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CAN A DIAGNOSTIC TEST PREDICT PERFORMANCE IN NUMERACY ASSESSMENTS IN PHARMACY STUDENTS?

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Abstract

A diagnostic test comprising questions ranging from simple arithmetic to calculations of concentration was presented to a cohort of first year pharmacy students in the first week of term. Each student was assigned to a group (red, amber or green) based upon their performance (39% or less, 40-69% and 70% or better, respectively) and was informed of their group via their academic tutors. Most students (67%) were assigned to the amber group. Following a lecture series in pharmaceutical calculations, the students' performance was then monitored in an in-course assessment and an MCQ examination. Our data show that including calculations in the curriculum improved performance in both assessments. The majority (70%) of students assigned to the green group remained there in the in-course assessment and all but one passed the MCQ at the first attempt. Of the 15 students in the red group, five remained in this group following the in-course assessment and four of these failed the MCQ at the first attempt. There was significantly more movement, both up and down, in the amber group. We also monitored student access to calculations support resources on our e-learning system but found little difference between any of the groups. In all, the diagnostic test proved to be useful in identifying the weakest and most capable students and predicting their subsequent performance.

Keywords: *diagnostic test, numeracy skills, prediction of performance, pharmacy undergraduates.*

Introduction

In the United Kingdom, current entrance requirements for science-based degree programmes usually include a minimum of a C grade pass in General Certificate of Secondary Education (GCSE) mathematics or equivalent *(this is a school leaving examination for pupils aged 16 years, and a precursor to advanced 'A Level' studies which are university entrance tests aimed at 18 year old students)*. It is assumed that this is sufficient to ensure that students are proficient in basic concepts in numeracy and will be able to apply them appropriately. However, there is widespread concern that many students are entering degree programmes or employment following graduation who are ill equipped in this core skill, so much so that the C grade GCSE qualification is no longer considered to be of value by employers and that they often have to devote considerable resource to remedial training (Henry, 2003; Tariq and Durrani, 2009). Academic institutions are, therefore, faced with a clearly identified problem which they must attempt to resolve.

For students studying medicine, nursing and pharmacy, the ability to perform calculations of drug dosage is crucial in ensuring safe and effective treatment of patients. Indeed, it has been reported that incorrect dosage calculations may account for a significant proportion of medication errors (Aronson, 2009). Numeracy amongst nursing students has been a cause for concern for some time (Hutton, 1998; Haigh, 2002; Jukes and Gilchrist, 2006) and is also an issue amongst qualified nurses (McMullan, 2010). Medical students' ability to perform relatively simple drug dosage calculations has also been shown to be less than one might predict for a degree course with significantly higher entrance requirements (Sheridan and Pignone, 2002; McQueen et al., 2010). In pharmacy, several studies have been undertaken to examine numeracy in undergraduates and the approaches that might be taken to increase their proficiency in this area. Malcolm and McCoy (2007) undertook a seven year study where students were tested on entry and again after a basic numeracy course in the first term. Despite increased entry qualifications, performance on entry decreased year on year over the period of the study, however, a more acceptable score could be achieved in all years following numeracy support in the form of workshops and on-line directed study. Very similar findings were reported by Batchelor (2004) in a single cohort at another school of pharmacy. Thus, diagnostic testing followed by targeted teaching is an effective strategy to improve performance in numeracy assessments. However, these studies focused on cohort performance rather than on the individual student. We believe this to be an important consideration and one that often overlooked. In a recent paper we described a simple, visually-displayed diagnostic test which we used to assess basic numerical skills in first year

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students at two schools of pharmacy (Hitch et al., 2010). Our findings supported those of others in terms of identifying the types of problems many students find difficult to solve, but did not determine whether the diagnostic test is a good predictor of individual performance in subsequent assessments.

Aims of the study

Our aim was to use a simple diagnostic test in order to classify students according to their basic numeracy skills and to monitor their performance in subsequent assessments to determine whether the diagnostic test is a useful tool to identify students with difficulties in this core skill. In addition, we wished to know if informing students of their classification in the diagnostic test influenced their approach to their learning.

