THE ROLE OF E-ASSESSMENT IN MATHEMATICS

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1. Introduction

The last decade has seen an explosion in the use of e-assessment, or on-line assessment, in all branches of education. Their introduction is costly in terms of software and staff costs and so it is efficacious to consider who benefits from this type of technology when it is introduced. There are a number of possible benefactors:

- Administrators

- Academic Leaders

- Academics

- Students

As much as administrators find electronic systems helpful for gathering data and monitoring students progress in general, academic leaders see increased research productivity and academics dream of reduced marking loads; we must never loose sight that the major beneficiary must be the student body. Unless these systems can be shown to improve the learning and teaching experience, then their introduction is a mere Trojan mouse driven by the technology. Accordingly, the introduction of such systems should be fully investigated to decide whether this is the case.

2. So what's the problem – why do we need to change?

2.1 Changes in qualifying examinations.

In the UK, the government had, until early 2010, a target to get 50% of the 18 year old cohort into higher education. The rapid growth in the number of students entering HE has come about at a time when the qualifications of students are apparently rising. Entry to the majority of UK Universities is based on the Advanced (A)-level examination with the expectation that almost all students gaining at least a grade A or B at A-level. Table 1 shows the number of students obtaining the various A-level grades between 1992 and

2009. The interesting factor here is that only 35% of students achieved grades A or B in 1992, less than 35% failed to do so in 2009. It would be simplistic to assume that the examination grades have just been inflated but closer examination of the papers gives many examples of where this is not the case. (Quinney, 2008).

Table 1: A level grades 1995-2007. (DCFS, 2010)

	Number of students	Grade A	Grade B	Grades A or B	Failed students
1992	72,284	20.1%	14.6%	34.7%	24.1%
1997	68,853	27.8%	20.3%	48.1%	10.9%
2002	53,940	31.1%	19.0%	58.1%	9.5%
2005	52,897	40.7%	21.5%	62,2%	2.9%
2007	60,093	43.5%	21.6%	65.1%	2.0%
2009	64,519	45.4%	21.7%	68.1%	1.7%

Table 1 also shows that until 2007 the number of students deciding to study A-level mathematics was in decline; perhaps this self selection might be the reason why the percentage of higher level passes has grown but the recent increase in student numbers in 2007 would seem to discount this. There has also been a move to a modular structure where students can continually repeat modules and improve their grades. This may be a major contributing factor but as yet there is no conclusive evidence. However, there is no doubt that many of the students arriving to study mathematics are less well prepared and as such there is a need to provide support without over burdening teaching staff. Providing online help and assessment may well be able to deal with this.

2.2 Conceptual Understanding

As mentioned to in the previous section, the lack of mathematical preparedness of a substantial number of students needs to be addressed. However, another issue which afflicts a much larger number of students is their limited level of conceptual understanding, i.e. deeper understanding, of a cohesive mathematical argument. To study this issue the MSOR Network, which is part of the Higher Education Academy in the UK, funded a project to investigate the conceptual understanding of students entering HE. (Hibberd & Grove, 2009) Part of this study, which involved over 700 students, was a simple diagnostic test investigating comparative conceptual understanding. One of the questions is given below.

Exercise 1: Tabulate the function $y(x)=10/x+40x+5$, $0 < x < 6$, and use the result to plot this function. Find the slope of the curve at $x = 0.5$ and comment on the result.

As this exercise involves concepts from the first 2 core modules in A-level, it might be expected that most students at this level would find this relatively straight forward. Most

