
Participation (Diagnosis + Prescription) = Resolution

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This short paper will demonstrate how appropriate mathematical diagnosis followed by study support improves engineering students' performance. Diagnostic testing of new undergraduates has become common in Higher Education Institutes (HEI) because of the need to identify a student's mathematical ability early enough to ensure any deficiencies do not hinder progress [1]. This is particularly true of students on engineering courses for whom a good standard and understanding of mathematics is crucial for successful completion. The awareness of 'blockages' is important for both the learner and teacher. This identification process is not as straightforward as it may first appear since many students will exhibit the same symptoms but actual prescription requires correct diagnosis and not simple identification.

This article will look at the use of a basic mathematics diagnostic assessment (BMDA) to identify mathematical ability and assess skills deficiencies in engineering students at the Robert Gordon University (RGU) and how the results are used to assist student's to address deficiencies before any negative effect on progress arises. In addition, the capability of the BMDT to correctly diagnose the students will be examined.

Basic Mathematics Diagnostic Assessment

The BMDA used at the RGU is based on one developed by Dr John Appleby at the University of Newcastle-upon-Tyne [2], whose approach is similar to the one taken at the Study Support Facility (SSF). In order to provide adequate mathematics support, course pre-entry requirements needed to be identified and matched to students' ability in these areas followed by targeted support. Therefore, before diagnostic testing could be implemented it was necessary to consult Course Leaders and Mathematics Specialists in order to identify the pre-requisite mathematical skills required for each of the relevant courses within the engineering school. Key issues identified for attention were:-

- the whole new cohort to be assessed either via the SSF's diagnostic assessment or with an established diagnostic assessment for specific courses;
- for it to be of value the testing ought to be carried out at the very beginning of the semester, preferably before the start of undergraduate classes;
- that results need to be fed back to the Course Leaders;
- that the students should be assessed only on the pre-course mathematics required for their undergraduate programme of study;
- time pressure and/or constraints should be avoided.

For our purpose to deliver the assessment online, the questions were transferred to Question Mark Perception™. The assessment questions were based on the pre-requisite understanding and ability in mathematics to carry out the engineering courses. The computer based assessment alleviates the time consuming task of marking. However one drawback is the lack of opportunity to see the students' working of the problem, which can reveal much about the individual's approach and can thus help to identify misunderstandings. The program decides which answers are correct simply by checking the exact matches between a bank of correct answer permutations and the students' responses, so it is important to ensure that clear instructions are given. This highlights another deficiency of computer based assessments; the student's

proficiency and confidence in the use of computers becomes a factor in the level of success.

Once deficiencies have been identified the approach of the SSF is student centred and holistic in terms of the support it provides [3]. A wide range of methods and resources are employed but individual tuition still remains the most popular and successful (see Table 2). The mathematics diagnostic assessment forms only part of the prognosis of the student; a further informal assessment takes place when the student first sees one of the tutors. This assessment takes the form of a pre-study support 'chat'. At this time the tutors are looking for verbal and other signals that might indicate the student's needs, not just the academic needs but the more subtle requirements to aid successful study, such as motivation and self-esteem. The intention of the tutors is to enable the students to become responsible for their own learning and a conscious effort is made to involve students in their own learning processes. The BMDA (formal diagnostic) allows for the field dependence cognitive style of teaching [4] whereby questions are used to check knowledge, and the informal diagnostic 'chat' allows for field independence cognitive style [4] where the questions are used by the tutors to begin teaching and instruction.

Results and Analysis

The dataset used for this analysis is a sample of 1403 engineering students for the years 1997-2002. In total, 695 (49.5%) of these students were diagnosed and 141 (13.5%) students attended the SSF for support.

The mathematics diagnostic results are based on a percentage score; consideration was given as to whether to reduce the pressure on students by having ratings such as 'Excellent', 'Satisfactory' and 'Revision' [5] but percentage scores were preferred to enable finer analysis of results. Table 1 gives the frequency of mathematics diagnostic result groups.

