An exploration into the most effective way to teach drug calculation skills to nursing students

Kerri Wright *

School of Health and Social Care, University of Greenwich, Avery Hill Campus, Avery Hill Road, Eltham, London SE9 2UG, United Kingdom

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Summary
Drug calculations are an essential skill for nurses. Nurses need to be able to perform them accurately to calculate correct dosages of drugs to administer to patients. Incorrect calculations can cause drug errors and potential harm to patients (Department of Health (DOH), 2000; O’Shea, 1999). For student nurses therefore learning how to calculate drug dosages is an important skill that they need to be taught during their nurse training. This paper describes an action research project undertaken to explore the most effective way of teaching drug calculations to a group of 2nd year diploma and degree pre registration nurses. The evaluation of this project has demonstrated that a three stage approach to drug calculation appears to be an effective teaching strategy. These stages involve addressing mathematical concepts, teaching drug calculation formulae and then practising these skills in a clinical setting.

Introduction
It is clear that drug calculations are an essential skill for nurses and that patient safety is at risk if nurses are unable to perform calculations accurately. Incorrect calculations can cause drug errors and potential harm to patients (Department of Health (DOH), 2000; O’Shea, 1999). For student nurses therefore learning how to calculate drug dosages is an important skill that they need to be taught during their nurse training. I recently taught a group of 45, 2nd year student nurses drug calculations in a 2-h lecture. During this teaching session, I felt uncomfortable with both the content and delivery of the session as well as my ability to evaluate students’ learning effectively. This led me to undertake an action research project to explore the most effective way for me to teach drug calculation skills to nursing students. This paper, will discuss the rationale for this action research project, outline the research plan using the action research spiral (Bruner, 1960) and discuss the results and evaluation of these in relation
Drug calculation skills of nurses and student nurses have been highlighted as poor (Kapborg, 1994; Hutton, 1998; Weeks et al., 2000). Numerous research studies have demonstrated that both student nurses and qualified nurses are unable to correctly calculate all drug dosages presented in a maths test, with some studies finding an error rate of at least 1 in 10 calculations (Kapborg, 1994). Improving the drug calculation skills of nurses is one strategy identified by the DOH to try to reduce the number of drug errors in the NHS by 50% by 2005 (DOH, 2004). Currently drug errors account for 25% of all litigation claims in the NHS. Their reduction is thus an important financial incentive for the DOH in addition to eliminating the obvious distress that a drug error could cause patients. Within my university a drug calculation test that is required to demonstrate competency in intravenous additives has a consistently high failure rate. This test is taken by both student nurses at the end of their training and qualified nurses. With both groups there is widespread difficulty with successfully completing the tests to the required pass rate to be deemed competent and many nurses have to return to retake the test again. Drug calculations skills are therefore an important educational need for student nurses and a valid area of research to ensure that my teaching addresses these needs.

Action research was chosen as the most appropriate methodology to investigate and improve my practice of teaching drug calculations. ‘Action research is a form of self-reflective enquiry undertaken to improve a practitioners own practice, their understanding of these practices and the situations in which these practices are carried out’ (Kemmis and McTaggart 1988:9). Action research is thus an effective method of research that allows the practitioners to be active participants in the research itself so that the outcomes directly relate to the improvement of their own practices. Action research differs from the scientific method of research where a hypothesis is tested by changing a variable in relation to another, to test if this made a difference or not (McNiff, 1993). In order to improve and evaluate any improvements in my practice of teaching drug calculations the variable that changes would be my teaching practice (Carr and Kemmis, 1986). Evidence thus needs to be collected relating to my practice as a result of any changes implemented. Action research develops through a self reflective spiral that involves reflecting on ones practice, planning changes, implementing these changes before reflecting on them again and planning new changes, thus repeating the cycle (Lewin, 1946). Due to the evolving nature of my teaching practice and the personal focus of this research, the action research method was used to improve my practice of teaching drug calculations to student nurses. The action research method I followed is represented in Fig. 1 (Bruner, 1960).

