

Chapter 21

Mathematics Lecturers' Practice and Perception of Computer-Aided Assessment

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Abstract This case study investigates, from the practitioners' point of view, the advantages and disadvantages of Computer-Assisted Assessment (CAA), and how lecturers that use this type of assessment deal with the issues involved. Data were collected through a questionnaire and follow-up interviews with lecturers that use CAA in their first year mathematics modules at a large university. Some of the advantages lecturers mentioned were saving time in designing and marking tests and giving feedback to large groups of students, student motivation, socialisation of learning and peer support, and students having a more relaxed way of being assessed (when tests were not invigilated). On the other hand, lecturers noted the procedural nature of CAA tests, poor quality feedback and the inability to change an "antiquated" system. Lecturers using CAA make compromises in order to retain the advantages of the system by, for example, reducing the contribution that CAA tests have in the overall assessment scheme or testing conceptual understanding through other means; but it is clear that they would welcome a simpler, more effective system that could address the shortfalls of the current one.

21.1 Rationale and aims

Mathematics lecturers at the target university are in the position of being able to utilise Computer-Assisted Assessment (CAA) without the need to develop their own questions. Two projects undertaken a few years ago by colleagues at the university and elsewhere have resulted in question banks containing thousands of questions ready to use (HELM, 2006). This project evaluates the issues arising for lecturers who use these resources as a method of assessment.

It would appear at first sight that the ready availability of CAA questions is an extremely efficient way of assessing hundreds of first year students and would be wel-

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comed by all involved. Question banks are available for both practice and coursework tests and lecturers are freed from marking students' work. The workload for lecturers is minimal, as dedicated e-learning technicians are available to upload tests and the computer software provides pre-prepared feedback to the students and summary statistics for the lecturers.

However, all is not necessarily as straightforward as it might appear. For most large classes it is not possible to invigilate the coursework tests due to the lack of availability of computer labs for this purpose. If students then take the tests in their own time, some lecturers and departments are concerned about plagiarism and, in these cases, paper-based invigilated versions of tests may need to be prepared and marked, thus reducing the efficiency of the system. Other lecturers are concerned about the questions that are available for use. Sometimes they do not fully cover the required syllabus, but the steep learning curve and associated time involved in developing new questions is prohibitive and so lecturers may be tempted to "make do". Other concerns involve the nature of many CAA questions, which seems more suited to testing techniques or procedures than conceptual understanding.

This project addresses the following research questions:

- RQ1 How is CAA implemented in first year mathematics modules for mathematics and engineering students at the target university?
- RQ2 Why are lecturers using CAA?
- RQ3 What are the lecturers' perceptions of issues arising?
- RQ4 How are lecturers dealing with these issues?

21.2 Background

Lecturers in the mathematics and mathematics education departments of this university are responsible for the development and delivery of the teaching of mathematics and statistics for undergraduate mathematics students and most undergraduate engineering students. This study focuses on CAA delivered to first year students. Currently there are over 200 first year mathematics students and approximately 600 first year engineering students taught by staff in the two departments.

The question banks were developed for engineering mathematics modules as part of the HELM project (Harrison, Green, Pidcock and Palipana, 2007). These cover all the first year engineering mathematics topics such as vectors, complex numbers, matrices, differential equations, etc. In parallel to this, staff in the mathematics department developed CAA questions for the two main first year modules for undergraduate mathematics students, namely calculus and linear algebra. The question banks are each separated into two parts – one for practice tests and one for assessed coursework tests. Lecturers may choose to use CAA for both practice and coursework tests or for just one aspect or not to use it at all. Lecturers can also choose whether to provide detailed feedback or simply indicate which questions have been answered correctly/incorrectly. Figure 21.1 shows a typical question and Figure 21.2 the specific feedback provided to students.

Determine the real value of k for which

$$\frac{d^2y}{dx^2} + k \frac{dy}{dx} + 16k = 0$$

has the solution $y = xe^{-4x}$

Enter your answer in the box provided.

