Bill Foster

Using computer based assessment in first year mathematics and statistics degree courses at Newcastle University

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Introduction

In early 2006, I was asked to set up, from scratch, a comprehensive CBA (Computer Based Assessment) system for all first year Maths and Stats modules in the School of Mathematics and Statistics at Newcastle. This was to be in place for October 2006 and furthermore each of the 6 modules per semester had to have 4 CBA assignments. I viewed this as potentially risky given the timescale.

However, the project was successful and this article describes the process, the outcomes and the firm place that CBA now holds in the school's teaching and learning strategy. Other schools and faculties in the university are also using the system in the academic year 2007-2008.

The success of the project is largely due to the total commitment of the school, especially the Head of School, Professor Guyan Robertson, the Head of Statistics, Professor Richard Boys and the CBA Chairman, Professor Robin Henderson. The expertise and patience of the IT officers Dr Michael Beaty and Dr Anthony Youd together with the support from the developers of i- assess have also been invaluable.

The Project

As Numeracy Support Coordinator for Newcastle University, I had been planning to use the CAA system i-assess for various projects in Numeracy and Mathematics for general use. I had chosen i-assess for several reasons; it was capable of setting questions at various levels, it was the direct descendant of the CALM system which I used successfully at Brunel University, and I had a good relationship with the development team who listened and acted upon my suggestions when they made sense. See **http://mathstore.ac.uk/newsletter/aug2003/iassess.pdf** for a review by Duncan Lawson – although the system has changed since then.

In early 2006, the Head of the School of Maths & Stats asked me to consider setting up CBA for first year modules for the next academic year. The main impetus was from in course assessment for first year modules. There was a heavy workload on postgraduate markers and as a consequence a large bill to pay for this marking, which also varied in quality. It was felt that most of the assignments at this level could be handled by computer based methods, and computer based marking, without compromising standards. This was not without controversy within the school, as this was a major change in assessment together with a natural scepticism that CBAs would not be challenging enough, and there were several meetings to decide upon the principle.

Once a decision was made, the following happened:

- A CBA committee was set up including all first year lecturers. This committee agreed and set timetables for CBA preparation and for CBA assignments and also asked for reports on progress;
- Members of staff attended workshops on CAA and contact was established with those academics active in this field;
- A review of all relevant CAA assessment tools (capable of implementation in the time scale and also capable of recognising and marking symbolic input) was carried out and reported to the CBA committee for a decision on which tool to use. Eventually i-assess was chosen for the reasons given above. The other systems examined were Maple TA, Wimba Horizon, WebWorks, MyMathLab and all were capable of realising the CBAs, but time was the major factor;
- An "away day" was organised for all staff in the school which fully discussed the CBA implementation together with a demonstration of i-assess;
- Cliff Beevers gave a teaching forum talk on CAA to the school and met the CBA committee to discuss the issues; and,
- The IT officer in the School of Maths & Stats was charged with the software and hardware issues in implementing the system. This rather bland statement covers a multitude of problems which we discuss in the second part.

As can be seen the school swung its weight behind the project and was committed to its success.

The organisation of the first year CBAs

It was agreed that there would be 4 CBAs plus two fuller text based assignments per single semester module. Typically a CBA would contain 5 or so questions. The 4 CBAs would together contribute 10% of the total assessment for a module. Each CBA would be timetabled over a two week period and during that time students could practice the assessment as many times as they liked. They could see the full solution to any question at any time during practice.

Note that the questions are randomised so that it was unlikely that the same questions would arise twice.

After the first week, the exam could be taken at any time up to the deadline. Only one attempt was to be allowed and full solutions given only after the exam had finished.

Writing and testing the CBAs

Initially, I was the only person who could author the questions using i-assess. I had to contact the lecturers to get the assignments to convert into the CBAs. As can be imagined, this was a non-trivial exercise. During the period May to September 2006, I wrote assignments for Semester 1. The main difficulty encountered was testing of the exams/questions once published on the intranet. Most lecturers relied upon me to do this – not a good idea for the writer to do the testing. So I employed a postgraduate to do the testing. Even so, mistakes were found by the first year students when the system went live, usually during the practice phase of a CBA, which meant a hasty edit before the exam started in the second week.

An assistant IT officer was employed in January 2007 and he took over some of the question writing and testing for the second semester CBAs. Three trained postgraduates are now (Summer 2007) reviewing the first year CBAs and writing questions for the planned extension to second year modules.