Method

The diagnostic test described previously (Hitch et al., 2010) was presented to the first year cohort (n = 183) at a School of Pharmacy in the UK in the first week of term. The scores were analysed and each student placed in one of three broad categories based upon the score achieved. These were colour-coded as red (39% or less), amber (40 - 69%) and green (70% or better). The students were informed of their category by their academic tutors and advised whether they were considered to be at risk with regard to their numeracy skills.

The first term of study included eight 1 h lectures on pharmaceutical calculations which focused on calculations of concentration, dilutions etc. Examples were worked through in class and became progressively more complex throughout the term. The lectures were supported by posting the step-by-step solutions on the School's e-learning platform (Blackboard). Additional problems were also posted over the break between terms. Students were then required to sit an in-course assessment in the new term. This consisted of 8 problems based upon work covered in the lecture series. These were to be completed within 1 h and students were allowed to use calculators. The mark for each problem was weighted according to its difficulty. Three were considered simple and given 2 marks, three were more difficult and given 4 marks, the final 2 were the most difficult and given 6 marks. Marks were awarded for correct answers only. The scores were classified as red, amber or green using the same criterion as described above. The test papers were returned to the students within two months and the solutions to the problems posted on the e-learning site. Examples of each type of question are given below:

You are given a stock solution of a drug at a concentration of 2.5 µM. You add 0.05 mL of this to a flask containing 250 mL of saline. What is the final concentration, expressed in µM, of the drug? (2 marks)

You are given a stock solution of a drug at a concentration of 2×10^{-5} M. What volume of this solution would you need to add to 50 mL of saline to give a final concentration of 4 nM? (4 marks)

A patient weighing 80 kg must receive 0.25 mg/kg/h of a drug (RMM=200) over a 4 h period. The drug is contained in 1 mL volume ampoules at a concentration of 20 mM. How many ampoules will be required to deliver the correct dose of drug? (6 marks)

One month later, students were required to sit an MCQ paper in pharmaceutical calculations as part of the mid-year examinations. This paper comprised 15 problems, each with 5 possible answers of which one was correct, to be completed within 1 h without the use of a calculator. The marks for these questions were not weighted although they did differ in their difficulty. This assessment is pass or fail, with the pass mark set at 70%. Examples of these questions are given in the text box.

The recommended daily dose of ibuprofen in adults is 1.2 to 1.8 g, increased if necessary to a maximum of 2.4 g in divided doses daily. One formulation of ibuprofen contains 200 mg ibuprofen in each tablet. Which one of the following dosages for this formulation would be regarded as being ***OUTSIDE*** *the recommended dosage?*

A Two tablets taken every 4 hours

B Two tablets taken every 6 hours

C Three tablets taken every 4 hours

D Three tablets taken every 8 hours

E Three tablets taken every 6 hours

Benzoic Acid Compound Ointment BPC (Whitfield's ointment) is formulated as containing benzoic acid 6% w/w, salicylic acid 3% w/w, and emulsifying ointment to 100% w/w. Which one of the following statements is correct?

A 1 g of Whitfield's ointment contains 6 mg of benzoic acid

B 1 g of Whitfield's ointment contains 91 mg emulsifying ointment

C 1 g of Whitfield's ointment contains 30 mg salicylic acid

D 1 g of Whitfield's ointment contains 0.6 mg benzoic acid

E 1g of Whitfield's ointment contains 0.2 g salicylic acid

Drug A has a relative molecular mass of 200 and is provided at a concentration of 10 mg/mL. A 0.2 mL aliquot of this solution is added to a flask containing 20 L of water. What is the molar concentration of the solution in the flask?

A 5 :M

B 50 :M

C 0.05 :M

D 0.5 :M

E 0.005 :M

Results and Discussion

An analysis of the scores for each question in the diagnostic test revealed findings that were not dissimilar to those previously published (Hitch et al., 2010) in that students experienced difficulty with problems involving calculations of concentration, dilutions, powers of ten and units. In this study, however, we focused more on the overall score achieved by each student. **Figure 1** shows the distribution of scores in the three categories described earlier. It is evident that the majority (67%) of the cohort fell into the amber group with 25% in the green group. Interestingly, relatively few (8%) were assigned to the red group.