This question is worth 2 mark(s)

Fig. 21.1 A typical question on differential equations for first year engineering undergraduates

Constant coefficient ordinary differential equation have solutions of this kind when the auxiliary equation

$$\lambda^2 + k\lambda + 16 = 0$$

has a double root for λ .

This will occur in this case when $k^2 = 64$.

Note: $\lambda = \frac{-k \pm \sqrt{k^2 - 64}}{2}$

So the value of $k = 8$ will lead to the solution $y = xe^{-4x}$
 Had we taken $k = -8$ a solution of the form $y = xe^{4x}$ would have been obtained.

Fig. 21.2 Feedback for the differential equations question

21.3 Methods

In order to answer the research questions, the approach adopted was that of a questionnaire followed up with interviews.

21.3.1 The questionnaire

A questionnaire was developed and then piloted with postgraduate students and one lecturer of a second year module that uses CAA. All thirteen lecturers teaching mathematics modules to first year mathematics and engineering students were then invited to complete it. Four of these were eliminated from this study, since currently they do not use CAA with first year undergraduates.

The first section of the questionnaire (questions 1-7) focused on how each lecturer used CAA in his/her module and covered aspects such as availability of prac-

tice tests, format of coursework tests and whether these were paper-based or invigilated, the type of feedback provided and the lecturer's policy on collaboration for tests. Responses from this enable us to address RQ1. Question 8 focussed on the lecturers' perceptions of the type of mathematical understanding that CAA tests. Question 9 explored reasons for using CAA (RQ2) and question 10 focussed on authoring of CAA questions. Question 11 gave lecturers the opportunity to provide additional comments. Finally, respondents were invited to indicate their willingness to take part in a follow-up interview.

21.3.2 The interviews

Those lecturers that indicated willingness to take part in the follow-up interview were invited to suggest a time that would be most suitable to them. Some were conducted in the lecturers' own offices and others were held in rooms booked in the mathematics education department building. The interviews were semi-structured, using the questionnaire as a basis from which to establish lecturers' detailed reasons for their choices.

The interviews lasted between 27 minutes and 54 minutes (median time 34 minutes). The questions addressed in the interviews were:

- Why do you use CAA?
- Why is CAA set up this way in your module? What changes might you make in the near future?
- What does CAA test?
- How have your interactions with students and other lecturers influenced the way you use CAA?
- What are the reasons for your policy on collaboration between students in CAA activities?
- In what ways do students collaborate in CAA exercises?

21.4 Results

We first focus on the results from the questionnaire and then turn our attention to the interview findings.

21.4.1 Questionnaire findings

The use of CAA

All nine lecturers use CAA practice tests with their students and seven of these use CAA for coursework tests. One lecturer uses paper-based tests in order to ask more challenging questions: this lecturer allows students to access the practice tests, since they are preparation for some of the paper test questions. A second lecturer also makes practice tests available to students, but they are not followed by a test. Three of the seven lecturers that use the CAA summative test invigilate the test in a computer lab; and the paper test is invigilated in a lecture theatre. The remaining four lecturers allow the students to take the tests at a location of their choosing and in their own time, within a specified time-period (usually two or three days). Lecturers' perceptions about the need for invigilation were explored in more depth during interviews. Availability of practice tests also varies and details of this and the information regarding invigilation and use of paper-based tests are summarised in Table 21.1.

		CAA test		Invigilated	No test paper- based test
		Invigilated	Non- invigilated		
Access to practice test granted more than one week before a test	Access to practice tests granted after the test	0	2	1	1
Access to practice test granted up to one week before a test	Access to practice tests granted after the test	0	1	0	0
	Access to practice tests not granted after the test	3	1	0	0
Totals		3	4	1	1

Table 21.1 Summary of implementation of CAA

Reasons for using CAA

In question 9 lecturers were presented with nine possible reasons for using CAA and asked to select from a scale of 'strongly agree' to 'strongly disagree' with the given statements. Not all lecturers responded to all the statements.