students were able to tabulate the function and plot the points on suitable axes. However, a substantial number tabulated the function at integer points and based on this data simply joined them with a straight line and then extended it to the whole interval – understandable but regrettable. Most students were able to differentiate the function, evaluate the derivative at 0.5 and then recognize that $x=0.5$ is a turning point at which the slope is horizontal. Unfortunately, though many students were able to carry out these individual steps they were unable to see the bigger picture and go back to correct their misconception about the linearity of the function. Figures 1 and 2 give some typical "answers". However, note the comments that show that these students still have only a procedural knowledge and lack deeper understanding.
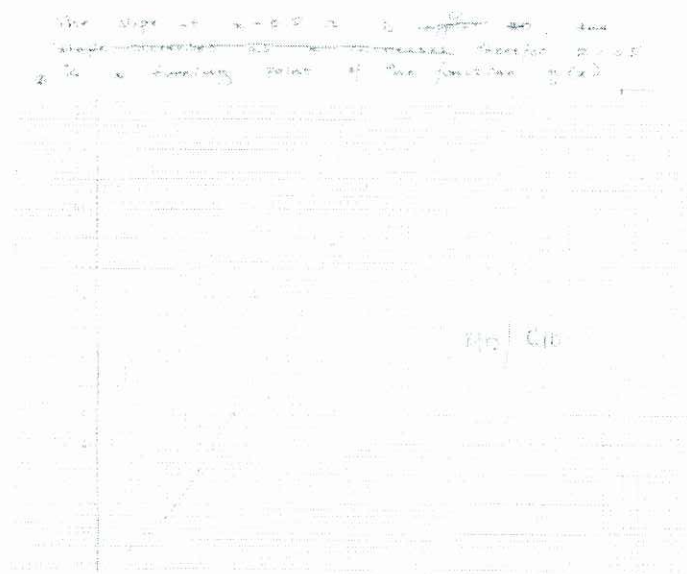
Figure 1: Student response to Exercise 1. Note the student comment "Therefore $x=0.5$ is a turning point of the function $f(x)$" but no attempt to correct the graph.
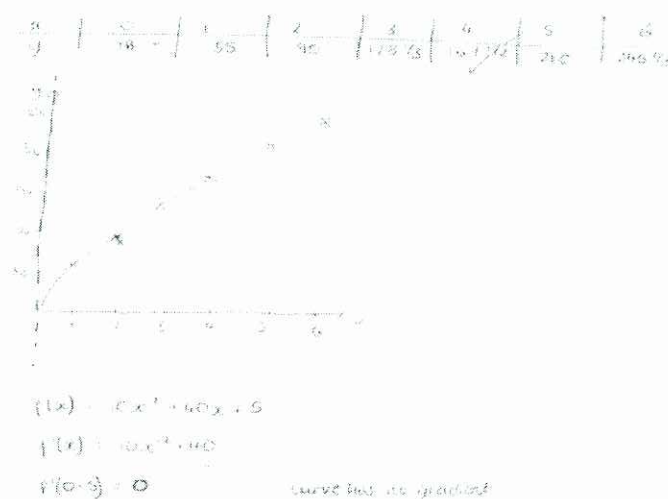

Figure 2: Student response to Exercise 1. Note student comment "$f\,'(0.5)=0$ curve has no gradient."

Part of the problem here is that in the drive for improved "standards" teaching, but perhaps not learning, has become assessment driven. Students get little or no time to practice basic skills. They will no doubt get one chance to pick up such concepts but if they get it wrong they may never revisit it, in this case their misconceptions are never corrected, in some cases they are may be re-enforced. One way to overcome this is to provide students with multiple attempts and provide opportunities for immediate feedback.

2.3 So what do we do?

In order to detect these and other misconceptions we have, since 1996, been using a simple diagnostic computer test that provides individual students and a cohort breakdown of mathematical skills. (See Figure 3.) Once detected there is an obvious cure – we develop suitable "remedial" material to address the skills gap.

Figure 3: Diagnostic Results 2009
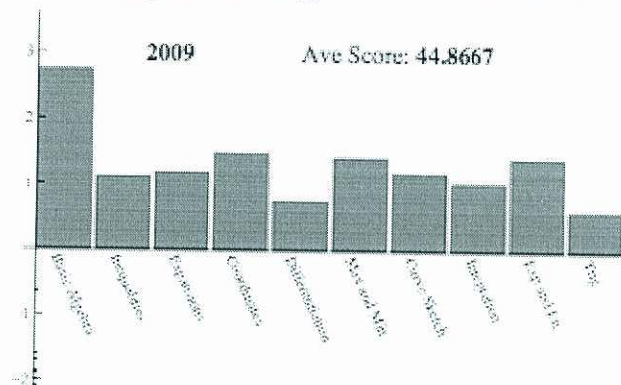
Figure 4: Diagnostic results 1996-2008

