Analysing Nursing Students' Drug Calculation Errors

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Nursing students at universities are often tested on drug calculations through their degree. These are usually pencil and paper tests which may provide an imperfect picture of drug error. A project, based at the University of Southern Queensland's academic support unit, was developed to investigate the cognitive and metacognitive processes used by students who have difficulty with drug calculations. This paper presents some of the findings of this research, based on group interviews of nursing students. It identifies student strategies, error and reasons for error. The results of this research will provide a framework for future support for nursing students.

Universities often provide support to nursing students to improve their numeracy skills and more specifically to assist students undertake medical calculations confidently and correctly. In order to provide the correct support, lecturers need to know where students' errors are occurring, understand why errors occur, and provide appropriate support to reduce future error.

Traditionally, support programs have provided testing. This, in combination with faculty input from students' results in various drug calculation tests, has provided comprehensive data on where student error occurs in pencil and paper tests. Many of these tests have been used as a basis for providing support for students. However, one-to-one support has provided anecdotal evidence and recent research have provided further evidence to suggest broader reasons why students make errors as well as a different picture on the errors themselves. Support programs in many universities, are providing programs such as workshops, and one-to-one support and are now based on general constructivist and situated abstraction theories (Stillman, Alison, Croker, & Tonkin 1999; Hoyles, 1998). These programs may provide the right environment for student learning, but what should they learn? If various programs rely on information from student error based on pencil and paper tests, then the picture is incomplete.

A project, based at the University of Southern Queensland was developed to investigate the cognitive and metacognitive processes used by students who have difficulty with drug calculations. More specifically the project aimed to use group and one-to-one interviews to identify student strategies, error and reasons for error and provide a framework for support based on past practice at USQ, current practice at other institutions and information from interviews.

This paper will examine a section of this project which identifies the errors and the reasons for error made by the students in the group interviews. It will also provide suggested directions for support programs such as nursing.

Literature Review

There are a number of types of medication errors identified in the literature from nurses and from nursing students. A study by Gladstone (1995) was based on actual errors of nurses in hospital. While this study suggested errors in incorrect infusion rates, and drug dosages it also included errors in administration to the wrong patient or giving the wrong drug. Other studies were based on written tests given to nurses (Bliss-Holtz, 1994; Santamaria, 1997; Miller, 1992) or nursing students (Blais & Bath 1992; Calliari, 1995; Gillham & Chu, 1995). These tests are typically standard pencil and paper drug calculation tests found in most tertiary institutions and hospitals. The mistakes from these tests have been identified using various error analysis techniques. Bliss-Holtz (1994) testing 51 registered and graduate nurses, separated those due to calculator absence (39%) and conceptual error (61%). Gillham and Chu, (1995) testing 153 2nd year nursing students identified ten error types: six were mathematical errors; two measurement errors, one approximation error and one formula error, and concluded that 60% of the errors were due to mathematics type errors. Blais and Bath (1992) also analysed student error and identified three error types – conceptual, mathematical (addition & subtraction (1%); multiplication and division (53%); decimals (44%) and fractions (2%)) and measurement (metric (8%) and apothecary (eg conversions of drops to flow rates) (92%)). They concluded the conceptual errors accounted for by far the highest error rate (68%). These studies have all concentrated on analysing the results of standard written tests.

Recent mathematics education research has questioned the accuracy of written tests in correctly assessing student knowledge with Clements and Ellerton, (1996) suggesting that they are "good at reliably generating *mis*information." Written tests only tell some of the picture. Therefore, a deeper analysis of student problem solving strategies is needed to more accurately identify student error.

If nurses in practice actually obtained their information about a drug in written problem form, then written pencil and paper tests would be appropriate, but this is not the case. Nurses gather information that is written from a doctor's orders, perhaps seen in charts, spoken by the doctor or another nurse and they see the patient and physically administer the drug. Nurses also calculate the drug in many different ways (Pozzi, Noss, & Hoyles, 1998). It is not surprising then, to read that Hoyles, Noss, and Pozzi (1999) conclude there is little relationship between drug tests and nursing "competence in practice". (p 49).