I use CAA with students because ...	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
it is easy to set CAA tests for my students	1	1	0	4	2
it was used by a previous lecturer	0	0	0	4	4
I am encouraged to by the department	0	0	6	1	1
students receive immediate feedback	0	0	2	4	3
students receive good quality feedback	0	2	3	3	1
CAA frees up time	0	0	0	5	4
CAA is convenient	0	0	0	5	3
CAA provides students opportunities to practise	0	0	1	4	4
CAA provides students motivation to practise	0	1	2	5	0

Table 21.2 Why lecturers use CAA – questionnaire responses

From Table 21.2 we see that although there is strong agreement that CAA frees up time, is convenient, provides opportunities and motivation for students to practise and provides immediate feedback, there is disagreement on the quality of feedback received by students. This conflict, between what the system provides for their students in terms of feedback, and what they might wish to provide will be explored in more detail in the analysis of the interviews. There is also disagreement regarding the ease of setting up CAA tests – this will also be explored in the analysis of the interviews.

Setting questions

The current bank of questions provides a permanent source of questions to set tests, but lecturers disagree when asked whether these questions provide students with sufficient challenge (2 believe they do; 5 believe they do not; the remaining 2 neither agree nor disagree). While it would seem that developing new questions would then be worthwhile, some lecturers feel that developing new questions takes too much time (4 agree; 5 neither agree nor disagree) and some feel that developing questions is too difficult (3 agree; 6 neither agree nor disagree). Only three of the lecturers have attempted to write their own CAA questions and fewer still (two) believe it would be worthwhile to learn how to do so.

Thus there is an issue and potential conflict here. Over half the lecturers questioned do not believe the questions provide enough of a challenge. However the alternative, of developing new questions, is not a route they are adopting. We explore this in more detail in the interviews.

Collaboration of students

All of the lecturers are happy with collaboration in the practice tests, but only three explicitly encourage students to collaborate. Those lecturers that have an invigilated test (either online CAA or paper-based) prevent collaboration by enforcing “exam conditions”. However, the four lecturers that do not invigilate the CAA coursework tests do not wish students to collaborate, but they do not communicate these wishes to the students.

Testing of recall, procedural ability and knowledge of concepts

In question 8 lecturers were asked to indicate the extent to which they agree that CAA tests recall, procedural ability and knowledge of concepts.

CAA tests my students' ...	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
ability to recall mathematical facts, rules and equations	0	3	1	3	2
ability to carry out mathematical procedures and methods	0	0	1	5	3
deeper understanding of mathematical concepts	0	3	5	1	0

Table 21.3 What lecturers believe CAA tests of students

From Table 21.3 it may be seen that there is strong agreement that CAA tests recall and procedural ability, but not so in the case of knowledge of concepts. Interviews were used to probe this and try to ascertain how much of an issue this was for the lecturers concerned.

Most lecturers provide detailed feedback to students through CAA practice tests (seven; and two do not). Of the lecturers that use the online coursework test, two lecturers provide more detailed feedback at this opportunity as well as in the practice tests.

21.4.2 Interviews findings

Reasons for using CAA

Established practice

All six lecturers that were interviewed say that the reason that led them into this practice was that they inherited it from previous lecturers. One lecturer said, “That’s the way it has been done” before adding, “One of the reasons that I have been supportive of using CAA is that it was in operation here” (P1). Other lecturers suggest similar histories: “that’s what I inherited” (P3); ‘the honest answer is probably because I’ve inherited it that way” (P4); “I’ve inherited it with the Calculus module that was taught previously” (P6).

