Assessing numeracy for nursing

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In this paper we present work in progress on the assessment of numeracy for nursing in two interdisciplinary projects. The background to these studies is that despite widespread recognition that numeracy is a key competence for safe and effective professional practice in nursing, and research studies in various countries which reveal a lack of proficiency within both the student population and amongst registered nurses, there is no international consensus on the nature and scope of numeracy for nursing. The studies are: 'Medication dosage calculation: a benchmark assessment for nursing' and 'Numeracy for nursing'. The first study aims to create a national benchmark for numeracy for nursing in Scotland against which numeracy for nursing may be assessed, initially at point of registration but potentially thereafter at other stages of nurse preparation and in practice. The second study is an exploratory investigation of aspects of teaching, learning and assessment of numeracy for nursing in the undergraduate/Diploma Nursing programme in a large School of Nursing in England.

Keywords: HE; curriculum; assessment

Assessment measures performance in relation to a particular question or situation but the value of competence assessment lies in its ability to predict likely future performance in a particular activity. In nursing, as in some other safety-critical areas, competence in numeracy can be a matter of life or death so the onus is on assessment procedures to ensure safe practice as far as possible. The assessment of numeracy for nursing should enable candidates to demonstrate that their numeracy is fit for practice, fit for purpose and fit for award. Students at point of registration and qualified staff should be able to demonstrate independence, good critical judgment, proficiency in practice and accountability to relevant stakeholders with respect to numeracy. However, while numeracy is acknowledged to be a key competence for professional practice in nursing, it is poorly conceptualized and understood, and, as a result, likely to be inadequately assessed. Successive studies reveal a lack of proficiency amongst students and registered nurses in the UK and elsewhere, together with efforts to remediate the situation (Sabin 2001).

Recent research encompasses various aspects of numeracy for nursing including: conceptual and theoretical analysis (Weeks, Lyne, and Torrance 2000); study of pediatric nursing practices (Noss, Hoyles, and Pozzi 2002); development of online teaching, learning and assessment systems and materials (Behrend et al. 2006); and evaluations of interventions (Hall et al. 2005). Meanwhile, from September 2008, numeracy is included in the "Essential Skills Clusters" specified by the Nursing and Midwifery Council (NMC) to be included in pre-registration nurse education throughout the UK. From September 2008, nursing students completing their training must achieve 100% in a test of "numeracy in practice" before they may register as nurses (NMC 2007). No national standards for competence in numeracy for nursing

have been specified in the UK (or elsewhere, as far as we are aware). The absence of such a standard raises the question '100% of what?' Against this background, the projects outlined in this paper are: 'Medication Dosage Calculation: a benchmark assessment for nursing'[2], funded by NHS Education for Scotland (NES) (2006-09) and 'Numeracy for Nursing[3]', funded by King's College London (2008). In the remainder of this paper we shall discuss work in progress on the assessment of numeracy in each project in turn.

Medication dosage calculation: a benchmark assessment for nursing

NES is seeking to establish a national benchmark for numeracy for nursing at point of registration in Scotland in this interdisciplinary (education / nursing / psychometrics) project. The study addresses issues of parity, scope and level in assessing numeracy skills for successful calculation of medication dosages by nurses when they qualify. It seeks to create an associated assessment instrument to be used initially with students at point of registration and subsequently by qualified staff to check their proficiency at intervals. In the process, we are refining our conceptualization of numeracy for nursing (a paper is in preparation by the NES 'benchmark' team).

In the first phase of the project the team developed an evidence-based assessment tool utilising interactive computer simulations that approximate to real world practice, using Gulikers et al's (2004) five dimensional framework for authentic assessment (see Figure 1) and Coben's definition of numeracy:

> To be numerate means to be competent, confident, and comfortable with one's judgements on *whether* to use mathematics in a particular situation and if so, *what* mathematics to use, *how* to do it, what *degree of accuracy* is appropriate, and what the answer *means* in relation to the context. (Coben 2000, original emphasis)

