INTEGRATING ON-LINE ASSESSMENT WITH CLASS-BASED TEACHING AND LEARNING: A PRELIMINARY STUDY OF THE *AIM* MARKING SYSTEM

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Integrating on-line assessment with class-based teaching and learning: A preliminary study of the *AiM* marking system

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Abstract

This paper reports on the development and implementation of an on-line assessment system (*AiM*), introduced to mathematics courses at the University of York. **A**ssessment **i**n **M**athematics (*AiM*) is open-source, using the Maple symbolic mathematics program, giving it a built-in understanding of mathematics. The program includes a facility to randomise questions for different users, detect correct answers given in unusual forms, log individual student performance and provide intelligently tailored feedback. *AiM* therefore addresses many of the restrictions of established assessment tools, notably their inflexibility in terms of the range of questions that can be asked and the types of answers that may be submitted and processed.

We report on the implementation of this system during the first two terms of the 2003-04 academic year, focusing on the introduction of on-line assessment methods within traditional taught courses delivered on campus. We consider how the flexibility of *AiM* and its support to individual learning may transform pedagogical practice, challenging the prevailing culture of instruction.

Why should we use on-line assessment in mathematics?

By conviction, mathematics instruction has been based on a teacher-centred ‘chalk and talk’ model, with students observing the lecturer in class and then tackling problems in their own time. Students are usually given one week to complete an assignment and hand in their solutions. They are then marked, either by the lecturer or by a graduate assistant, and handed back to the student about a week later.

The traditional assessment system, that is so universally followed, is designed to encourage individuals to apply the knowledge acquired in the lectures and to make it their own. Research suggests however that this approach has some flaws, with students tending to adopt surface approaches to learning (Gibbs & Simpson, 2002). The delay in receiving feedback does not encourage students to reflect on their approach to a problem, nor to learn from their mistakes. When students finally find out that they have made an error in an assignment, there is little incentive for them to go over the problem and correct it. The "learning from one's mistakes" does not always take place.

The introduction of computer-aided assessment may help to address these problems, encouraging the development of critical thinking amongst our students. Sophisticated CAA systems such as *AiM* offer students immediate feedback on their work (for each part of a problem, not just the final solution), as well as the opportunity to take greater control over their own learning, by receiving personalised problem sheets and immediate feedback on their solutions. CAA systems indeed encourage students to be more self-reliant, trying out solutions on their own, rather than relying on lecturers for guidance.

Description of the *AiM* System for on-line assessment

AiM (http://aiminfo.net) is a web-based assessment system that uses the computer algebra system (CAS) Maple (http://maplesoft.com) to perform the randomisation of questions, the marking of student answers, and the tailoring of feedback. The built-in knowledge of mathematics that the CAS provides opens up entirely new possibilities to computer-aided assessment, of which we will now present a few examples:

Equivalent answers

AiM can mark questions where the correct answer can be expressed in many different forms. In mathematics this is the rule rather than the exception because of algebraic equivalence between expressions, for example $(x+1)^2 = x^2 + 2x + 1$. The computer algebra system can identify these equivalencies.

Ask for examples

AiM can mark questions that ask the student to provide an example. Giving examples is a higher-order skill that was impossible to assess with conventional CAA systems (Sangwin, 2003). Here is a simple example of such a question:

- *Find a singular 5 by 5 matrix with no repeated entries.*

There are many such matrices. To mark this question *AiM* simply checks that all entries of the matrix given by the student are different and that the determinant is non-zero

Intelligent randomization

AiM can randomise problems in such a way that the level of difficulty is kept as a constant. For example, if a question asks the student to 'diagonalize' a 2 by 2 matrix, then it would not be a good idea to simply randomise the entries of this matrix, because for some matrices the answer will involve only integers whereas for others it will involve rationals. *AiM* can randomise this problem in a way that guarantees that the answer always contains only integers. The trick is to reverse-engineer the randomised question from a randomised answer.

Give feedback and partial credit

For example in a question like:

Give an example of a cubic polynomial $p(x)$ *with the following properties:*

a) $p(0)=1,$

b) $p(x)=0$ *at* $x=2$ *and at* $x=3$.

AiM can check each condition separately on the student's answer and assign partial credit accordingly. If the student gave the answer $p(x)=x^2-5x+6$ for example, then *AiM* could reply: "*Your answer does have zeros at the required points but its value at zero is not equal to 1. You received 2 out of 3 points. Please try again.*"

More detailed descriptions of the *AiM* system can be found in the work of Hermans (2002), Strickland (2002) and Klai et al., (2000).