Departmental influence

The interviewed lecturers have discussed the use of CAA with other lecturers at some point. However, the extent to which these discussions have had an effect on their teaching and use of CAA differ. One lecturer said, “When it comes down to it, I use it because I’ve been told to use it” (P5). Another lecturer suggests she would not have implemented CAA had it not been for her colleagues’ influence: “I suppose [*discussions with other lecturers have*] been a strong influence, because I hadn’t used it before” (P1). When asked whether discussions with other lecturers have influenced his use of CAA, one lecturer replied, “Not much” (P4).

Saving time

There are two aspects of CAA that help save time. First, CAA handles the distribution and marking of tests and returns feedback with little further human intervention. Second, the task of setting the tests and questions can be shared with others. Most lecturers are wary of spending a disproportionate amount of time on assessment. This is particularly troublesome with large student groups: “If I’m going to consider [*giving*] a written piece of assessment . . . to 200 students, there’s just too much marking involved” (P5). CAA offers the means to distribute and mark students’ work without further input: and this is convenient, “It certainly frees up your time; it’s convenient” (P3).

The university has dedicated staff that work closely with CAA systems and set up access to the tests. For the lecturers, this means that they can simply choose questions from the question bank and ask someone else to compile the test: “what’s particularly good about them . . . is that, more or less, somebody else does all the work” (P1) and “the system is all set up, so I don’t have to do any of that” (P3).

Student responsibility

Some motivation for using CAA is to encourage students to accept some responsibility for the learning they do. Lecturers say: ‘[With CAA] they have to take a strong degree of responsibility for their own learning’ (P1); “with the computer tests, I think you encourage them to go and do some work” (P2); “it does give them opportunities to practice” (P3). And another lecturer believes that students seem to relish this responsibility: “the teaching coordinator asked me to have a look at how many students actually do that [*attempt the practice tests*] and it turns out that they do this quite a bit . . . For me it was a surprisingly high average of how many times students do these tests” (P4). For some lecturers, this is part of a wider approach to fostering a mature approach to learning at university: “a practice test is for not just practising getting the right answers, but understanding what the questions are, how to go about them and, if they have a problem, to find out what it is they have a problem with” (P5).

Lecturers’ perceptions of the issues

Antiquated system

Some limitations of the system are attributed to its age. Some lecturers commented on this aspect of the CAA system when highlighting particular problems with it: “that we have to produce the question in a ‘jpeg’ is, I think, rather odd. I don’t know where it comes from. Maybe it just shows that the system is ten or fifteen years old” (P4); “the discussions that I’ve had with lecturers have been along the lines of, ‘This is such an antiquated system.’ ” (P6).

Although age does not necessarily render an assessment technique such as CAA useless, the emergence of other, younger systems attracts attention. “I have been to talks where . . . you get potentially better feedback . . . and that sort of thing is very appealing” (P3), in contrast to “I think there probably are systems which would make it not so onerous, but the one that we currently have is just a nightmare” (P6).

The burden on time

One of the key issues that lecturers face when developing new questions is that it is time-consuming and involves a steep learning curve. One lecturer examined the possibility of developing questions to suit her teaching group, however she found that considerable effort was required: “There is a system where you can write your own questions, but that is a lot of work. I think it’s five hours for one question, and you have to really learn the system” (P5).

Many lecturers would like to change the questions but feel unable to. The large bank of questions is a treasured and time-saving resource: “if we use something

else, then that means that we've got to leave behind the question bank that we're using" (P6). However, the existing questions no longer provide sufficient challenge for the students: "they don't offer as much of a challenge as I want" (P1); "the level is similar to the ones in the tutorial. And as I said, it's just a matter of repeating" (P2).

Testing students

There is a growing desire to test students more deeply: "I'd be even happier if I could push to more complicated and more conceptual questions" (P4). However, the existing questions do not always provide this, hence the need to develop new questions. There is an emerging acknowledgement that CAA is most effective at testing procedural ability: "it's quite effective at making sure that they can carry out the procedures" (P6). It falls short of being able to test conceptual knowledge and recall: "I don't think it tests their recall, because they can have all of their materials in front of them" (P6).