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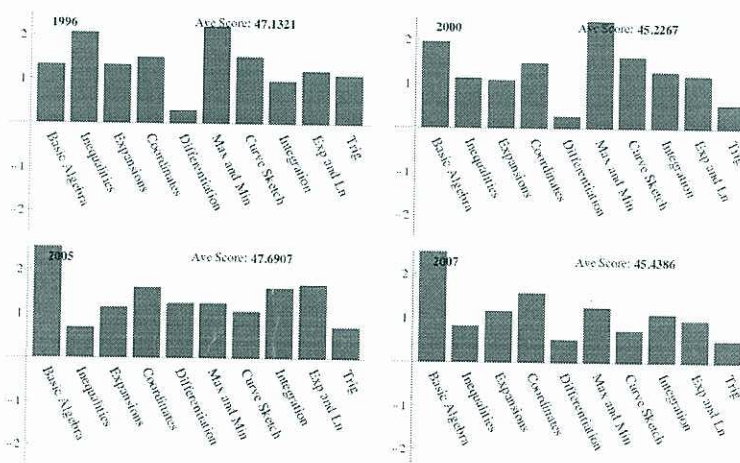
Unfortunately, each year we get different students and their cohort profile is different. (See Figure 4.) The only way to address this is to develop individual learning profiles and then assess the students' work but this is very time consuming. Again the use of online material with suitable assessment can overcome this problem. When the diagnostic test was first introduced the course relied heavily on students following up the diagnostic profile and be motivated to correct any deficiencies. It soon became clear that self-motivation was insufficient and a more formal course was introduced together with a naive e-assessment policy.

2.4 Supporting students

To encourage students to take more responsibility for their learning a more formal but self paced system course, MAT10030: *Fundamental Techniques*, was introduced which include the following components:

- Individual Study Plans linked to the diagnostic test.

- Self paced online teaching modules using *Mathwise*. (Harding & Quinney 1996.)

- Embedded Computer based assessment – a home grown system

Unfortunately, because this system was directly linked to individual study plans this was deemed unacceptable by a quality assurance audit as not all students were carrying the same load, what is more the course was deemed to be penalizing the weaker students by increasing their workload. At around the same time the degree structure at Keele University, which was based on 12 modules each of 10 credits was considered to be over-examined and the number of modules reduced to 8 per year. This meant combining MAT10030 *Fundamental Techniques* with MAT10014 *Mathematical Methods I* (Calc 1-2) to for MAT10025: Mathematical Methods, which forms 50% of the undergraduate studies for dual honors students. As part of this re-organization the e-assessment policy in mathematics was reviewed to utilize newer technology subject to the following requirements.

System Requirements

- Wide variety of QA'd Questions correctly graded and certified.

- Variety of assessment techniques, including numeric, algebraic, graphic and free text in addition to multiple choice and selection.

- Additional resources with direct text links.

- Ease of generation of assignments.

- Comprehensive Grade book – preferably linked to an existing VLE.

- System support, extensibility, portability.

After some discussion it was decided to use WileyPlus, which fulfils all the above requirements and is linked to one of the supplementary books used for the course. A

major factor in selecting WileyPlus was the variety of question types beyond text entry, multiple choice and selection, numeric, which is illustrated in Figure 5 where free text input is illustrated. Figure 5.1 shows a typical integration question. The answer is passed to Maple for checking so any answer algebraically equivalent to the specified one is correctly graded. In this question the constant of integration has been supplied in others the student is required to include it in their solution. Figure 5.2 shows the complexity of answers that can be supplied, conceptual questions involving integrals, derivatives and in this case a summation can be graded automatically. A significant feature of WileyPlus is demonstrated in Figure 5.3 that involves vectors. Notice that the student is given no indication of whether the answer is scalar or vector; again the answer is checked by Maple.

Figure 5: Examples of questions types with free text input.

QuickTime™ and a
decompressor
are needed to see this picture.