The York approach to on-line assessment

In our view, the biggest challenge for lecturers is to consider how to integrate computerised assessment with traditional study methods, so that the benefits of CAA are combined with the strengths of traditional homework problems. Students should still be encouraged to take problems home and carefully work out their solutions, rather than attempt quiz questions that can be easily be dealt with while sitting at a computer. The key is to employ technology to motivate students to work on challenging problems, so that they reflect on their solutions and the approaches they have selected.

The York approach seeks to achieve this by introducing computerised questions as part of the traditional problem sheets, which students receive for their weekly assignments. Students receive typeset problem sheets in the lectures every week to take home with them. Each problem sheet is different, with the questions randomised by *AiM*. Students are allocated an ID number for their problem sheet, which can be recognised by the system*.* After logging on to the Department's virtual learning environment *Moodle* (http://moodle.org), which serves as the hosting environment for *AiM*, course participants access *AiM*, entering their ID number to identify themselves and then submit their answers to the problem sheet. Their answers are marked immediately. If they get an answer wrong they can come back at a later time to correct themselves and will still receive partial credit.

AiM was introduced for a range of first year undergraduate modules during the first two terms of the 2003-04 academic year. During the summer we had employed some of our best undergraduate students to take the problem sheets from 18 of our existing modules and computerise some of the questions. At the beginning of the autumn term all students were given a one-hour training session to familiarise themselves with *AiM* and *Moodle*. Lecturers were thus able to employ *AiM* in a range of courses, without spending any further preparatory time on explaining how the system would work. The research approach employed to observe this new system and the preliminary results arising from the study are summarised below.

Research approach

Introducing on-line learning and assessment in such a rapid way into a department where there was no prior tradition was certainly an usual experiment. We selected an exploratory case study design (Robson, 1993; Yin, 1993) in order to research the experiences of course participants following this approach for the first time. The study focused on the learning experiences of 182 first year undergraduate students, who were asked to complete two survey instruments, with the first one presented to them after the training session (at the beginning of the academic year) and the second instrument distributed to them later on at the end of the spring term. The zero measurement captured student expectations and feelings towards maths assessment and its delivery online. The second instrument invited students to reassess their attitudes to these questions, as well as to reflect on their experiences in using *AiM* for computerised marking of problems across a range of modules (Calculus, Maple, Matrices etc.). Responses were recorded using a 5-point Likert scale, with an open response section included at the end of the questionnaire to enable participants to comment on their learning experiences. Interviews were also conducted with students and staff, in order to provide a rounded view of the learning and instructional processes.

Feedback from students

Both survey instruments attracted a healthy response rate, with 98 submissions recorded for the spring survey (a 54% response rate). The survey feedback revealed a strong level of support in favour of on-line assessment methods. This was encouraging, given the rapid way in which on-line learning was introduced to the Department. Students valued the opportunity to reattempt questions and to receive immediate feedback on attempted solutions. Two-thirds of respondents in both surveys viewed computerised marking as relevant to mathematics and complementary to traditional teaching methods. Preliminary findings suggest that the introduction of AiM encouraged students to reattempt questions prior to seminar classes and to learn from their mistakes, due to the immediacy of feedback that they received when tackling a problem. 85% of respondents in the spring survey agreed that the automatic feedback from the marking system encouraged them to reattempt questions. 68% of respondents agreed that the software supported their reflection on solutions, encouraging them to consider where they went wrong in performing a calculation.

Feedback from staff

Beyond the freeing up of teaching time with a reduced marking load, staff highlighted the value of *AiM* in encouraging students to be more self-reliant, trying out solutions on their own, rather than relying on staff for guidance. Partial feedback was deemed to be valuable in indicating an error range, encouraging students to review their solutions. In this way individuals were encouraged to develop an intuitive understanding of what is right – how to complete a solution independently. The logging of student attempts on a specific problem also gave lecturers valuable information on individual performance in these tasks.

Future plans

The research in progress has revealed a wish by staff and students to expand the level of personalised feedback, so that individuals are presented with the reasons behind their errors, enabling them to distinguish between syntax and methodological errors. The future may indeed see on-line assessment extending beyond calculations to more complex mathematical problems, which require creative solutions. Progress has already been made in this direction, with the system providing examples of mathematical objects with certain properties. Future plans include an investigation of the Computer Algebra Based Learning and Evaluation (CABLE) system, considering how it may be used to mark mathematical learning objects.

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