Don't just do it, Do it Right! Diagnostic Tests

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Over the last 3 years, Björn Haßler, Mike Barry, Douglas Quinney and myself, aided by a development grant from the LTSN Maths, Stats & OR Network have been investigating 'The Experience of Fresher Students in Mathematics Diagnostic Testing'. Some of the case studies gathered during our survey have been reported elsewhere (Diagnostic Testing for Mathematics LTSN MathsTEAM http://www.ltsn.ac.uk/mathsteam). Our final report will also be posted on the mathstore web site, whilst this report hopefully provides a 'taster' to encourage you to look at it for more details.

Background

A growing concern for many university departments is the discrepancy between the *expected ability* of incoming students, based on their qualifications at A level, and their *actual performance* in assessments soon after their arrival.

In mathematics, this gap was clearly illustrated in THES 26/03/04, which reported on statistics collected by Professor Duncan Lawson, from a 50 question multiple-choice maths test used with incoming Coventry undergraduates since 1991.

> 'The average score of students with a grade D at A level in 1991 was 37.3 out of 50; by 2001, the average had fallen to 29.1. Meanwhile, the average score for a student with grade E at A level was 35.6, compared with the 2001 cohort who scored an average of 28.4.
>
> Professor Lawson also found that students in 2001 with a grade B at maths A level who sat the Coventry test showed "*slightly lower levels of competency in those basic skills*" than undergraduates ten years earlier with a grade N (fail) at A level.'

Similar concerns are also recorded in the report of Professor Adrian Smith's Inquiry into Post-14 Mathematics Education, '*Making Mathematics Count*'. Paragraph 4.37 states

> '.. the distribution of grades for A-level mathematics presented in Chapter 3 suggests that more able students are insufficiently challenged and the least able are frequently overstretched….. University mathematics departments have made clear to the Inquiry that they are often unsure of the real value of a grade A pass at A-level.'

This problem of 'perceived' grade inflation is not restricted to mathematics, and other university departments are tackling this issue in their own way. For example, eight British university law schools are planning to make prospective undergraduates sit a new admissions test from autumn 2004. The "*National Admissions Test for Law (LNat)*" is designed to help discriminate between students with similar high GCSEs/A-levels profiles.

Testing

Whilst many mathematics departments may be reluctant to go down the path of 'another exam' for students who are already the most tested students ever, some method of identifying the 'true' ability of newly arrived students is necessary. Hence the diagnostic test. Such tests are becoming more widely used around the country in a number of different ways, for a number of different reasons and inevitably, with varying degrees of success.

Depending upon the resources available, incoming students may either be given a computer-based or paper-based test. Regardless of the medium used, tests usually fall into one of two styles. Multiple-choice tests can be easy to mark, and in the case of computers avoid the problems caused by not knowing the correct computer syntax. The alternative, where students write down or enter a mathematical answer in full on a computer, has benefits that may out-weigh the extra marking/programming time, by allowing more precise assessment as to the level of any individual student's ability or the nature of their misunderstandings.

The failure of a student to achieve a desired level in a diagnostic test is attributable not only to their lack of ability. Many of the students we surveyed believed that they had under-performed and some attributed this to being unprepared. Reasons given were as follows:

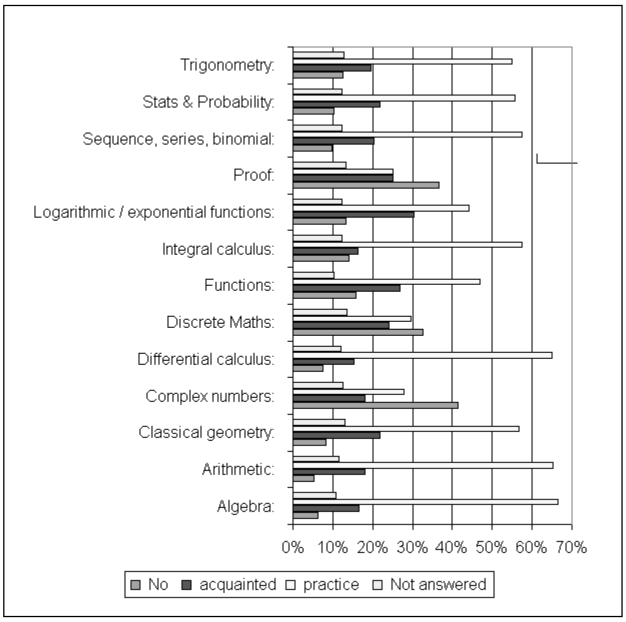
Reason	Replies (Out of 97)
lack of revision	64
hard questions	14
new/unknown material	13
summer break	45
longer break	29
illness, accident, other	12

Thus the summer break/lack of revision were more of an issue, rather than students' feelings they were confronted by hard questions (new/unknown material). How this ties in with Professor Lawson's statistics is not immediately clear.

Knowledge Real/Expected

Something we thought was very important was to try and establish what kind of mathematics knowledge the student thought they did/did not have. This can then be compared with our own expectations and that suggested by the various A level syllabi. In order to ascertain what areas of mathematics students were familiar with they were given a detailed questionnaire. This covered thirteen topics, each of which was broken down and asked about in detail.