Figure 5.1: Integration Question

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Figure 5.2: Student response can be a complicated expression.

Figure 5.3: Vector notation before (i) and after (ii) partial student input.

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are needed to see this picture.

(i)

QuickTime™ and a
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are needed to see this picture.

(ii)

As shown in Figure 5 each question is accompanied by hints and solution and when appropriate to direct links to the text. Access to all these resources is controlled when the assignment is constructed. For example, we fond it helpful to release the hint link after one failed attempt at a question, the link to the text after 2 but only in a practice mode. The assignment tool is very flexible and so that assignments can easily be customized.

3. WileyPlus - Evaluation.

It is clearly not possible to carry out double blind randomized trials when evaluating e-assessment in any form but attempts at both formal and informal evaluation has been published by Hauk et al (2004), Zerr et al (2007) and given by La Rose (2010).

At Keele we are fortunate that we have been using the same diagnostic tool for some years as this gives a good base line to judge students admitted to the course. (See 2.3) We also have a parallel course that does not have an e-assessment component and which is taken by the same cohort. This year we have been able to analyze final exam results but our intention is to follow students for the next two years to investigate the long-term effect of introducing e-assessment.

3.1 WileyPlus - Results.

The response from students has been very positive, there has been a significant improvement in student engagement, a significant reduction in students leaving the course, and at a time when there has been a significant increase in student numbers the overall marking load. However, these are benefits for the system, the more important point is have students benefited?

3.2 WileyPlus - Student feedback

In the end of course evaluation students were invited to comment on WileyPlus and how it had affected their studies

- "Great because I can keep trying until I get it right."

- "Opportunity to practice before I try the assessed work is brill."

- "Before I only had one chance to get it right"

- "Getting immediate feedback is the best part – I don't have to wait 2 weeks"

but then there are always those who want more!

- "OK, its ok for basic stuff but how will it help me prove theorems?"

The students were very positive and particularly liked the immediate feedback and the way they were encouraged to repeat assignments. Students reveled in the fact that if they got a poor mark in am assignment they could repeat it without falling behind and, perhaps defying the law of diminishing returns, repeated assignment until they scored 100%. This may seem a little generous but in the process they were gaining practice in core mathematical skills and at this level isn't this what we want them to do as part of the learning process.

3.3 Examination and overall results

Table 2 shows a comparison of student performance over the academic years 2006-7 to 2009-10. The academic year 2007 was a particularly good intake and corresponds to the first year of our single honors mathematics course and is reflected in the high diagnostic score. The overall performance on the MAT 10031 Foundations of Analysis course in 2009-10, which forms the other 50% of the undergraduate studies in mathematics, was similar to previous years. (The overall course mark is a weighted combination of coursework, final examination and other factors.) The performance on the Methods course overall was significantly better taking into account the low diagnostic average in 2009-10. The final row give row in Table 2 shows a "value added" mark for each course based on the difference between the original diagnostic score and the overall score on MAT10025.

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3.4 Conclusions

The preliminary results presented above are very encouraging. Student engagement has increased, and retention was significantly improved especially amongst those students who actively engaged with WileyPlus.

Table 2: Diagnostic and Final Examination Results for MAT10025 & WP in 2009-10

	2006-7	2007-8	2008-9	2009-10
Diagnostic Test	47.69	53.26	44.17	44.86
MAT 10031:Foundations of Mathematics				
Coursework	76.9	81.2	84.6	64.4
Final Exam Mark	37.3	48.2	56.8	45.6
Overall	48.9	52.6	51.4	52.3
MAT10025: Mathematical Methods				
Coursework	72.2	77.1	82	72.43
Final Exam Mark	42	55.6	50.2	54.77
Overall	55	58.9	55	62.95
Value Added	7.31	5.64	10.83	18.09

4. So what is the role of e-assessment

There can be little doubt that the benefits of reduced marking loads make the inclusion of e-assessment very attractive particularly in times of falling resources but the incentive to encourage students to practice is even more so. If nothing else it provides an effective filter so that at risk students can be identified and any available resources targeted towards them in a cost effective way.

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