	4	5	6
12	2	6			
9	5	5	1	1	
10	6	4		1	
12	3	6			
12	2	6			
10	5	6			

Appendix 3

Qualitative Evaluation Data

2. Evaluating the diagnostic test: the mental maths 6 minute programme

Q: Did you experience any problems with this part of the programme during the test? If so please give details

The only problem I had was I could not finish it in the allocated time'

Needed more time

I didn't have enough time to answer all questions'

I didn't realise you had 6 mins to do the 2 out of 13 pages.'

I thought 6 minutes was too short to answer 30 questions'

I could have done with just a little more time to answer the questions because not completing them gave me a low score same as with above'

No problems other than the currency questions. It only accepted the correct answer with currency before the number ie £4.20 not 4.20'

3. Evaluating the diagnostic test: the 20 minute programme

Q: Did you experience any problems with this part of the programme during the test? If so please give details

Not having enough time to calculate answers'

Again I ran out of time'

Other comments: as written by the students

The CD ROM was very useful and gave me some indication of what I needed to learn (I received a GCSE level 3 in maths)'

I felt that the cd-rom is a good idea, by giving the student each a copy it allowed me to use it when I felt ready. It showed me some maths skills I need to improve. Also the fact it included calculations related to nursing made it more relevant. ' (GCSE Maths B: Key Skills 2 Pass)

The tablet dropping question was a bit confusing. The program seemed to register more tablets than I thought.' (GCSE Maths Grade B)

Maths GCSE grade B and AS level (Did not find syringe activity useful)

Maths GCSE Grade D (needed more time)

I felt the CD Rom very helpful. It gave me an idea on what to expect in the real test and I would find this useful for revision' (GCSE Maths Grade C)

Overall would have to say it was very helpful' (no qualifications in maths)

Not enough time on the diagnostic tests (access to nursing course)

I enjoyed taking part in this activity and it has left me feeling more confident showing me the areas of learning I need to concentrate on. (School was terrible college was very good/ access to nursing)'

The CD Rom was straightforward and interesting. It was easy to follow and the questions were worded well. I think it was a good idea how you can see how the calculations is

worked out in stages and again this was easy to follow'

Very useful showed me that I need some help with my maths' (O level Grade C) + A28

Very useful showed me that I need some help with my maths' (O level Grade C)

This will be a useful tool to assess students I quite enjoyed the test' (GCSE Maths Grade B)

Not much maths experience apart from household use)

Very good can't wait till its finished. Very helpful (Grade E GCSE Maths)

I found the CD Rom very useful' (Maths GCSE Grade E)

(CSE Maths) Responded did not comment but scored some reservations about readability and level of tutorial material)

Found it excellent' (GCSE Maths)

GCSE Maths C Studied AS statistics for 1 year)

The CD Rom was a great help. I know I was weak in some areas and this picked it ip for me. I now know how weak but felt I could have done better given a little more time. I really like this idea for students. I did an access to nursing course but found i was as weak at fractions as I was in school. I feel more time should be spent in this area as it goes in and we soon forget'

GCSE Maths (Previous experience with maths rated as 'brilliant')

GCSE Maths (Grade D)