For every topic/subtopic students were asked whether they had practised (ie knew the subtopic quite well and would have felt competent to attempt an examination question), were acquainted (ie would have seen the subtopic demonstrated by example, but little more) or 'no' to indicate that the subtopic had not been seen and was thus new to them. Their overall answers are charted below.



One point perhaps worth highlighting are the small percentage for whom 'arithmetic' was new. Whether this is sign of the changing vocabulary of students or something more sinister, who can tell? One other observation, not visible above, but only under more detailed analysis of the functions topic, was that 40% of students had not used software to plot a function. Again this may be down to vocabulary. Alternatively it could be down to not understanding what a graphical calculator does, or an error in *our* belief in the ubiquitous exposure to computers in schools.

Follow-up Afterwards

The most important aspect of diagnostic testing must be what happens after the diagnosis has been made. Having identified individual or cohort problems, what is to be done?

In our survey, the possible consequences for students of their performance in a diagnostic test were found to be quite broad. They ranged from 'the test has identified your weaknesses, go and sort them out', to actual streaming of a cohort, on a temporary basis, in order to address more widespread gaps in knowledge. Clearly this latter approach has implications as to what happens to 'successful' students whilst their contemporaries are catching up, but it does offer efficiency if weaknesses identified are widespread.

From a time point of view, the best observed practice consisted of a computer-based test, which had automatic marking, leading immediately to a personalised, directed program of study, linked in with further computer-based notes/study material addressing identified areas of weakness.

Conclusions

My view as to what constitutes best practice with diagnostic testing is summarised below:-

1. **Advise students of the diagnostic test and supply revision materials *before* arrival**.
   Supplying students with examples of the type and style of questions they will face in a diagnostic test are best supplied with admission information. This needs to be augmented with suitable revision material eg Algebra Refresher/Calculus Refresher from the LTSN Maths, Stats & OR Network. Emphasising that the nature of the test is to inform, so that students can address any problems that emerge through directed self-managed learning. If the students are to be given a computer-based test, an opportunity to try computer based questions should be provided, either through web based material, or by supplying a computer disk with examples of how answers will be expected to be entered.
2. **Make sure the purpose of the diagnostic test is clearly defined.**
   Inform students as to what information is being sought and explain how the results will be used by staff and individual students.
3. **Provide follow up and support**.
   Have a clear strategy for remediation; provide support materials and have a mechanism whereby students can assess their progress. (This could simply be a repeated attempt at the diagnostic test). Publish cohort results to enable peer reflection on performance.

To re-iterate, diagnostic testing is now an important part of the university educational process, and should be done, but to be most effective, the process needs to be thought through carefully, right from the initial test to the final consequences. Don't just do it, 'Do it Right'.

(The views expressed in this article are my own, and may not necessarily be shared by anyone else named in this article.)

maths-caa update

http://ltsn.mathstore.ac.uk/articles/maths-caa-series

Computer-Aided Assessment (CAA) is likely to become an important form of testing in the next decade, and we have initiated a series of monthly articles on CAA in mathematics. Please read the articles as they appear and send your comments to the discussion list maths-caa@jiscmail.ac.uk. Below are summaries of some recent contributions. You are invited to suggest articles for this series by contacting the series editor Cliff Beevers, email c.e.beevers@hw.ac.uk

Feb 2004: Creating questions for Automatic Assessment in Mathematics
Contributed by H S Ashton and M A Youngson of Heriot-Watt University.

This article seeks to demonstrate some of the difficulties encountered in the design of questions when translated onto the computer. It describes the resolution of some of the issues and extends the debate on the provision of partial credit in e-assessment provided, for example, at http://www.pass-it.org.uk/resources/031112-goodpracticeguide-hw.pdf.

Mar 2004: CAA in context: a case study
Contributed by Dirk F M Hermans of The University of Birmingham.

An introduction into AiM will focus on the benefits the coupling of a Computer Aided Assessment (CAA) package with a Computer Algebra System (CAS) generates. The type of questions possible in AiM will be discussed to illustrate how systems like AiM will empower the educator to go beyond what can be achieved with most standard CAA packages. Case studies are presented of the use of AiM in first year core mathematics courses at the University of Birmingham, in particular its use in an unusual type of module, aimed at supporting weaker students. The paper will list in detail how the CAA was used to complement traditional approaches and how different CAA elements were constructed to serve different purposes.

Apr 2004: Embedding CAA and Support for Mathematics in a Web-based Learning Environment
Contributed by S Hibberd, C D Litton, C Chambers and P Rowlett of University of Nottingham.

In this article, the provision of an integrated web-based learning environment for non-specialist mathematics students in Engineering and Science introduced for the Service Teaching provision at the University of Nottingham is outlined. The integration into the Environment of pilot formative assessment mechanisms consisting diagnostic and interactive self-testing is evaluated and discussed. Case studies on student use, performances and feedback on the Environment from recent student cohorts provides information on different learning styles and preferences.