Evaluating the Costs and Benefits of changing to CAA

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Abstract

This paper investigates the introduction of Computer Assisted Assessment (**CAA**) into a **Mathematics** course that was already being delivered using Computer Aided Learning (**CAL**). It shows that this method of assessment can reduce, quite dramatically, the hours spent by staff on setting and marking examination papers. It can also provide **cost gains** to the institution by improving **retention rate** and allowing students to join a course without having gained the usual prerequisite qualifications. It allows students from **diverse backgrounds** to complete a course at their own pace. By setting more short assessments that are topic related, the students cannot miss out difficult topics and have to gain a pass in them all. A survey of the students found that the majority of them preferred this method of assessment to traditional exams.

Background

The Bachelor of Technological Education (BTechEd) Degree produces teachers to teach Craft and Design, Graphic Communication and Technological Studies in Scottish schools (Doughty 1998). During the four year honours degree course, students learn the three subjects they have to teach well beyond school level. They learn about the professional and educational background to teaching and spend twenty six weeks on school experience. Those students with no industrial or commercial background, including all students entering directly from school, spend six weeks on industrial placement.

Students are accepted from a wide variety of backgrounds, from school leavers to mature students from all walks of life, so the experience and entrance qualifications of the first year cohort is very diverse. Entrance requirements are Scottish Higher Grade or equivalent in English, Maths and a Science or Technology subject. However, we accept many other qualifications such as National Certificate (NC), Higher National Certificate (HNC), Higher National Diploma (HND), City and Guilds, thus the maths qualification is varied ranging from the Scottish Higher to a variety of continuously assessed modules.

Students are required to demonstrate a reasonable mathematical ability, firstly to complete the technological elements of the degree course and secondly to enable them to use maths accurately when teaching technology in schools. We find that all students entering the course have gaps in their mathematical knowledge, especially those with other qualifications. The latter students have often demonstrate other aptitudes, such as craft or design skills, these being very important for the job, and we do not wish to turn them away from the course.

This means that the students joining the first year of the BTechEd degree have a vast range of skills, and they must all complete and pass the first year maths course. The course itself does not go much beyond the Scottish Higher level but, with the introduction of CAA, its requirements are much tighter so the students have to tackle all the topics as they are tested on each of the topics individually. They cannot leave out anything that they find difficult or do not understand.

Development of the course

Over the past thirteen years the maths course has been taught in several ways, finally adopting Computer Aided Learning (CAL) in 1995. Originally a three year course, it was gradually reduced to one year because of continuing pressure to reduce contact hours and so all irrelevant topics have been removed. Due to a change in partner institution delivering the education part of the degree, who also taught the maths on the degree, a radical rethink in delivery was required, one that did not put too heavy a burden on teaching staff. The new institution was no longer going to teach the maths. CAL was opted for using the programme **CALMAT** (**C**omputer **A**ided **L**earning in **MAT**hematics produced by Glasgow Caledonian University) (Cook 1994, 1995, Tabor 1993) with supplemental use of textbooks and worksheets (Pollock 1996, Doughty 1997).

Course Delivery (CAL)

The class was run in one block of three hours per week over 25 weeks. In session 1995/96 there was no lecture or tutorial input and students were helped on an individual basis. This resulted in a pass rate of 81%. In the following sessions set lecture/tutorials were run alongside the students work time and the pass rate was increased to an average of over 95% (taken over the last four years). This meant slipping back to using lectures as well as CAL. Students were encouraged to buy a copy of CALMAT and use it to study at home if they had access to a PC. This option was taken up by many students, particularly those who were struggling with their maths, giving them unlimited access to the teaching programme.

With the introduction of CAA in 1999, the class delivery is now back again to three hour sessions on the computer with students getting individual help and no lecture input. They can take breaks as often as they like during this time, but they are required to complete their assessments in the timetabled sessions.

Assessment

Before the introduction of the CAA, the main tool of delivery for the course was computer, but the assessment remained as traditional examinations. There was one class exam before Christmas, one class exam after Easter, a degree exam in June and an opportunity to resit in August. Students whose aggregate score for the two class exams was 60% or above were exempt the degree exam. Students who failed the degree exam were offered a further resit.