Modules and questions

The questions asked in the CBAs were in general the same as those asked in the standard exercise sheets for all modules. The i-assess system has some limitations in that the student input, although assessed, is not trapped for further analysis e.g. feedback depending upon the answer. This also meant that "follow-on" questions could not be asked i.e. a subsequent part of a question depending on the answer to a previous part. However, for first year modules this is not a serious issue as with careful design all questions could be emulated apart from the very few which needed several lines of reasoning to be assessed e.g. as in proofs of continuity – although, even there, it is possible to set questions which challenge the students.

Examples of questions

1. Algebra

The practice question from a pure mathematics course shown in Fig 1 considers a randomly generated sequence:

$a_n = \dfrac{an+b}{cn+d}$ where the coefficients are random up to

$cn+d \neq 0$ and asks for the least integer such that

$\left| x_n - \dfrac{a}{c} \right| < 10^f$ for random f between -5 and -2.

The screenshot in Fig 2 shows the answer on pressing the "Reveal" button.

2. Statistics

This question shown in Fig 3 is on probability distribution functions (pdfs) and cumulative distribution functions (cdfs)

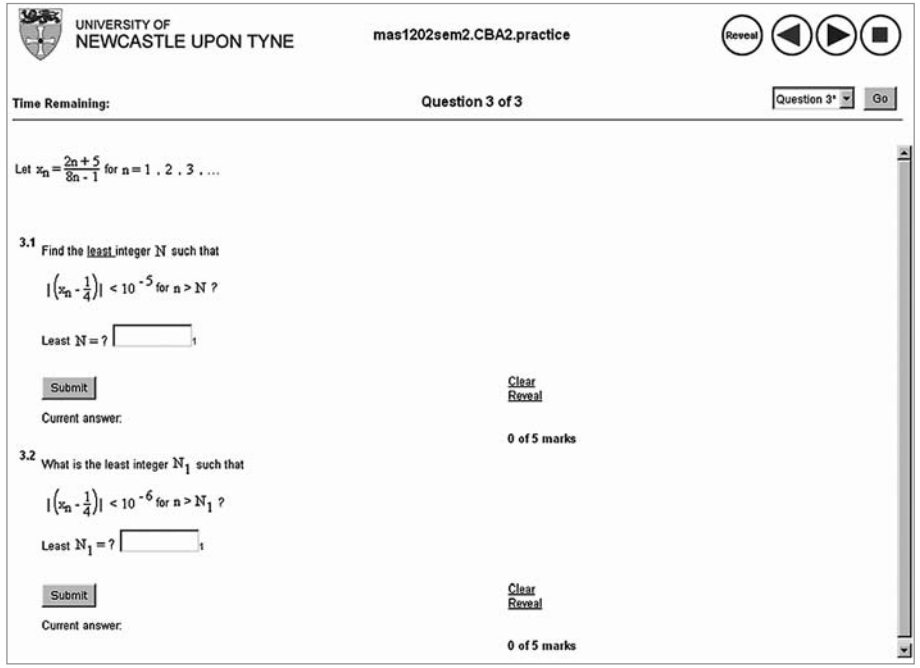
The next screenshot in Fig 4 shows part of the solution.

Students and CBA

Induction and reaction

The arrangements for CBAs for 2006-2007 were explained to first year students during the induction week. In the first 2 weeks of the semester, classes were held in computer

a)



