Rationalisation of a Basic Maths Diagnostic Assessment

Background

The Robert Gordon University Moodle basic maths diagnostic quiz is a development of a paper-based test first transferred online using QuestionMark Perception in 2003 by Patel and Little [1] that uses mainly CALMAT [2] and Diagnosys [3] questions selected by teaching staff, copied to the University’s new moodle VLE in 2008. The quiz addresses concerns regarding mathematical preparedness of new students expressed by the Engineering Council [4], STEM [5] and, more recently, QAA Scotland through Whittaker [6] who states that the “...level of maths skills is often uneven...and requires a diagnostic approach towards targeting additional support.”

In 2004 selected quiz question statistics were presented to the STEM (Science, Technology, Engineering and Maths transition to university) team during their visit to the university that year were incorporated as an appendix in the STEM final report. These give an indication that there are some questions that new students are particularly averse to or unable to answer correctly. There is also a group of the same questions that have been found to be problematic every year. Quiz rationalisation has focused on removal of questions that are too easy or too difficult or that are not correlated with overall outcomes but some questions have been retained precisely because they do attract wrong answers due to misconceptions.

Rationalisation of Quiz

The original set of 81 questions was rationalised using question statistics and item analysis for results recorded over the period 2003-2007 using QuestionMark Perception [7] guidance. This was in response to staff and student feedback questioning whether the quiz duration could be reduced.

Criteria [7] of discrimination coefficient >= 0.2, discrimination index >= 0.15, 0.1 < facility index < 0.9 and point bi-serial correlation >= 0.2 were used to review question suitability and to rationalise content and duration.

Based on the 2003-2007 data and using the above criteria, in 2008 the number of questions used was reduced from 81 to 48 and these 48 questions were used to create a quiz on the University’s new Moodle VLE. This makes for a more efficient assessment, the longest participant duration being reduced from two hours to one hour. Moodle quizzes [8] also provide item analysis data in the results record but less on question statistics.

In rationalising the quiz care was taken not to scythe down everything that falls out with question selection criteria. For example, in Figure 1 we can see that “Q1 Negative Numbers” yields a high facility value because it is a trivial question with only one
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incorrect response. However, if we additionally look at the four responses of 17 to "Q2 BODMAS" whilst deciding what to do with Q1 we can infer some detail of further problems for a small number of students dealing with negative numbers so it is useful to retain Q1 to cross reference with Q2 responses. Also, even if there is only one wrong answer to Q1 this question is important to that individual respondent.

A question like Q2 that induces large numbers of similar wrong answers may indicate the existence of a seemingly logical yet wrong approach. The responses of "-21" for "Q2 BODMAS" are obviously the result of not knowing the order of precedence concept under investigation. Wrong answers can open up opportunities for engagement, motivation and quick resolution of problems when re-stated in proximity to support resources. This question and its responses are, therefore, the kind of thing we'd like to both 'diagnose' and remedy and should, therefore, be retained. Beyond that, this is the sort of thing that should interest curriculum developers now, particularly perhaps in view of what has been reported by principal teachers of mathematics in Scotland as the inadequacy of Intermediate 2 algebra compared to Standard Grade algebra as a preparation for Higher maths [9], concerns raised about school league tables pushing schools and students towards easier alternatives to maths [10] and doubt over primary school maths teaching [11].

Multiple Quiz Visits Help Resolve Misconceptions

Students over the period 2003-2007 were able to self-assess and improve their basic maths skills through immediate feedback with specimen answers. This has, since 2008, been augmented with the facility to retry or revisit the quiz and links to vodcasts of solutions and the national mathcentre [12] resource. Students are also informed in their quiz feedback of the University's maths support service which, as of 2010, provides remote support via Wimba Classroom [13] and, since 2009, a video solution service.

For the 2008 quiz group 1 of 69 students made a total of 400 quiz visits and group 2 of 29 students made 199 visits compared to this year's group 1 of 79 students making 659 visits and group 2 of 16 students making 112 visits. This indicates that it is perhaps true to say that post-quiz 24 hour availability helps students to engage with the quiz feedback and videos as a learning resource. However, almost all of the students were not retrying the whole quiz, presumably they were following up on specific topics or questions. This is different to behaviour observed in nursing students who repeatedly re-tried their quiz [14], perhaps because they were answering fewer questions in a formative quiz that was preparatory to a summative assessment with a 100% pass mark.

The quiz design derives from Race's [15] model that places the student at the centre of waves/cycles of feedback used to inform an action plan and experience of multiple quiz attempts supporting autonomous improvement in nursing students' numeracy [14].

Quiz Validity and Targeting of Limited Tutor Resource

As well as the quiz having content validity, based on teaching staff question selections, there is a moderate (Spearman's rho >0.3) and significant (p<0.01) correlation between 2009 first semester maths exam grade and 2008 diagnostic percentage score for non maths support students. There is no significant correlation for supported students which implies some sort of predictive validity and perhaps is evidence of the impact of maths support. Nine out of ninety eight 2008 participants subsequently made use of maths support and, of those nine, only two had relatively high diagnostic scores (>60%). All nine passed their first semester maths exam. All four students who scored poorly (<40%) and did not choose to follow up with maths support failed their first semester maths exam. In the past it has been shown [1] that non-participation in the diagnostic assessment in conjunction with a lack of uptake of maths support opportunities more or less predicts maths exam failure. Consequently, the diagnostic quiz has been a requirement for all first year engineering students since 2007 though a small number still fail to participate.

The Staff View

Tutors get an overview of all scores and access to item analysis, each grade score being represented by a clickable icon that reveals further details -see Fig 2 overleaf or the video demo here:

http://www.youtube.com/watch?v=-m6Kt3rTSRQ
The Student View

On completion, students are presented with an overall score and either commended for their score or else encouraged to refer to the feedback and, if necessary, to re-try the quiz or seek face to face support. There is a need to avoid reinforcing negativity in students who may be weak in maths; on the other hand it is necessary for all the students to have these basics in place.

The formative diagnostic quiz helps identify and resolve problems in a non-threatening way that falls between non-intervention and excessive or off-putting or stigmatising intervention (since the students can follow up on their own).

Students get instant feedback including vodcast solutions (e.g. 20_quadratic_roots.wmv for the above in Figure 3) on each quiz attempt in the form of clickable scores that open up to reveal the detail of how the students’ answers differ to the specimen answers:

http://www.youtube.com/watch?v=18dfLCdFZR8

Thus students are engaged interactively not only with assessment participation but also in investigating what they got right and wrong, again with the opportunity to engage with the resources and specimen answers contained in the feedback.

Frequently Wrongly Answered and/or Avoided Questions

As a natural extension of reviewing quiz question statistics and item analysis, frequently wrongly answered and/or avoided basic maths questions persisting across the years 2003 to 2007 have been copied to a separate moodle quiz to target the ‘true’ common gap in knowledge of first year science and engineering students by means of self-assessment. Perhaps unsurprisingly all but two of the twenty two questions involved belong to the category ‘algebra’.

Conclusion

Positive feedback gives the author some confidence that reducing the diagnostic quiz duration and the switch to moodle quiz were actions that enhanced the diagnostic quiz experience for both students and teaching staff interested in reviewing results. Whilst there are doubtless some grey areas in deciding whether to retain or remove quiz questions there are, equally, some criteria that are clearly useful in this process.

References


