Using Mathematics Diagnostic Testing on Engineering Courses

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Abstract

Even as long ago as the mid-1990s, a survey for the Open Learning Foundation [1] found that most universities were using some form of mathematics diagnostic testing on their first-year undergraduates, usually during Induction Week. With the advent of computer-aided mathematics diagnostic systems such as DIAGNOSYS [2], it has become easier to obtain an off-the-shelf diagnostic system. Even so, many people still use their own in-house tests. This study considers one such example.

The Execution

This case study relates to a paper-based diagnostic test that has been in use unchanged since the early 1990s. Originally written as a computer-based test using Question Mark software, it was soon found that network problems, an insufficient number of PCs and student reluctance to use computer-based testing forced the author to transcribe the questions into a paper-based test.

The in-class, 40 question, multiple-choice test is given to *all* design and electronics undergraduates during their induction week. Although the test is not officially time-limited (so helping to relieve student anxiety with respect to timed tests), all students invariably finish within 30 to 90 minutes.

Some of the students have A-Level Mathematics, although most do not. Even so, the content of the test is unashamedly pitched at GCSE level since, for many, it is the underlying basic mathematics (algebra, in particular) that is the major problem. An A-Level in Mathematics is no guarantee that a student will pass the diagnostic test (or the more student-friendly, 'quiz', as it is euphemistically known).

Examples of questions and post-test student feedback and analysis can be found in references [3] - [6]. All students use a 'tick the box' sheet for their answers. Solutions on a transparent overlay allow the tests to be marked rapidly – usually by the time all students have left the room. Optical character recognition would be a better way of marking since this would also facilitate a more comprehensive analysis of the students' responses; this is a future refinement.

The test is in sections, including numeracy, algebra, and geometry. Students who gain a good overall score but who do not perform well in particular sections are given directed reading to help in these weaker areas. Usually this is in the form of handouts with some explanatory text, examples and exercises. An 'open door' policy on the lecturer's part ensures that students can discuss these exercises and have their solutions checked if needed. However, for students who do not achieve an overall 50% score on the Diagnostic Test, the main help comes from a set of one-hour-per-week 'Extra Maths' classes. These are run in parallel with the students' main lectures throughout the session and each usually takes the form of an approximate 20-minute discussion followed by exercises for the students to complete. Care has to be taken here that students are not stigmatised by having to attend – some even have to be dissuaded from speaking of these classes in terms of "Maths for Dummies". This is not a major problem, however, since the Extra Maths classes can contain a large proportion of the total student cohort. A register is taken each session for all those who obtain a test score of less than 50%. Students obtaining between 50 and 60 are 'recommended' to attend, but do not have to, and those who score more than 60 do not have to attend, but can do so if they wish. The topic for Extra Maths is usually announced during the week's main lectures and often covers topics chosen by the students themselves.

Possible Barriers

Departments have to agree to their students undertaking a mathematics test in Freshers' Week. Fortunately, since the test's aim is to direct extra support to students who may otherwise be lost at the end of the first year due to failure in analytical subjects, this is not too great a problem. A diagnostic test on its own does nothing to help weaker students. Follow-up support is needed and here it is imperative to convince serviced departments that they should finance this extra support – in our case, for a one extra hour per week class. Again, this should not be a problem since, when put in financial terms, it only needs half a dozen students to be 'saved' and the scheme recoups all expenses.

Unfortunately, diagnostic testing and comprehensive follow-up support can fall foul of its own success. The whole process can encourage a dependency culture in which students are not willing to help themselves. What has to be borne in mind, however, is that the diagnostic/follow-up combination is used, amongst other things, to tease out those students for whom learning mathematics may already have been an unpleasant experience and for whom further mathematical study may be a daunting prospect. When bearing in mind, also, that these students are quite often excellent independent learners with respect to their 'main' engineering subjects, then a sympathetic approach to spoon-feeding in basic mathematics can be tolerated.

Quality Assurance

There are a variety of mechanisms that elicit feedback from students including representation on course teams and departmental and school committees. However the most telling feedback is that obtained from student/course tutor interaction and from the teaching and learning assessment forms that all students have to complete both during and at the end of each academic year. Feedback is invariably positive.