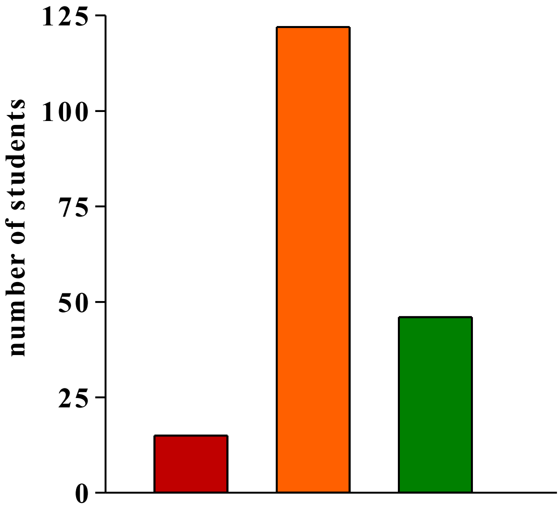

Figure 1. The distribution of students according to their performance in the diagnostic test. Red, amber and green refer to scores of 39% or worse, 40 – 69% and 70% or better, respectively.

As stated earlier, the pharmaceutical calculations lecture series was devoted largely to addressing the areas of difficulty identified in the diagnostic test. The in-course assessment which followed the lecture series showed a marked improvement in performance by the cohort compared to that in the diagnostic test. **Figure 2** shows that 58% were assigned to the green group with 29% and 13% assigned to the amber and red groups, respectively. **Figure 3** shows that the increased size of the green group was due, in the main, to the movement of students who had been assigned to the amber group as a result of the diagnostic test. However, it should be noted that most (70%) of those who had been in the green group initially, remained there following the in-course assessment with only five students slipping into the red group. The diagnostic test identified 15 students in the red group. Figure shows that five remained in this group whilst five moved into each of the amber and green groups.

Almost 90% of the cohort achieved a score of 70% or better in the pharmaceutical calculations MCQ. Of the 21 students who failed, 20 had been classified as either red or amber in the diagnostic test and had either remained in those groups or moved from red to amber or vice versa following the in-course assessment (**Figure 4**). Only one of the failures had initially been assigned to the green group following the

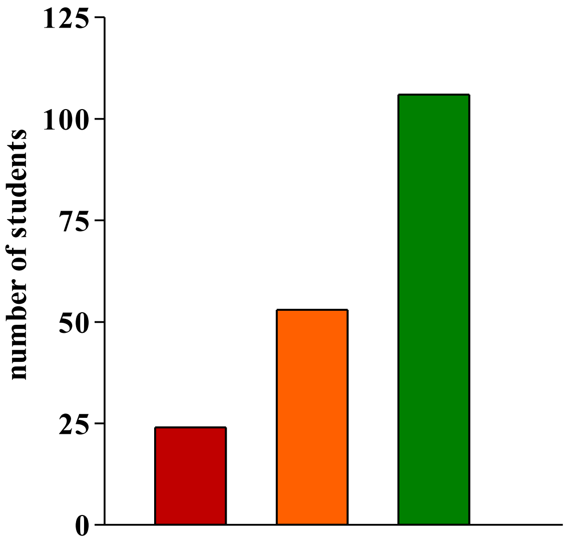

Figure 2. The distribution of students according to their performance in the in-course assessment. The groups are as stated in the legend to Figure 1.

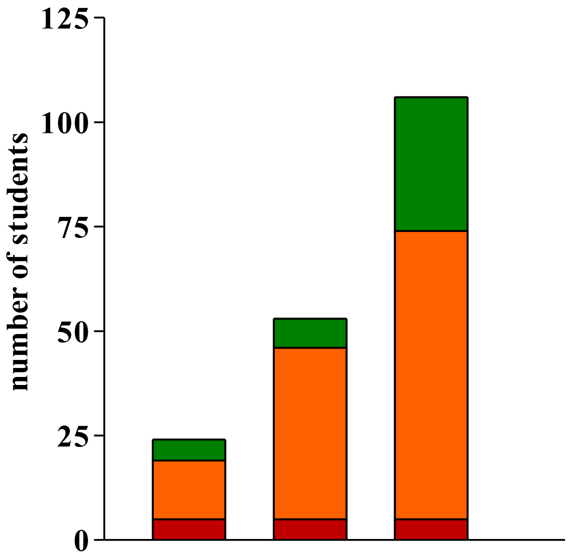

Figure 3. The distribution of students according to their performance in the in-course assessment showing their classification in the diagnostic test.