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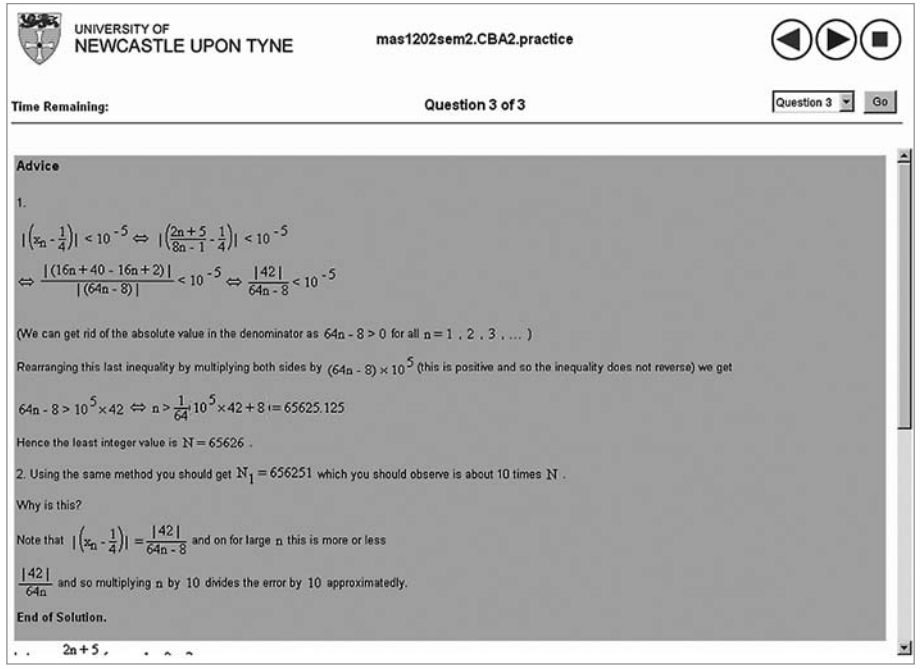

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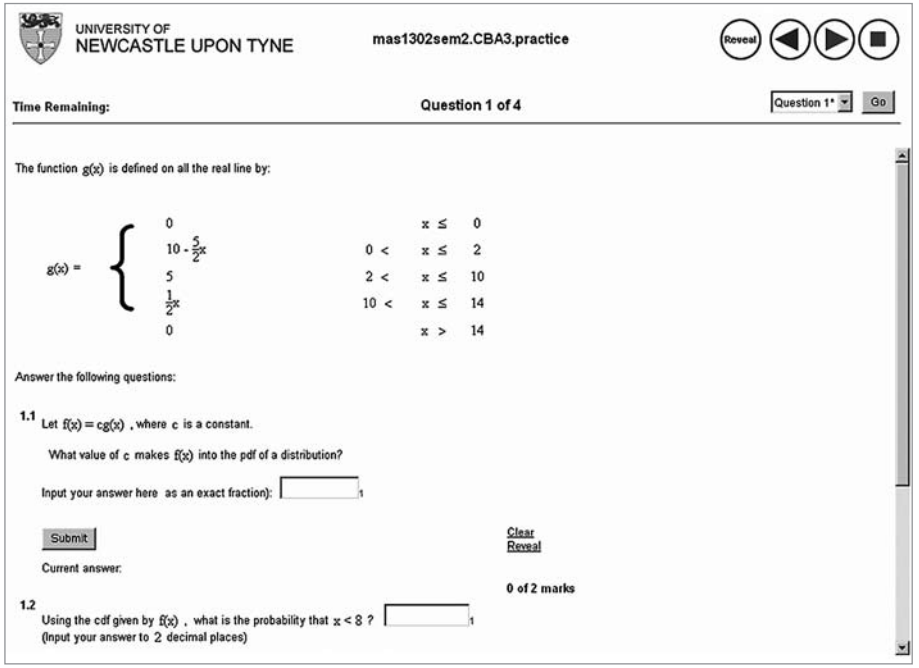

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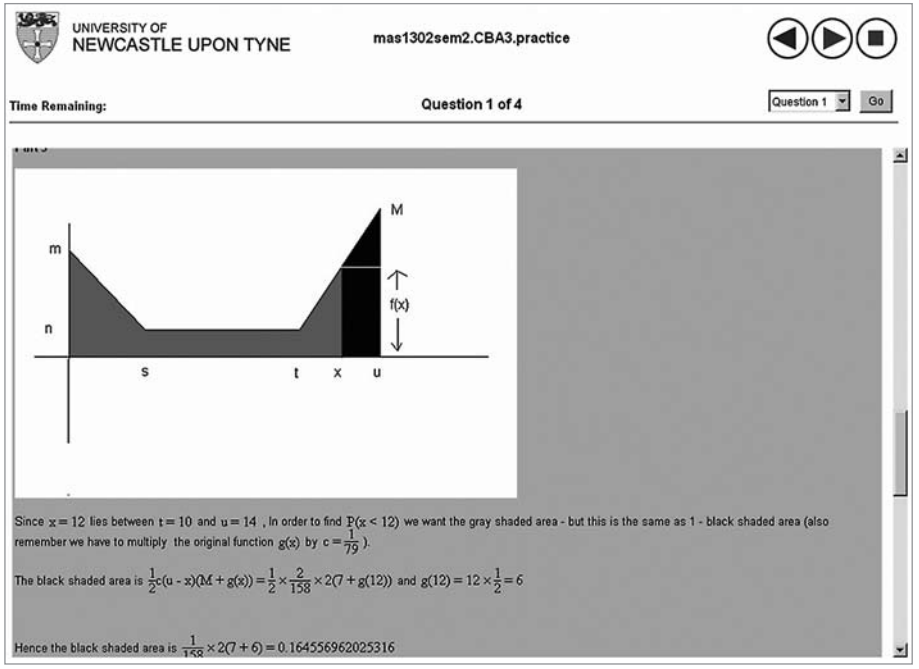