Evidence of Success

There is no way of counting the number of students who *may* have failed if they had not undertaken the test/support combination outlined here. However, various correlations have been analysed [5]. For example, there was found to be no significant correlation between the students' diagnostic scores and their end-of-year results in analytical subjects. This is fortunate, since a significant (positive) correlation here would show that a weak student on entry was still weak at the end of the year, i.e. the support provided had not added any value. The strongest correlation found is between Extra Maths attendance and students' end-of-year results in their main (analytical) subjects. The friendly approach adopted in these classes and the extra time that can be taken to explain fundamentals shows that the selection via the diagnostic test and subsequent follow-up support is a successful combination. Another indicator of success is that each year, continuing students are disappointed to find that Extra Maths is not provided in their second year of study. It is also interesting to note here that some of the students who score more than 60% also attend regularly.

Recommendations

- With the current eclectic mix in the background and abilities of current students, all courses in which mathematics is a non-specialist subject should use diagnostic testing on entry.
- Further, it is recommended, though not mandatory, that content should be set at GCSE level in order to ensure fundamental mathematics is sound. (There is no point in students trying to use partial fractions, for example, when they cannot even handle numerical fractions.)
- Even students entering Mathematics degree courses can benefit, albeit from a higher-level test.
- Point out to whomsoever, that diagnostic testing (and follow-up support) can help student retention and hence save money.
- Computer diagnostic testing is already available in the form of DIAGNOSYS. If you have the computing resources, this is the easiest route to take. If not, a paper-based multiple-choice test is the easiest to mark (although perhaps time consuming to produce if it is to have meaningful distractor answers).
- The use of meaningful distractors (e.g. 1/3 + 2/5 = 3/8) can highlight misconceptions that can be specifically addressed in the Extra Maths sessions.
- Use an 'I don't know' option for every question. Encouraging students to use this when they do not know the answer will inform you where specific support is needed.
- For paper tests, keep the question sheets and the tick-the-box answer sheets separate. That way the question papers can be used in successive years, so reducing printing costs.
- Students are 'fragile' in Week 1. Let them know that the results of the test go no further than your desktop, and that the marks will not be used in any summative way.
- Test students on what they know, not on how quickly they can answer a test – allow a two-hour slot, say, if you are using what you consider to be a one-hour test.
- Further recommendations can be found throughout reference [1].

References

[1] *Implementing Diagnostic Testing for Non-Specialist Mathematics Courses*, The Open Learning Foundation, London, Edwards, P., (1996), ISBN 1 86050 034 X.

This is also available on http://www.eds.napier.ac.uk/flexible/OLF/materials/case%20 studies/Idtfnmc.pdf [Accessed 03/02/03].

[2] The DIAGNOSYS Home page can be found at http://www.staff.ncl.ac.uk/john.appleby/diapage/diagindx.htm [Accessed 03/02/03].

[3] Some Mathematical Misconceptions on Entry to Higher Education, *Journal of Teaching Mathematics and its Applications*, 14(1), 23 - 27, Edwards, P., (1995), ISSN 0268-3679.

[4] Mathematical Proficiency on Entry to Undergraduate Courses. In Houston S.K., Blum, W., Huntley, I., and Neill, N. (eds.) *Teaching and Learning Mathematical Modelling*, Albion Mathematics and Applications Series, Chichester, UK pp. 125 - 133, Edwards, P. (1997), ISBN 1-898563-29-2.

[5] Just How Effective is the Mathematics Diagnostic Test and Follow-up Support Combination? *Journal of Teaching Mathematics and its Applications*, 16(3), pp.118 - 121, Edwards, P. (1997), ISSN 0268-3679.

[6] Falling Student Enrolment and Mathematics Diagnostic Testing – Links and Pointers. A UK Perspective. In Jensen, J. H. et al. (eds), *Justification and Enrolment problems in Education Involving Mathematics or Physics*, Roskilde University Press, Denmark, pp. 207 - 218, Edwards, P., (1998), ISBN 87-7867-070-5.