The time taken for the lecturer to prepare and mark the four exams for about 30 students took around 60 hours (see table). The first class exam was always a mixture of multiple choice questions and short standard questions which took considerable time to prepare but was reasonably quick to mark. The second class exam was a standard examination with 10 long questions and no choice. The two degree exams followed the same format as the second class exam. These exams took less time to prepare but longer to mark. As the pass mark for progression to the next year of the degree is only 30% and the pass mark for the course is 40% students could avoid topics they found difficult or were unsure of.

The following table shows the time spent setting and marking traditional exams and also the total time spent by students sitting these exams. Class exams were sat within class time, but degree exams take place outside class time. These figures were obtained by lecturer estimates of the time spent setting exams and students sitting assessments.

	Class Exam 1 40MCQs+10shortQs 10min/student	Class Exam 2 10 Long Qs 20min/student	Degree Exam Main (50%students) 10 Long Qs 20min/student	Degree Exam Resit (10%students) 10 Long Qs 20min/student	TOTAL TIME HRS
Setting Time Fixed (hrs)	10	5	5	5	25
Invigilation Time Fixed (hrs)	3	3	3	3	12
Marking Time (hrs) 30 students	5	10	5	1	21
Marking Time (hrs) 50 students	8.33	16.67	8.33	1.67	35
TOTAL Students Hours 30 students	90	90	45	9	234
TOTAL Students Hours 50 students	150	150	75	15	390
TOTAL Staff Hours 30 students	18	18	13	9	58
TOTAL Staff Hours 50 students	21.33	24.67	16.33	9.67	72

In session 1999/2000 the assessment was changed from the classical method of examination to CAA. A set of nine assessments, each on a different topic, were developed and the students sat an assessment when they felt ready. Each assessment normally consists of 10 questions (two having only five questions) and they were set up using **TASMAT** (**T**utorial and **AS**sessment in **MAT**hematics), CALMAT's own tutorial and assessment system. No special time was set aside for the students to sit an assessment, as they were to be completed during the timetabled hours, at the students own pace. It was difficult for the students to cheat as the questions were presented in a different order to each of them and the numbers within individual questions were randomly generated. Other students in the class were too busy with their own work to help a student sitting an assessment, and there was always a tutor present to check on progress.

The lecture/tutorials were no longer run or necessary because the students could tackle each test as a tutorial first before attempting the test. The tutor and lecturer spent their time giving individual help to students as they needed it. This also meant that students within the class were tackling different topics at different times and again this reduced the scope for cheating. Since the introduction of CAA students could no longer avoid topics that they were unsure of but needed to tackle all to a certain level.

Student Feedback

Students were given a questionnaire to allow them to express their thoughts about this method of assessment, especially as a comparison with classical examinations which they have all experienced at some time. In fact two students on the course were repeating it from last year as failures, and both preferred this method of assessment to the examinations they had last year. Of the 29 students on the course 20 returned the questionnaire and of that number 16 preferred CAA to traditional exams. A selection of student responses to questions follow.

The responses of the four students who said they preferred traditional exams to the question “If you prefer traditional exams please give your reasons” were:-

> *Traditional teaching with textbook reference, You can’t ask a computer questions - its hard for the teacher to provide explanations due to the fact that everyone’s at different stages and maybe their mind is not as focussed as it would be if the class as a whole were tackling the same topics.*
>
> *The points system is totally based on the final answer with the computers and not on the actual method of how you gained the final answer.*
>
> *You can work for them at home.*
>
> *On the computer I tended to forget how to go about the questions after a lack of revision This does not tend to happen when revising for an exam, but I believe there is an awful lot of material in the Higher Maths course.*

Some of the responses to the question “If you prefer the Computer Assisted Assessment please give your reasons” were as follows (number of students who made similar comment are in brackets):-

> *More organised, less pressure (+ 9 students), able to work at own pace (+ 5 students).*
>
> *Its simpler and much easier to use (+ 4 students).*

Continual assessment is much less stressful than exams. Takes off a lot of pressure. It allows the student to study techniques with both CAL and books. I found it beneficial as maths has never been my strong subject.