**Action research plan**

The plan for the action research will be discussed following Bruner’s spiral of action research (Bruner, 1960) (see Fig. 1). Following a drug calculation skills session, I taught to 2nd year student nurses, I decided that my teaching skills need to be improve in this area. The session I taught was for 2 h to a group of 45 student nurses. I planned the session so that I taught didactically for 30 min demonstrating how to use drug formulae and then gave out exercises that the students could work through at their own pace. This gave me the opportunity to attend to students’ individual areas of difficulty. During this session, I observed that many students did not understand the basic principles of maths in order to correctly use the formulae. This meant that I frequently had to try to explain some of these concepts in order to address the issues students had with the calculations. Trying to address the
deficiency in maths with the students highlighted to me that I did not know how to teach maths concepts effectively. It also meant that I had to spend longer than I had planned with certain groups of students. The result was that I felt the lesson was not under control. I felt overwhelmed by the student’s lack of mathematical knowledge, which I had not expected and pressurised due to the differing needs apparent in such a large group. At the end of the session, I felt dissatisfied with my teaching as I did not feel that I had addressed the students’ diverse needs or evaluated whether any of my teaching was effective.

My reflections during and after this session led to my research into teaching drug calculations. This research involved discussing the teaching strategies used by other lecturers and those presented in the literature in order to gain new insights and ideas. Strategies used by other lecturers in my department did not appear to be vastly different from the one I had used which allowed students to work at their own pace whilst the lecturer helped individual students. The literature search identified two key difficulties with drug calculation highlighted through research with nurses and student nurses (Bliss-Holtz, 1994). The first was the inability to interpret information found in clinical areas into a drug calculation (Calliari, 1995). Studies, where nurses were given visual cues such as syringes or drug ampoules found these to help nurses perform the calculations (Weeks et al., 2000; Hendry et al., 1999). The second difficulty with drug calculations was the mathematical skill of the nurses (Bliss-Holtz, 1994). The most common areas of maths that nurses needed support were ratios, percentages, fractions and place value (Haigh, 2002; Blais and Bath, 1992). Colleagues who teach drug calculations also highlighted these areas as the main difficulties they had observed. Strategies used successfully in the literature were maths diagnostic tools at the beginning of nurse training and maths revision sessions or study guides to help address areas students needed help on (Hutton, 1998). From my analysis, I hypothesised that student nurses needed help with their maths skills in order to be able to perform drug calculations.

The mathematical skills of student nurses were investigated using a diagnostic test to gain further insights into my hypothesis. The test was given out to 71 student nurses at the beginning of a module, which included drug calculations in its content. The test had 30 questions divided into 6 categories of five questions each covering the key areas of need identified in the literature; percentages, ratios, fractions, place value and interpreting information. In order to ensure consistency and to test the student’s mathematical skills, calculators were asked not to be used during this test. Students were informed of the test’s purpose and were given the option of returning the test to me with or without their name on the top. However, students were also informed that writing their name on their test would allow them to receive a mark and specific feedback on the main areas they needed to work on. Analysis of these data was used to plan the timetabled 2-h drug calculation skills session for the following week. This session was timetabled in a lecture hall for 80 students. It was hoped that the analysis of the diagnostic test would allow me to differentiate between students’ needs and to separate those that were able to work independently from those that needed more mathematical input. Through this strategy, I hope to be able to focus on a smaller number of students and address their mathematical needs before going on to use the drug calculation formulas. To do this I also acknowledged that I needed to read up on how to teach the basic skills of maths.

**Implementation**

The diagnostic test was given to 71 students and was completed and returned by 70. The results of the tests showed that the students had difficulty with maths relating to drug calculations. The results below show the spread of marks for the group.

![Scores](image)

<table>
<thead>
<tr>
<th>Category</th>
<th>0–4</th>
<th>5–9</th>
<th>10–14</th>
<th>15–19</th>
<th>20–24</th>
<th>25–30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>0</td>
<td>6</td>
<td>20</td>
<td>27</td>
<td>15</td>
<td>3</td>
</tr>
<tr>
<td>Percentage</td>
<td>0%</td>
<td>8.5%</td>
<td>28.2%</td>
<td>38%</td>
<td>21%</td>
<td>4.2%</td>
</tr>
</tbody>
</table>

Although I had hypothesised that student nurses would need further teaching input into their mathematical skills, I was still shocked by the poor results from this test. The mean score from the test
was 16 (53%) and 36.7% of the students unable to correctly work out even half of the questions. The main areas of difficulty for the students were the sections on multiplying fractions, ratios and interpreting information. The break down of mean marks for each section can be seen below:

![Means of Each Section](image)