Percentage Group	Maths Diagnostic Freq
0.5 - 39.49	115
39.5 - 49.49	146
49.5 - 59.49	176
59.5 - 69.49	120
69.5 - 100	138
Total	695

Table 1 Mathematics Diagnostic Assessment Results by Percentage Groups

The mathematics diagnostic testing of RGU engineering students has now been taking place since 1996; there are no diagnostic assessment results for the year 2002

Usage Hours	Total Hours Freq	Total Tutor Hours Freq	Maths & Stats Hours Freq	Writing & Study Skills Hours Freq
No Hours	1078	1118	1168	1353
1 to 4 Hours	142	154	121	41
5 to 9 Hours	59	54	48	5
10 to 19 Hours	60	42	41	2
20 to 29 Hours	30	21	15	2
30 to 39 Hours	9	6	5	0
40 to 49 Hours	8	4	4	0
50 and Over Hours	17	4	1	0
Total	1403	1403	1403	1403

Table 2 Usage Hours for Subject and Tutor Support

because of technical problems related to running the assessments for the first time on a network of PC's. Fig 2 shows a detailed breakdown of the routes these students went through.

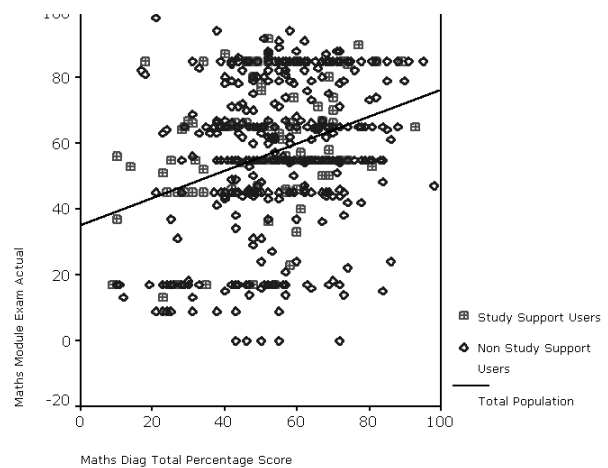


Fig 1 Mathematics Diagnostic Scores as Predictors for First Year Mathematics Module Score

Fig 1 shows how the BMD score can be used to predict students' mathematics exam scores. The Pearson correlation for this relationship is 0.299 and it is statistically significant at p-value 0.01. However with support this prediction will be superseded.

Study support usage hours have been summarised in Table 2. From this summary it is evident that the 1 to 4 hours of usage category is the most common.

Fig 2 provides a graphic representation of the different student groups with the respective mean FYMM percentage and Table 3 provides the numerical data.

Conclusion

When SSF Users are compared with Non-Users it is evident that in the Failed Mathematics Diagnostic (FMD) students' category there is a 14.09% improvement in the First Year Mathematics Module Score (FYMM). This is

an important finding for retention and needs further consideration because the mean score of 36.81% for FMD students is close to a border-line score and if these individuals struggled to get a pass in first year they will surely find the second even harder.

For the Passed Mathematics Diagnostic (PMD) students there is again an improvement of FYMM score by the SSF Users – this time by 1.21%.

This improvement is further verified by Table 3 where all individuals (except group 59.4-69.49) in the BMD groups do better in their FYMM if they make use of the SSF. The students who were not diagnosed but who used the SSF actually get a worse score than those in that group who did not use the SSF. This would need further analysis but the reason for this may be that the improvement is better when the study support is targeting specific needs.