Flexibility and can be done in separate sections instead of all in one go.

From one of the students who preferred traditional exams - *I don't mind this but don't have access to a computer at home.*

The preference from the students seems to be for working at their own pace, and reducing the stress of examinations. In fact, all 20 students said they said they preferred to work at their own pace when questioned about it and some of the comments made were:-

Student who preferred traditional exams - *In that respect I suppose it releases the pressure (+ 6 other students).*

Student who preferred traditional exams – *definitely.*

The best way to learn anything is at your own pace. A subject can be boring if the pace is slow and a fast pace can be complicated to understand.

Ability to cover problem areas in more depth frequently.

Yes, although sometimes I allow too long on one topic.

However, there has to be guidelines so you don't fall too far behind.

Although it does encourage you to be lazy.

You don't miss anything as you go at your own speed.

The recurring theme was that CAA reduces the stress on students. Three students, however, point out that they may spend too long on one area or that it could make them lazy. Certainly, most of the students appeared to have been working steadily through the tests and all have passed the individual tests they have completed. One or two students have completed the whole series.

Towards the end of the first year of using CAA timetabled classes had finished and some students realised that they still had assessments to finish, and there was a last minute rush. This was partly due to classes being missed because of two consecutive Bank Holiday Mondays. Extra time was made available for them to complete the assessments.

We were surprised no student commented on the usefulness of immediate feedback.

All the students liked being able to tackle the assessments as tutorials beforehand. Those students who were struggling with maths spent quite a long time tackling the tutorials and learning from them. Some comments were:-

> *It lets you know if you're ready (+ 7 students).*
>
> *Means more effective learning - find problem areas.*
>
> *This means you can have a go at a similar set of questions as what is in the assessment, so if any problems occur you can go over them again.*
>
> *It gives you a chance to learn or recap on subjects you haven't attempted since school. They are well constructed and a lot of help when going on to do the assessment.*

Students were also asked if they had anything else to say about using CAA.

> *I believe that traditional exams can be used in the computer based assessment system.*
>
> *I think I can perform better with this system of examination.*
>
> *On the down side it has a kind of impersonal feel to it.*
>
> *It works for me. Keep it going.*
>
> *It enables mature students who are not very maths friendly to work at their own pace.*

Evaluating Costs and Benefits

Most aspects of evaluating the costs of introducing and using computers are not particular to Higher Education (Farby 1993), although there are some specific features (Carnoy 1995, Doughty 1998)) and guidelines (HEFCE 1997). "Opportunity cost" should be identified. This considers the cost of a proposed or actual new activity in relation to the cost of any feasible alternative, which may include the traditional method it is intended to replace. The "opportunity cost" is based on the value of the next best alternative action to the one which is chosen. An example of an opportunity cost to a teacher could be their value placed on an afternoon of research which would need to be given up to write CAA questions.

There may be "fixed costs" such as for capital equipment, general software site licences and copyright. There may be "variable costs" - teaching assistant salaries, extra learning software, consumables. Institutional policy may apportion to courses any extra costs of staff training, administration, IT support & maintenance. A department may need to consider "marginal costs", eg the costs of adding more students to an existing course. In many institutions the time of staff with no fixed hours of work is regarded as always available for marginal extra work, in others every hour is jealously costed.

Institutions often consider costs in terms of the "cost per student". This varies with volume of activity (eg between little CAA use to all CAA use), the number of students involved and the phase in the life cycle of a course and of the technology. Estimates are sensitive to time horizons and the rate of change of technology. Computers, networks, buildings and books have different useful lifetimes. Because of rapid technological change there is little time to accumulate reliable predictive data. It is worth considering who pays for changes in teaching and assessment resources - students (who always pay for books, often photocopying, but seldom computers), teaching staff (time, stress, promotion prospects), budget holding units, and central administration's top slicing and pump priming.

Benefits of applying CAA need to be evaluated. Teachers and managers tend to ask for evidence such as peer acceptance, claims by authorities, whether the theory of its use fits their beliefs about learning, if there is widespread adoption by others, and whether there are well conducted and analysed evaluations showing that CAA met the objectives of assessment.