<table>
<thead>
<tr>
<th>Categories</th>
<th>Mean value out of 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentages</td>
<td>3.96</td>
</tr>
<tr>
<td>Ratios</td>
<td>2.34</td>
</tr>
<tr>
<td>Fractions</td>
<td>3.9</td>
</tr>
<tr>
<td>Place Value</td>
<td>3.21</td>
</tr>
<tr>
<td>Multiplying Fractions</td>
<td>1.83</td>
</tr>
<tr>
<td>Interpreting Information</td>
<td>2.14</td>
</tr>
</tbody>
</table>

The interpreting information section involved students having to use the information presented to work out the amount of a drug to give. This is an area that nurses reportedly found difficult in the literature (Calliari, 1995; Weeks et al., 2000) and these results reflect this. The test also gave me insights into some of the mathematical principles that students were lacking. For example the section on place value involved dividing and multiplying numbers by 10, 100 or 1000. Only 7% of students were able to get all these questions correct. If students had a basic understanding of place value such questions should be relatively easy to work out. In the fraction section some student’s answers reflected that they had divided the denominator by the numerator showing a lack of understanding about what a fraction represents.

During my analysis of the test results, I became aware that the level of maths deficit was too great to address in a 2-h session as well as teach students how to use drug calculation formulae. In my initial plan, I had decided to divide the group up according to ability so that I could have a smaller group of students with the most difficulty to work with. The results of the test, however, showed that the level of need was too great to carry out my plans. Only 18 students gained more than 66% in the test. Due to the large numbers these students were considered to have sufficient knowledge to work on their own. This still left 52 students in the main group. Analysis of the main areas of need showed that most students had some difficulty in almost all of the areas presented. On reflection, I felt that I could not begin to address this need in the planned session and decided to concentrate on teaching the students to follow through the basic steps of using a formula without actually having to understand the mathematical principles underpinning this formula.

My 2-h drug calculation session focussed on teaching what I thought was a foolproof way to use the drug calculation formulae. The strategy involved simple steps that students had to follow to arrive at the correct answer. Calculators were encouraged to overcome any arithmetic deficit (Bliss-Holtz, 1994). During the session, I demonstrated how to use the strategy using an example before encouraging those who obtained more than 20 in the test to work independently in another part of the room. The remaining 50 students were given 5 questions and asked to use the strategy to calculate the answer before moving on to a second exercise. During this time, I was able to move around the room and address individual difficulties students were having. Despite separating off some of the students more able at maths the 50 remaining still had a spread of marks from 7 to 19. This was reflected in my observations as I went around the room. The main areas of difficulty observed repeatedly were:

- Dividing denominator by numerator in fractions, e.g., 2/3 would become 3 divided by 2.
- Unable to calculate percentages even with calculators.
- Incorrectly multiplying numbers by 10, 100 or 1000 even with calculators, e.g., 20 × 1000 was frequently calculated as 2000 and the error not noted.
- Unable to begin to work out questions with ratios.
- Unable to convert drug dosages to the same measurement, e.g., milligrams to micrograms.
- Students demonstrated a lack of understanding about what it was they were calculating. One very able student after completing several questions that involved calculation of drip rates asked me what a drip rate was.
- Students expressing distress that they could not do maths and refusing to try. Several students were close to tears.

On reflection from this session and revisiting the literature I modified my thinking about teaching drug calculations. My reflections were:
Teaching drug calculations to students who do not understand the core maths principles required for drug calculations was ineffective. Use of a calculator was not a substitute for maths skills (NMC, 2002). Teaching maths principles to a large class was not effective. Highlighting areas of maths difficulty to students caused anxiety. Students needed to be able to 'visualise' the maths within practice for them to be able to conceptualise drug calculations (Hendry et al., 1999; Weeks et al., 2000).

From my reflections and using strategies suggested in the literature, I introduced a second change to my practice of teaching drug calculations. Firstly, I provided a maths virtual learning environment (VLE) for students to access and secondly, I added calculation questions to two clinical skills sessions on drugs and intravenous infusions. The VLE is a suggested strategy to address maths deficits in student nurses and qualified nurses (Weeks et al., 2000; Gray, 2004). The VLE was a section within a web site provided for this module. The content focuses on the areas identified from the diagnostic test and explains the key concepts behind each area using principles covered in key stage 2 education (Haylock, 1995). Self-assessment tests are used throughout to motivate and encourage students to evaluate their own learning (Knight, 2001). The VLE allows students to access the material in their own time and at their own pace (Heidari and Galvin, 2002). It also provides a safe environment for students to work through their maths difficulties. This could reduce the anxiety and stress felt by some students in the public classroom arena and thus enhance their learning (Haylock, 1995). In order to provide this VLE, I had to read and learn how to present mathematical concepts using available educational literature.