There are further concerns that Computer-Assisted Assessment conditions the students into learning in a particular way. The formulaic nature of the questions and the CAA testing routine encourages students to "just do enough repetition" (P6) until they are proficient in those questions. There is a danger that this miscommunicates to students the nature of other assessments: "if you, for example, prepare students under certain conditions, when it comes to the final examination, they get used to that" (P2).

This seems evident from the requests that students make to lecturers to have the practice tests available in the leading weeks before the final exam: "I had a lot of requests before the final examinations where students asked me, 'Is it possible to have all these tests, the practice tests, on the machine or on the system?' " (P2).

Obtaining feedback

Although CAA can help students become familiar with the procedures they need to learn, lecturers believe that the feedback they receive is not necessarily helpful. For the most able, CAA confirms to students that they have carried out the procedure correctly: "I am sure there are students who think it's [CAA is] very effective because they are getting 85%. They can tick it off. They know that they are doing well" (P5). However, CAA might struggle to provide the feedback necessary to facilitate understanding in weaker students. These students are presented with solutions that look similar to ones they have already experienced in lectures, giving no extra support than the one they already had: "the feedback that we're giving there isn't much more than another worked example, as you find in the lecture notes, or as you find in the textbooks" (P4). Consequently, lecturers tend to be dissatisfied with the feedback as it lacks the ability to respond to students' work: "I don't think it's good quality feedback in the sense of being individual, or being able to give hints"

(P3); “I do say to my students in the lecture that that level of feedback is not what I would like them to have” (P4). Some lecturers are also unhappy about the feedback they receive from the system, which ideally could help them identify what has been understood and which topics need more focus. One lecturer noted, “the CAA tests themselves . . . would not tell me what students can and cannot do,” adding “if they’re getting a low score, I cannot tell what they know and don’t know” (P5). Another agreed: “I have very limited knowledge of what the student has actually done” (P4).

There are also issues with the scores that students receive. The lecturers report that the students feel the scores awarded by CAA do not necessarily reflect the knowledge they have. One lecturer was disappointed that since CAA cannot interpret the intermediate work that students have done, students are harshly penalised if their answer does not match the solution: “They were frequently failing on the detail . . . and getting no marks, even though they were doing the right thing” (P5). Furthermore, there have been instances of mistakes in the CAA questions that only recently have been identified: “Embarrassingly, even in the problems that we actually have run for ten years . . . students did find mistakes” (P4). Some lecturers believe that CAA is seen as the epitome of fairness, since no judgements are made on students’ work: “because we are required to give them a mark, we at least want it to be as consistent and as fair . . . as possible” (P6). However, perhaps due to this perception, some students do not challenge the marks they have been awarded: “Nobody ever complains about the marks on a Computer-Aided Assessment, probably because they’re given by a computer” (P6).

Coping with large group sizes

Many lecturers are keen to maintain CAA as it helps with the assessment of large cohorts of students: “CAA testing didn’t come out of a bad intention. It was a drive to make things work for large groups” (P5). However, the consequence of using CAA with large groups is that there are no computer laboratories large enough to accommodate every student: “it’s 200 people. I’m not even sure we have a computer room that big” (P3). For these groups, invigilating the summative test is not possible. Consequently, students have much more freedom over their environment while performing these tests. This is an advantage for some lecturers, since students face many assessments in their first year: “they sort of like doing things in their own time, on the computer, in their own room, or whatever. I think it’s less stressful in many ways than other forms of assessment. And I think the poor first years are so stressed out most of the time that I think to make other forms of coursework that they have a test in . . . would be much more arduous” (P6). However, without invigilation, lecturers cannot be sure how the test was completed: “how do you know who’s done it? How do you know that they’ve done it on their own? How do you know if they’ve copied from somebody else or from the book?” (P1). For the practice tests, most lecturers encourage collaboration. However, university regulations prohibit collaboration in summative testing. There are concerns that some students

continue to collaborate when taking the summative test. Since invigilation is unviable, lecturers are made oblivious to the activities of their students: “To be honest with you, I have no idea” (P2); “I have no idea, I couldn’t tell you” (P3); and, “I have no idea where the answers come from” (P4).