diagnostic test. Those that failed the MCQ exam were required to re-sit during the summer examinations. Sixteen passed at the second attempt, one was absent, one had withdrawn from the course and three failed. The three failures comprised two who were classified as amber then red in the two prior assessments and one who was classified as red in both.

An important aspect of diagnostic testing, particularly if the result of the test is revealed to students, is whether that drives them to take responsibility for their learning. We were interested to see whether this was the case in our study and to use as an objective measure of this as possible. To this end we used data from our E-learning system and determined the number of times each student accessed the calculations

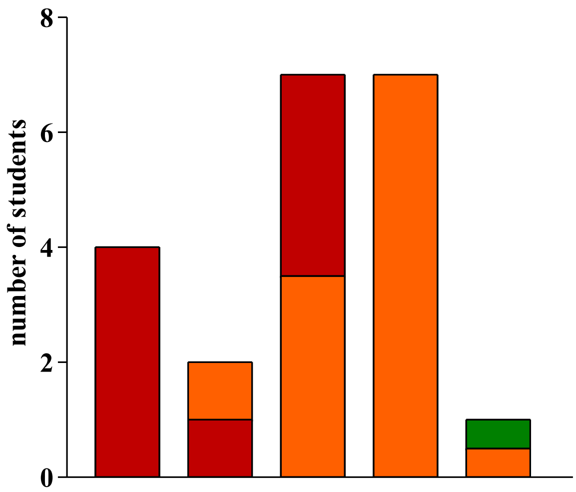

Figure 4. The distribution of students failing the MCQ according to their classification in the diagnostic test (upper part of bar) and the in-course assessment (lower part of bar). Solid coloured bars refer to students who were classified in the same group for both assessments.

material as a percentage of the number of times they logged on to the system over the period leading up to the in-course assessment. Figure 5 shows that there was very little difference between the groups, although somewhat surprisingly those classified as red in the diagnostic accessed the calculations material to a slightly lesser extent than the other groups. Further analysis of the red group revealed that the five students who moved up to the green group and the five who moved up to the amber group following the in-course assessment accessed the calculations material much less often (19 □ 9% and 18 □ 5%, respectively) than the five who remained in the red group (34 □ 8%). These findings are difficult to interpret. It might suggest that at the majority (10) of the students assigned to the red group were classified incorrectly because their performance in the diagnostic test was not a true reflection of their ability. Indeed, the five who moved from the red to green groups after the in-course assessment went on to pass the MCQ at the first attempt, however, only three of those who moved up to amber passed. Of the five who remained in the red group, only one passed the MCQ at the first attempt. Given that this group accessed the calculations material to the same extent as the cohort as a whole, one might conclude that they did take some responsibility for their learning even if it did not lead to a successful outcome in the subsequent assessments.

In all, these data indicate that the diagnostic test is useful in identifying weaker students and to some extent those whose numeracy skills are at an adequate level on entry. It is less successful, however, in identifying the majority who lie somewhere in between. This suggests the need to use narrower bands to classify students. It is also evident that the inclusion of teaching sessions devoted to calculations in the timetable, particularly if the teaching is targeted towards areas of concern identified in the diagnostic test, has the effect of improving performance in subsequent assessments as has been found by others (Batchelor, 2004; Malcolm and McCoy, 2007). Since instituting this scheme 2008, the number of failures in the MCQ has fallen from 41% in 2007 to 12% in 2011. Nonetheless, it is of concern that a number of students do not improve despite their own efforts to do so. Our intention is to identify these through the diagnostic test and supply additional support in small group sessions.

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