The second strategy was relating calculations to practice. Providing visual stimulus relating to drug calculations is also felt to be an effective strategy to encourage students to be able to conceptualise the problem being presented (Hendry et al., 1999; Leathard, 2001). Using this strategy, the clinical skills sessions were adapted to provide an opportunity for students to work through calculations relating to this skill. With the clinical equipment available this allowed students to 'visualise' their calculations. For example, the intravenous skills sessions involved students setting up infusions for patients. The calculations then focused on working out what rate students should set the infusion at. Another advantage to this strategy was that student numbers were significantly reduced. Clinical skills sessions are planned with groups of 20 students. Due to the arrangement of the skills sessions this meant that I could concentrate on 10 students at a time for at least 30 min. This not only allowed a greater tutor to student ratio, but also enabled me to evaluate individual students understanding more effectively.

Observations from this second change of practice are as follows:

Calculations relating to clinical skills improved students understanding. All students were able to correctly calculate all 5 questions with help. Students were also working and helping each other more in the smaller groups. I found that I frequently used the equipment and examples used in the session to explain the questions to students. This use of visual and conceptual stimulus appeared to help the students understand the questions.

Students are using the VLE. At the time of writing the VLE had 180 hits to date indicating that students are visiting this resource. The total time spent by the students going through the material is 10 h and 18 min.

My teaching skills online and face-to-face were assessed and observed by colleagues. Most comments centred on my increased confidence in handling maths problems with students and the clear presentation of essential mathematical concepts online. The stages of my action research can be summarised using the Bruner spiral of action research (see Fig. 2).

Evaluation

The intention of this action research project was to explore the most effective way for me to teach drug calculation skills to nursing students and to
improve my practice in teaching this skill. The results of the research have demonstrated that teaching drug calculations is not a single issue with a single solution as first implied in the literature (DOH, 2004; Bliss-Holtz, 1994), but a complex issue that requires several interrelated approaches to develop the drug calculation skills of nurses (Weeks et al., 2000). Firstly, the maths skills of student nurses need improving. The results from the diagnostic test and observations show this clearly. One strategy trialed in this study was the use of a VLE. This proved popular with students and allowed me to reflect on my teaching and express mathematical concepts clearly with illustrated examples. My face-to-face teaching has also improved since having to express concepts in a VLE. More detailed evaluation of this online strategy will be required however. Secondly, students need to be taught drug formulae and how to use them. Thirdly, student nurses also need to be able to conceptualise the calculations being solved. Providing calculation practise alongside clinical skills appeared to improve this. Finally, the results of this study point towards smaller class sizes for effective teaching of drug calculations. This project has thus changed the way I teaching drug calculations, my understanding of teaching drug calculations and the environment in which drug calculation teaching takes place.

Action research process has enabled me to focus solely on my teaching of drug calculations and to explore the issues surrounding this in order to improve my practice. Although results from this research cannot be generalised to other groups or situations, the ideas presented can be extrapolated and applied to similar situations (Kemmis and McTaggart, 1988). The action research process requires the research to be aware of the bias they can produce in the study, being both an active participant in the research as well as the researcher (McNiff et al., 1996) at times this was difficult when data relied on personal observations only. Using critical friends and colleagues was a useful way of minimising researcher bias in these incidences (Kemmis and McTaggart, 1988). Due to the dynamic and evolving nature of action research this project is far from complete. I will continue to reflect on my drug calculation strategies and plan to administer a second diagnostic test to the students at the end of the module to identify if the drug calculation skills of the students have improved through implementation of the above strategies. This will enable me to reflect on these strategies and establish further areas to research. Thus, enhancing my understanding of teaching drug calculations and illustrating the progressive nature of action research as reflected in the action research spiral (Bruner, 1960).

Conclusion

This paper has reported on an action research project that has explored the most effective strategies for teaching drug calculation skills to student nurses. The process of the action research has been explained and the results of the implementation presented. Evaluation of these results has demonstrated that a three stage approach to drug calculation appears to be an effective teaching strategy. These stages involve addressing mathematical concepts, teaching drug calculation formulae and then practising these skills in a clinical setting. The research has also highlighted the need for smaller student groups. My future teaching practice will implement these strategies using smaller group sizes before further evaluating the students learning.

References


Further reading