Fig 1 (a) – Example of algebra practice question. Fig 2 (b) – Answer screen revealed on pressing the "Reveal" button. Fig 3 (c) – Example of statistics question on pdfs and cdfs.. Fig 4 (d) – Part of the solution to question in Fig 3

clusters to demonstrate the system to all students and full documentation on using the system was supplied. There were, of course, several major glitches, for example, the wrong server software was installed which meant that only 10 students could use the system at one time! Also, the system was only available on a limited number of cluster computers for 2 weeks due to the cautious approach of Computer Services. However, these were all sorted out and student reaction, as reported by mid-semester feedback, was very favourable towards the CBAs. In particular, they appreciated the practice element and usage of the system has exceeded our expectation.

Eventually, the system was extended to all 1500 cluster computers and also to the Remote Access System (RAS), enabling students at home or in Halls to access the CBAs.

"Developing a new approach to assessment has benefited students and staff and the CBA system has been commended in a recent internal review."

Handling student queries/complaints

Student queries and complaints had to be handled quickly and effectively in order to make the system acceptable. They were told to contact me by e-mail if they found any problems – and they certainly did so in the first six weeks. It was absolutely crucial to answer all queries, no matter how trivial, and the workload involved in doing this was large. I enjoyed this interaction, as the vast majority were friendly, and I also made trips to the various computer rooms to talk to students personally. The added bonus was that the students valued this contact and reported this in their feedback.

Student use and performance

The headline figure is that there have been over 23,000 student CBA sessions (a session is the attempt of a CBA practice or an exam) over the 2 semesters since October 2006. There is an average of about 150 students attempting each CBA. The average time per session is about 22 minutes, and for each CBA exam there is on average 3 sessions (2 practice sessions plus the exam). Students also used the practice exams as revision for the examinations at the end of each semester – about another 2000 sessions.

Usage

There has been a general tailing off of CBA use over the two semesters. This follows the pattern of previous forms of in course assessments. However, the CBA usage exceeded in course assessment usage from previous years in both semesters.

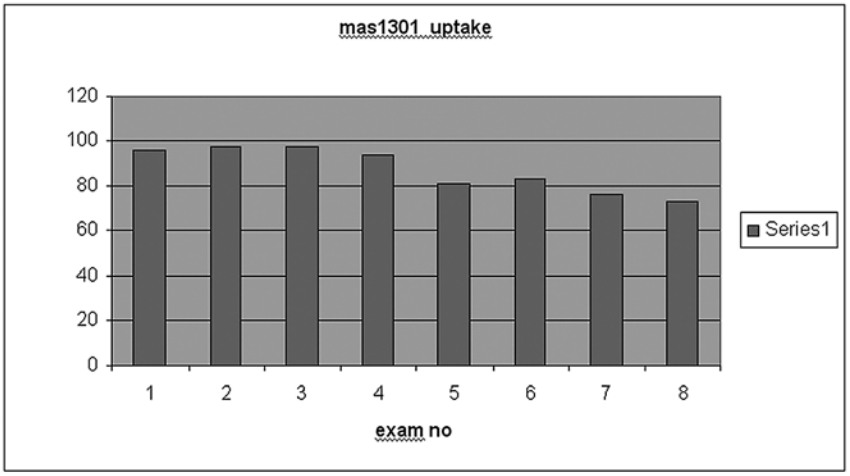

Fig 5 – Usage profile from the mas1301 *Introduction to Probability and Statistics* **course**