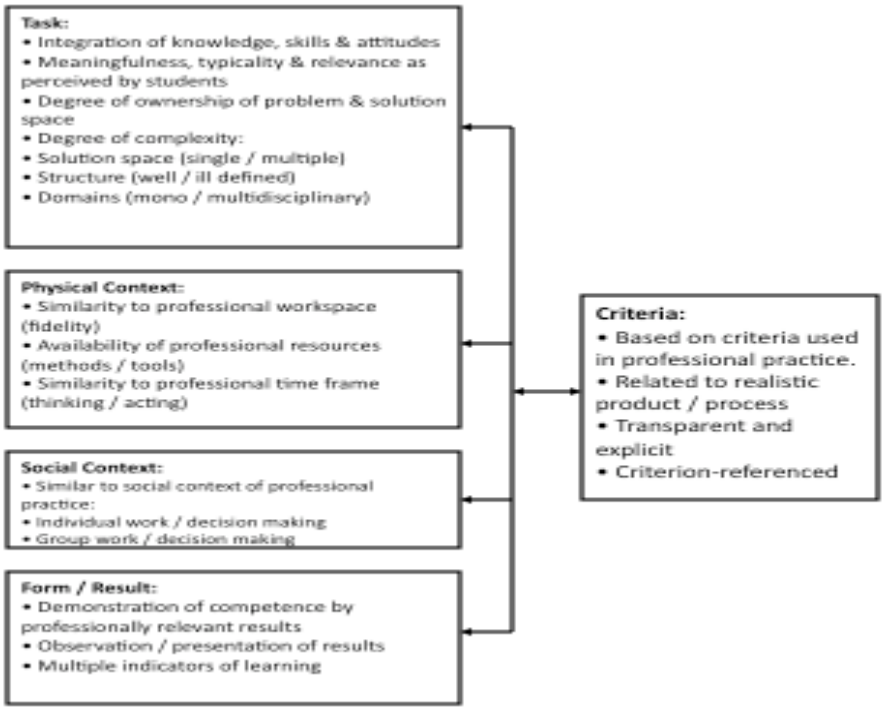

Figure 1: Gulikers et al's (2004) five dimensional framework for authentic assessment

On this basis we developed evidence-based criteria for the assessment of numeracy for nursing as follows: we believe the assessment of numeracy for nursing should be: *realistic; appropriate; differentiated; consistent with adult numeracy*

principles; diagnostic; transparent: well-structured; and *easy to administer* (Coben et al. 2008). Using these criteria, we developed an evidence-based benchmark assessment tool utilising interactive computer simulations that approximate to real world practice, for assessing the calculation of medication dosages by nurses at the point of registration, i.e., the point at which nursing students become qualified nurses (Coben et al. 2008). We decided to focus on medication dosage calculation because, while this is by no means the only area of nursing in which numeracy is required, it is 'at the sharp end' in that healthcare professionals' medication dosage calculation errors can have devastating effects on patients (e.g., ISMP 2008).

The assessment tool is comprehensive, covering typical unit dose, sub- and multiple-unit dose problems, complex problems, conversion of International System (SI) units and intravenous (IV) infusions. Items are derived from the Authentic World® database, adapted by members of the NES team (Keith Weeks and Norman Woolley) for use in the study. We have prior reliability and validity evidence for these items; content validity (domain-related evidence) has been established, with an appropriate (representative) domain of types and complexities of problems (Weeks 2001). From analysis of data collected in the preparatory stage of this study, internal consistency reliability of the selected Authentic World® items was found to be high (R=.92).

We are using a multi-method research design based on criterion-related evidence of validity. The focus for this phase of the study is: does the achievement of nursing students on our computer-based assessment replicate their performance on the criterion (practical) assessment? If so, the computer-based assessment instrument can be used to collect data on large samples in order to validate a benchmark assessment for nursing. Each participant is tested on the same questions in two different simulated reality settings: on computer (using our computer-based assessment tool) and in a simulated clinical setting, with the order of questions in the two tests counterbalanced.

We piloted our research design and evaluated our instruments with final year Adult Branch nursing students at a Higher Education Institution (HEI) in England in Spring 2008. We found a reasonable to very high level of congruence between the two assessment methods (44%-100% congruence; mean congruence for n=252 test item opportunities for error = 80% congruence) and concluded that computerised assessment using this particular platform is likely to mirror medication calculations done in a practical setting (Hutton et al. submitted 2008, decision pending).

Since September 2008 we have been using the research design piloted in England with final year nursing students at HEIs in Scotland. We are collecting baseline data on up to 500 nursing students and then, from this total, selecting a purposive sample of 100 Adult Branch nursing students and assessing them in two groups towards the start of their third (final) year of study.

Assessing 'Calculations for Nursing' in a School of Nursing in England

In the second project we are evaluating the teaching, learning and assessment of numeracy for nursing in a pre-registration nursing programme in one HEI in England. Here, we outline aspects of our preliminary analysis of the online summative assessment of a 'Calculations for Nursing' module.

Students are required to pass the 'Calculations for Nursing' module at 100%. Each candidate takes 10 items randomly selected from a bank of 41 items. The stakes are high since students who do not pass after three attempts are removed from the

programme. The 100% pass mark means that students must demonstrate their mastery of calculations for nursing – or at least of the calculations set.

Preliminary analysis of candidates' performance shows that, of 378 candidates, 199 were unsuccessful on their first attempt. Item facilities (i.e., the percentage of correct answers) are generally high (between 0.59 and 1; mean: 0.89; median: 0.93), but the tests manifestly vary in difficulty depending on the selection of the 10 items drawn from the item bank in any particular iteration of the test. We have undertaken a preliminary Rasch analysis of the performance of test items set against candidates' performance in the test and analysed the test items in terms of their mathematical difficulty and scope. Briefly, the Rasch model is a probabilistic model based on item response theory (IRT) model (Hambleton 1993). It can be used to estimate candidate "abilities" and items difficulties[4]. It assumes that the latent variables, ability and difficulty, can be measured on the same unidimensional interval scale. In our study we fitted a Rasch model using Winsteps. (See Figure 2 for a graphical representation of candidate abilities and item difficulties.)