Dealing with issues of CAA

Changing the place of CAA

With the acknowledgement that CAA helps students to learn procedures and methods, some lecturers have made the practice tests available throughout the year so that students can revisit the material and be tested on the content prior to the module exam: “when students have requested having it [*practice tests*] again for revision purposes, that has been done” (P1); “they’re really meant to be a study aid and a ‘Have you really understood things as well as you think you have?’” (P6). Some lecturers are able to invigilate the tests, where groups are smaller. In larger groups, where invigilation is not possible, lecturers have tried to minimise the problem by reducing the contribution that CAA tests have towards a student’s module mark rather than looking for ways to invigilate the tests: “I’m not sufficiently worried about it to really make my own life and theirs much more difficult by starting to run it as an invigilated test” (P3). In that way, students remain sufficiently motivated to use the practice tests and the impact of any cheating is made smaller: “For 2.5%, I just don’t think it’s worth putting up a major police operation to find out what students really do”(P4).

Some modules have been adjusted so that conceptual understanding can be assessed in other ways. One lecturer explained how the introduction of a project has also affected the weighting of CAA in the overall module score: “we actually restructured the whole assessment and reduced the number of CAAs and also the weighting, because the coursework then took that weighting away” (P5). The rebalancing of assessments in modules has enabled lecturers to focus on certain aspects of understanding with each assessment tool. While exams can test recall, procedural and conceptual knowledge, CAA can focus on procedures while other coursework can explore deeper understanding: “[CAA] is quite effective at making sure that they can carry out the procedures. And since I want them to be able to carry out procedures and I want them to be able to do the conceptual things, I just test the procedures through the computer courseworks, and I test the conceptual things through written courseworks” (P6).

Future practice

Lecturers still have certain misgivings about the CAA system, to the extent to which they describe it “antiquated” (P6), “awful” (P4), “a nightmare” (P6) and “poor qual-

ity” (P3), for instance. Other lecturers were less scathing, describing CAA as “good” (P5).

There is a general consensus that further change to practice and assessment structure is not necessary. However, it appears that the focus of change would be of the system, rather than of practice: “I guess it’s only a matter of time before we get some other kind of system, which will undoubtedly do some things better” (P3). Such a change would be an upheaval (“I think that the change to the system is not something that can be made at a single course level, because there are other modules that use the system” (P6)), and thus changing the system requires a carefully made decision: “a number of people in the department are looking at alternative software that we might want to use. So far, they haven’t come up with a decision” (P4).

21.5 Discussion, Learning and Impact

Our questionnaire and follow-up interviews show a number of issues that lecturers face when using CAA.

Lecturers have to deal with these and decide if the advantages that CAA gives are greater than the disadvantages. Obviously, the fact that a considerable number of lecturers are still using CAA shows that they think CAA is somehow useful in assessing their students’ mathematical learning (or some aspect of it). Some of these lecturers have to make compromises, at least until something “better” comes along. In making these compromises, they have sought to minimise the disadvantages by reducing the contribution that CAA tests have in the overall assessment scheme. Also, if CAA only tests procedural understanding, then conceptual understanding can be tested through other means, for example, a project. Some of these lecturers have also made available to students the practice tests throughout the year in the hope that students will use them as a complement to their studies and not only as a vehicle to get a “good” mark in the exam. One thing that was clear from the data was that lecturers are very aware of the downfalls of CAA and, whilst trying to minimise these, they would welcome a simpler, more effective system that takes into account the advantages that the current system gives but also addresses some of the issues presented here.

References

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