More emphasis should be placed on learning style and appropriate pedagogy. Apart from Bath and Blais (1993) who suggest that about 17% of error can be attributed to learning style in mathematics, few studies in the nursing literature have identified learning styles as a factor in this dilemma. Drug calculation tests have traditionally been pencil and paper tests which rely heavily on what Bath and Blais identified as sequential "inchworm" style, but drug calculations on the hospital floor rely on much more than an inchworm style. Recent research suggests we should be concentrating on at competence in a more realistic setting. Stillman and her colleagues (1999) concluded that improving mathematical skills will not resolve the problem but educators need to improve students' ability to conceptualise the problem. While many studies have identified context and real life scenarios as important (e.g. Cartwright, 1996), few have, to date, been able to put this in practice. Hutton (1998) and Stillman (1999) actually include this in a pedagogical methodology for nursing.

Analysing pencil and paper tests will not provide a clear picture of the nursing students' difficulty with drug calculations. Interviews have been regarded as a source of more accurate information, providing cognitive, metacognitive and affective information (e.g. Liedtke, 1988; Lowenthal, 1987). To provide this information accurately, various models have been developed. The Newman's analysis of error discussed in Clements and Ellerton (1996) is quite versatile and utilises student interviews to analyse student error in terms of five categories: Reading, Comprehension, Transformation, Process and Encoding as well as including carelessness and motivation as a factor in any of the above five categories.

Conducting interviews can also identify metacognitive awareness. A pilot study by Surman and Galligan (1994) on adults returning to study mathematics was based on work by Bastik (1993). This study investigated students feeling of knowing and confidence. Metacognition and anxiety has been mentioned in some nursing literature. Pozehl (1996) for example, concluded there was no significant difference between nursing students' mathematics anxiety and other undergraduate students in general, and Worrell (1990) specifically addresses metacognition for nursing education and concluded its application in drug calculations could be useful.

Apart from Gillies (1994), Hutton (1998) and Pozzi et al., (1998), few studies have concentrated on cognitive, metacognitive and pedagogical process of drug calculations, especially in the nursing literature.

Methodology

Subjects

The students in this project were 1st, 2nd or 3rd year students who were enrolled in a medical calculations unit in an undergraduate nursing degree at the University of Southern Queensland. The participation in the project was purely on a voluntary basis and some of the participating students had failed this unit in the past. Thirteen students altogether (one male) took part in one of more of the interviews each of which lasted about an hour. Because of timetable and other constraints the numbers in the group varied from week to week. Ten group interviews were conducted altogether. There were two groups for four weeks and an extra group for two weeks. The age of the students ranged from 18 to 45.

Method

The interviews were based on the cognitive and metacognitive processes students were using when solving problems. These interviews were semi structured around a series of 5 written questions given on a sheet to each student (condensed form below) for four typical drug calculation problems each week:

- How much did you like or dislike this type of question and why?
- How confident are you that you can do this question?
- Did you get stumped? Where? Why? How did you feel?
- Do you know you are right? Why?
- What method did you use?
- How do you feel? (after finishing the question)

Students were first asked to read the drug problem and then answer the first two questions about like or dislike, and confidence. This often prompted some discussion before starting the problem. They were then asked to attempt the question. Students were not allowed to use a calculator, as calculators were at that time, not permitted in the examination for the medical calculations unit. When the students finished, they were asked to complete the next three questions on: did they get stumped, feeling of knowing and the method they used. The interviewer then allowed for discussion on the problem, before the students answered the final question on feelings. They then moved on to the next problem. In total 103 sheets were completed by students. The transcripts of the interviews and the information from sheets were analysed using NVIVO.

Results

Of the 103 questions that were answered by the students, 49.5% were correct in the students' first attempt. While the questions in the interviews themselves did not follow the Newman method, it was possible to analyse error based on Newman's analysis. The decision to place an error was based on their written answer and the transcripts of the interviews. Table 1 below summarises this analysis.