Maths Diagnostic Score Groups (MDSG)	Non-SSF (FYMM Mean)	SSF (FYMM Mean)
Not Applicable	53.23211	51.79245
0.5 - 39.49	43.16364	51.18519
39.5 - 49.49	54.45349	61.86667
49.5 - 59.49	57.86667	58.28571
59.5 - 69.49	64.06154	56.38462
69.5 - 100	63.35632	70.33333

Table 3 FYMM Mean Scores against MDSG for SSF and Non SSF Users

References

- [1] Lawson, D.A., M. Halpin, and A. Croft, *After the diagnostic test - what next?* LTSN Maths, Stats & OR Network, 2001. 1(3): p. 19-23.
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- [5] Lawson, D.A., J.H. Tabor, and A. Whitehead. *The implications of the spread of entry qualifications of engineering undergraduates.* in *IMA Conference on Mathematical Education of Engineers.* 1996. Loughborough: Oxford University Press.

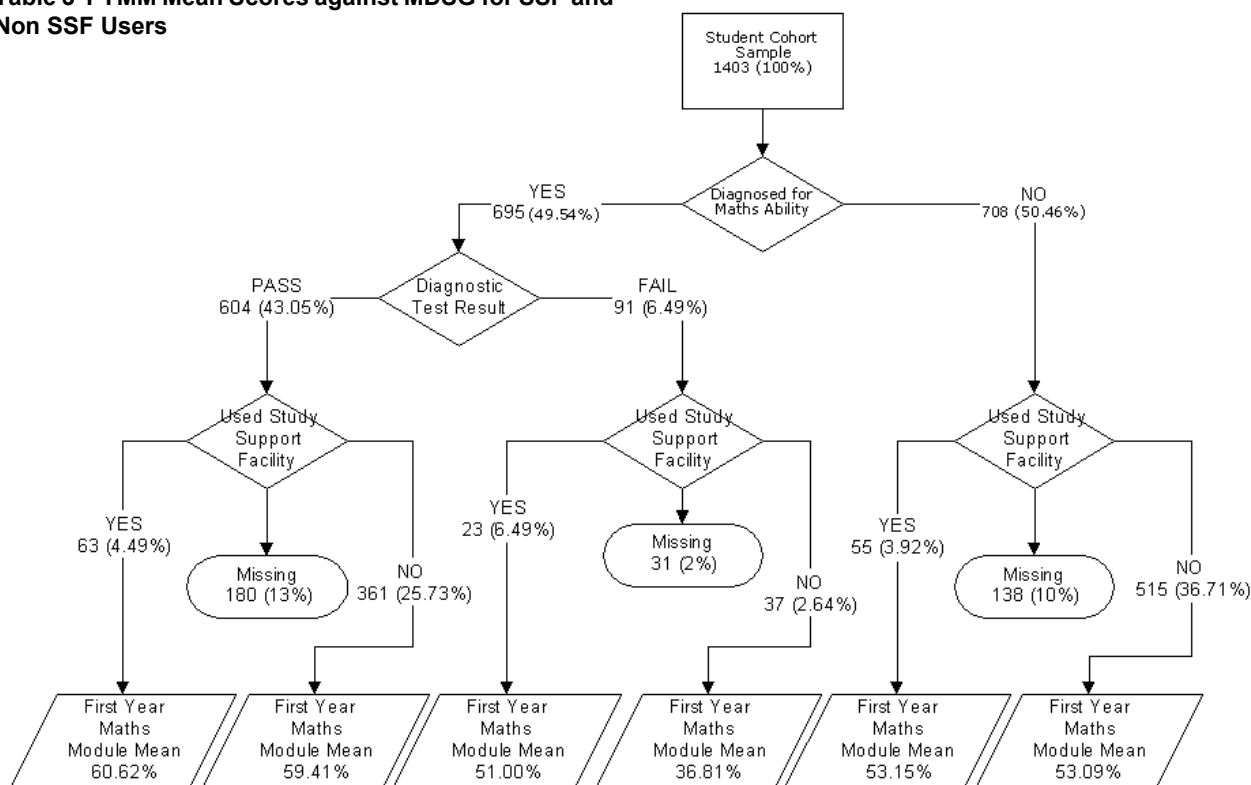


Fig 2 Effect of Mathematics Diagnostic and Study Support on Mathematics Module Results