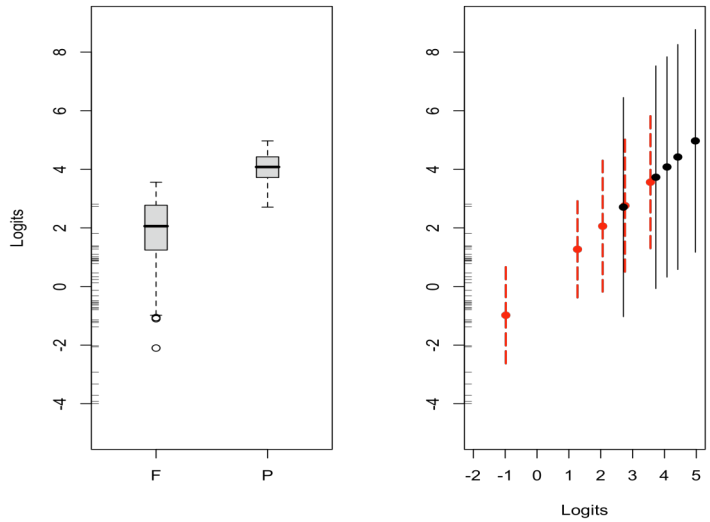

Figure 2: Comparison of Rasch ability estimates for "pass" and "fail" groups. 2(a): Boxplots on left show distribution of groups [Pass = P; Fail = F]. 2(b): Graph on right indicates ability estimates with 95% confidence intervals for candidates at highest, lowest, median and quartiles in each group [Pass: black, solid; Fail: red, dashed]. Rug on LHS of each graph indicates item difficulties.

However, the Rasch model only provides a self-referenced estimate in terms of the candidates and the items. Hence, we conducted a further analysis to identify the concepts underlying items using the levels established in the GAIM (Graded Assessment in Mathematics) programme (Brown 1992). The match to GAIM levels was fairly straightforward. However, we found the fit between the levels of difficulty of the test items and GAIM levels to be problematic. For example, facilities of items at GAIM level 8 varied from 0.59 to 0.90. In large part, this reflected the poor construction of many of the items. In addition, the mathematical content of the 'Calculations for Nursing' tests was restricted. In the examples we investigated several areas were excluded that the literature suggests may be important in numeracy for nursing, such as: estimation and approximation; accuracy; calculator use; time; probability and risk; and tolerance.

The combination of different levels of test difficulty, the requirement of 100% success, the small number of items for each candidate and the poor construction of items resulted in serious problems for the assessments. First, as can be seen from Figure 2(a), there was a large overlap in the ability estimates for the two groups and the ability estimate for the highest "failing" candidate was at approximately the 3rd

quartile of the pass group. Second, the confidence intervals (CIs) for all candidates, and particularly the pass group, were very large. As a result, relatively minor changes to the pass ability level would have major effects on the number of passing candidate. For example, if the pass level were set at the level of the *most* difficult item, 45 (or 12%) more students would pass; if it were set at the level of the lower bound of the CI for the candidate of highest 'ability', 154 (or 42%) more students would pass.

Our preliminary analysis thus points to problems in the reliability, validity and scope of the assessment of numeracy for nursing in the 'Calculations for Nursing' module. This is unsurprising, since the items and the format of the test have been developed by non-specialists, and the construction of such tests is difficult. We also note that on this programme the academic staff recognised these potential issues in inviting our evaluation. In fact, in our view this is likely to be one of the strongest courses mathematically in the UK. The concern is our evaluation may highlight significant, unrecognised and more widespread problems in the assessment of numeracy for nursing that may result in some nursing students with relatively "good" numeracy failing *and* a failure to assess potentially unsafe levels of numeracy practice. One factor underlying this problem is the equating of mastery with 100% error-free performance on a test, especially given the NMC's requirement that students' numeracy should be assessed "in practice". However, as we have already noted, our analysis is at an early stage.

Concluding remarks on the assessment of numeracy for nursing

The two studies outlined above may be seen as complementary in that the NES project seeks to create a benchmark, which, once established, could be used to evaluate the assessment of numeracy for nursing in HEI nurse education programmes such as that in the second study. Within and beyond these studies we plan to continue to explore the conceptualisation and assessment of competence in numeracy for nursing.

Notes

1. Diana Coben is working on both projects; Jeremy Hodgen is working on the second project only. The research reported here is the work of the whole teams of each project. Medication Dosage Calculation, funded by NHS Education for Scotland (NES): Mike Sabin, NES; Keith Weeks, Norman Woolley, University of Glamorgan/Authentic World®; Carol Hall, University of Nottingham; Diana Coben, Meriel Hutton, King's College London; and Dr David Rowe, University of Strathclyde. 'Numeracy for Nursing' comprises: Diana Coben, Jeremy Hodgen, Nicola Bretscher and Sherri Ogston-Tuck, all of King's College London.
4. We note that the term "ability" is used universally within Rasch analysis. Here, we use the term neutrally and do not intend to imply ability to be innate or fixed.

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