Table 1
Analysis of Error in 103 Drug Calculation Problems

Error	Number	Percentage
Reading	0	0
Comprehension	6	11.3
Transformation	24	45.2
Process	23	43.4
Carelessness	1	(1- process)

While there were no reading errors identified, from student transcripts, a number of reading issues emerged.

> In the b.i.d. and that, I get confused.

> Mine was just knowing what formula to use. I sort of knew how to do it, but it was knowing what formula and what really was, the b.i.d. I still couldn't and that's why I wasn't sure of the answer because I couldn't remember what b.i.d. stood for.

Often the problem itself contained a lot of information and some of the statements were irrelevant to the solving of the problem.

> Student: But a lot of times it's the problem, they've got so much information in the question that I don't know what information I've got to use out of that.
> Interviewer: So if there's some extra information?
> Student: Yeah that's where I fall down, totally.

Comprehension

Examples of comprehension, i.e., not understanding what the question was asking the student to do, usually related to misunderstanding the units required. For example students often confuse volume problems. The following examples show the different comprehension errors:

> What volume of drops' Yes, they're asking for drops.

> Then my answer'd be wrong because I've put it into mL, and they wanted drops
>
> I know this is totally unrelated but whenever a cooking recipe says they want 215 mgs, I get out a measuring cup, because 215 mgs equals 215 mL,….No, like 250 mgs of flour equals 250 mL of water.

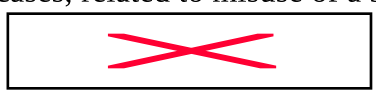
Another comprehension error was related to time. This question asked for mL/hr.

> Slowly infuse 550 mL over an 8 hour period, so naturally you would only assume that you divide 550 by 8 multiplied by 60.

From the interviews, it was evident that even if students were getting the correct answer, they were not confident they were correct, and comprehension did have a role to play:

> Student 3: But this is totally different than sitting in the exam. (Interviewer: I know)
>
> Student 4: And thinking, where do I start? What do I actually have to pull out? What information are they asking me for?

Transformation

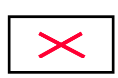
Examples of transformation errors, i.e., students not developing an appropriate strategy were, in about one third of the cases, related to misuse of a standard formula. For example if a student used the formula , they confused the dose required with the dose in stock. Students did not always specifically use or say they used a formula, but it was often in students' minds as they were transforming a problem:

> Student: When I read it a few more times and thought about it a bit more um whether or not I've got it right or not I have no idea what I did was because there was 10 mg per kilo and the patient was 25 kg that ud be 25 kg times 10 which comes to 250mg.. so it was then easy enough to use the equation again cause I did try to use - there is an actual ped equation for this as you'll find in that book. I couldn't remember it, so that's why I did it this way cause it would be the same anyway.
> Interviewer: Is that the same equation you have been using for the other two?
> Student: This part here wouldn't have been because 250 mg/125 mg by the 5 mls 5
> into 125 goes 25 times the 5mls and the 25 into 250 went 10 times so it was 10mls.
> Interviewer: But you still said you had no idea whether you were right
> Student: No because maybe mentally I can't work out if the numbers if they've worked out correctly.

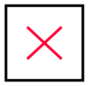
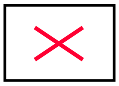
Process

Students having process errors generally had difficulty with division and decimals.

> Um no when I first saw the kilograms oh no I've got to work this out but it was ok it was 25 and it was 10mg so that's ok cause it wasn't a decimal or anything.

The interviews confirmed students' difficulty in this area. For example one student correctly wrote , but when calculating it wrote . Her interview confirmed her confusion with the dividend and the divisor in this and another example.

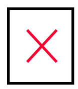
> Student: I put 250 mLs over 300 minutes, so I divided 30 by 25, and got 1.2, so 1.2 mLs a minute.
> Interviewer: You're doing the same thing you've done before.
> Student: It's the other way round, is it?