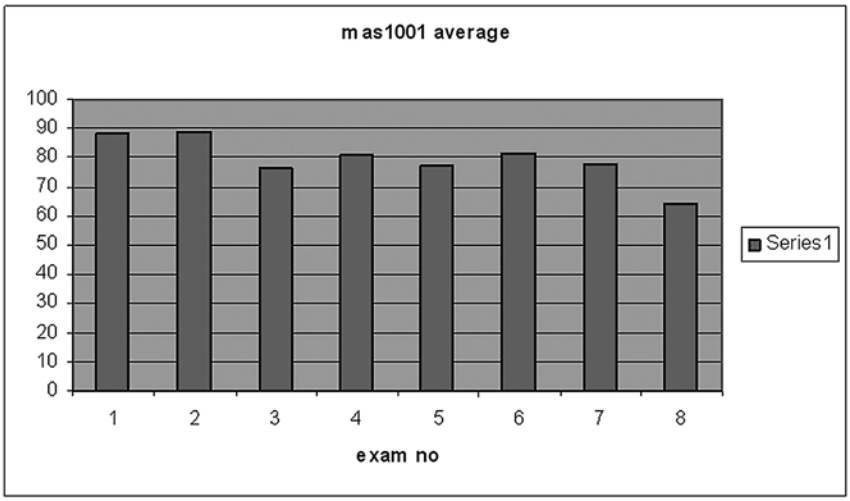

Fig 6 – Average decline in marks as questions set become more challenging

For example, the course mas1303 *Introduction to Probability and Statistics* has the profile shown in Fig 5. The first four CBAs are in the first semester and the next four the second semester. Typically, there was about a 75% rate for second semester modules against a 90% rate for the first.

Performance

As shown in Fig 6 and typical for most modules, the average marks for the module mas1001, *Mathematical Methods*, show a decrease. This can be explained by the general tendency to set more difficult questions in the second semester, as lecturers realised that they could set more challenging questions as the course developed over two semesters.

Overall Performance

The Director of First Year Studies reported after the first year of CBA:

- The number of students that we have had to 'chase up' is about 1/4 to 1/3 of the numbers in previous years;
- The number of students who have attempted some of the in course assessment is close to 100%, most notably in the CBAs;
- The overall failure rate (for Semester 1) is much reduced from previous years (Data not yet in for Semester 2); and,
- The students value the CBA assignments.

Summary

By any measure the outcome of this, in my opinion, somewhat risky project has exceeded expectations.

- In course assessment has seen a major change with strong evidence of a consequent increased student engagement and performance. This has been as a result of increased student practice – a major feature of the design of the assessment procedure. Feedback from students has been very positive.
- Lecturers have been won over; their workload has diminished and they recognise that the CBA questions asked at first year level challenge the students appropriately.
- The school has benefited as follows:
  - » Developing a new approach to assessment has benefited students and staff and the CBA system has been commended in a recent internal review (November 2006).
  - » There has been significant savings in postgraduate time and spend on marking.
  - » Expertise has been created that can be exported to other schools and faculties – for example the Medical Faculty is using the system for diagnostic testing and the School of Engineering plans to use the system for its first year course in mathematics.

"A web-site is being developed: http://www.madcaps.org.uk, for general community discussion and dissemination of CBA and CAA developments and where, for example, the Newcastle experiences will be included."

- The Teaching and Learning Committee of the School has decided that most second year modules in the School of Maths & Stats will now have a CBA component for 2007-2008. These CBAs are now being written under the guidance of the CBA committee and myself. Clearly, given the limitations of any computer based assessment tool, it is not possible to set all questions as CBA at this level. It is agreed that individual lecturers will agree on the number of questions and assessments that can be set – but there has to be at least one CBA per module. Note this extension to the second year has been influenced to some extent by the students' expectations of CBA, given their experience of the first year.
- The aim is now to roll out these CBA techniques to other schools and faculties within the university, as well as extending to other years within the School. of Maths & Stats where appropriate. It is planned to organise internal workshops in various aspects of the CBA organisation and authoring as part of the ongoing university e-learning development. A web-site is being developed: **http://www.madcaps.org.uk** (under construction), for general community discussion and dissemination of CBA and CAA developments and where, for example, the Newcastle experiences will be included. It is hoped that future workshops will be held to further inform, hopefully create standards and to cut down the duplication of effort by agreeing on the sharing of resources.