Another student wrote , suggesting a flaw in understanding of the decimal system. She also had another decimal misconception error in another question when she said 

> So that's where I'm going wrong where to put the decimal doing the correct sum but I don't know how to move it.

Some of these errors included misconceptions about time conversion for example a student correctly said the time was 133 minutes but then said this was 1 hr 33 minutes. As students could not use a calculator, division was often a source of error, and if a student didn't employ some cancelling techniques then this problem was exacerbated. While it was evident that many students were estimating or reflecting on their answer, some students had poor skills in this area. One mature aged student said explicitly that she couldn't estimate "never could" at another stage she said a similar thing:

> Student: Yeah, but I still can't picture and say it should be round about that. I cannot!
> Interviewer: This is very hard to see, isn't it?
> Student: I just cannot do it. In anything. I can't. No.

Another student couldn't recognize that  was 2, and hence was stumped because of division difficulties. Others had good estimation skills, but had poor computational skills:

> And then I just gave up and said, righto, between 7 and 8, but it would be more than (point) 8 because I knew I had 7.5 but it was .7 and .7 was nearly one, so it'd be closer to (point) 9.

While analysis of errors is important, a more important question is how many errors would the nurse make on the ward? Many of the errors above, especially in the processing ones would not occur if given a calculator. As well nursing knowledge of the context of the drug application would mediate any potential errors. Students are also aware of this:

> Student: In a ward it would be set out differently in a drug chart the dose that you want and it will actually say if the doctor wants it for 5 days you'll have the 5 days there and the rest crossed off so you then know those specific 5 days where as with this its a little difficult just what its saying.....I'm only guessing ....if you were in a ward would you criticise that.
> Student: In a ward they would not ... ..
> Student: I can't, I don't know, I've never actually had to key into the pump.
> Student: Depends how small the syringe is.
> Student: 1 mL syringes.
> Interviewer: In this case it's definitely .49 see
> Student: Because the 6 is larger than the 5.
> Student: But you got to remember too because it's a child you go down.
> Interviewer: Oh because you didn't want to overdose the child?
> Student: Depends on what drug it is.

Other errors may not occur, but exam phobia and the pressure of having to pass all the questions invokes such fear as to inhibit thinking.

> Student: But this is totally different than sitting in the exam.
> Student: Once you go into the exam and you see a question like the last one, you just go, oh no. Brain gets really.
> Student: You panic, because you know you have to get it all right.

Student: Especially when you can do them at home.
Interviewer: And as soon as you get into the test (Student: Mmm)
Student: And in the second test, I was so close, I missed out by 2 half marks

Discussion

It is vital that nurses do not make drug calculation errors in hospitals. Thankfully the proportion of errors that students make on drug calculation tests is not reflected in the wards. There are errors, and some would be identified by typical pencil and paper tests. However, many comprehension errors would not occur on the nursing floor as students would have the instrument with them and would know the instruments would require drops or millilitres. Some transcription errors would not occur as the formulas are displayed prominently around the ward. Many process errors would not occur as nurses routinely use calculators. Moreover many errors would not occur as most calculations are checked with another nurse.

However, nurses must have certain numeracy skills and it is evident from the interviews that these students have some fundamental numeracy errors. These include errors in understanding the difference between volume and mass, in understanding the basic arithmetic algorithms, in understanding some of concepts of the decimal system and time, and an inability to estimate. While Stillman and her colleagues (1999) do not believe that improving mathematical skills will resolve the problem, addressing these error issues in the context of nursing, with the appropriate learning environment to assist students to conceptualise, should be part of any support program for nurses.

While error analysis only provides part of the picture when investigating support required to assist students, it does give an insight into students' difficulties. Moreover when this analysis is based on interview and pencil and paper tests, it provides a more comprehensive picture of the difficulties. The interview also highlights students other metacognitive and cognitive strategies which teachers need to be aware of when providing support. The information provided from this error analysis plus the full analysis of their metacognitive and cognitive strategies will provide a basis for more comprehensive support in nursing and provide a model for similar support in other disciplines.

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