Benefits may be distributed between students, staff and administration. There could be unplanned or unexpected benefits of introducing CAA - change towards more flexible, open learning, ability to provide distance learning, or change to learning objectives.

Alternatives may be compared by expressing benefits in money terms, but it may be enough to estimate benefits on, eg, a 1 - 5 point scale, rather than in money terms. The total score may involve mathematical weighting ("Utility" to economists) of the value of the benefits, although this tends to obscure many complex quality issues.

Costs and Benefits of using TASMAT

The authors quickly considered all possible costs and benefits, and then focused on those which were judged to differ between the status quo and the use of CAA. The analysis presented here is mainly in the form of the differences between the marginal costs and benefits.

There have been no extra costs in introducing TASMAT, because we already lease the CALMAT programme each year for teaching the course, the computers for delivering the course have already been booked, and the salary of the teaching assistant has already been costed.

There are four main benefits to introducing the CAA into the course. Firstly there is the financial benefit to the institution by increasing retention rate and improving access, and also the financial benefit to the student by reducing the total hours spent on assessment. Secondly there is the reduction in time spent by the lecturer on assessment allowing their time to be used more productively. Thirdly there is the benefit to the course itself where the students are now assessed on each topic and they must pass the assessment so all gaps in their knowledge will be plugged. Finally students can tackle the assessments at their own pace so this allows the course to be delivered to a wide variety of students. Also students can get immediate feedback on their progress.

A few drawbacks have appeared all of which have been observed by the students. Some students are spending too long preparing for the assessments and as a result are in danger of not completing them by the end of class time. Extra time was allowed this year, but this will need to be addressed in future. As the students are all working at their own pace they are on different topics and the teaching assistant/lecturer has to be able to switch from one topic to the next quite quickly. Also CAA only marks the final answer, not the working as in traditional exams. This has been addressed by students all using workbooks for the assessments, and if they feel their work is worth some marks for effort, eg they made a silly mistake, extra marks can be given by the lecturer who checks the working.

TASMAT comes with a bank of questions already in the system and you must choose the questions that are the most suitable for your own course. The original setting up time for the assessments took about 10 hours including learning how to use the system and trying some of the questions. Now that this has been done once, the time should be reduced in subsequent years. This is about a sixth of the time taken to set and mark the exam papers for about 30 students. The overall lecturer time saving is more than 50 hours each year. Marking time is reduced to checking student requests.

At present we are increasing our intake and we could be taking up to 50% more students which will make a saving of between 60-70hrs for a member of staff. Thus the time savings are worth at least £1000 to the lecturer (calculated at £20 per hour). The benefits could be much greater if the released time is spent on increasing income to the department.

Students take an average of 45 minutes per assessment and for 30 students sitting 9 assessments this comes to approximately 200 hours. All these assessments are sat during class time so the total saving to the students is about 50 hours giving an earning capacity of £200 (assuming wages of £4 per hour).

Between 2 and 4 students used to fail the course each year and as a result often dropped out of the degree programme, resulting in a loss of income of £16500 per student. If improving the assessment technique leads to a greater retention rate as expected, then the change is also worth about £50000 to the university in student fees over a three year period.

Results from student feedback are so positive especially from students who used to struggle with their maths that the real cost benefit will come from improvements in recruiting and being able to offer greater flexibility to those students who could make a positive contribution to teaching technology with their background, but have not really been able to obtain sufficient maths qualifications to enter the course. They have often gained good qualifications in other areas which will allow them to be given credit for prior learning and time saved could be used to catch up with their maths. This will lead to wider access on the course. Every year we have had to turn students away because of their lack of maths qualifications and this would now enable us to take students in this category. Assuming three students a year this would

provide a cost benefit to the University of £22000 per student or £66000 over a four year period.

An unexpected benefit to introducing CAA has been the ability to set a number of short assessments and by making them topic related students are forced to tackle every topic and cannot miss what they find difficult. They are required to pass each topic. This is more difficult to do with traditional exams unless exams are set in each topic, and this would increase setting and marking time quite dramatically, and also students would no longer be able to work at their own pace.

Conclusion

The introduction of CAA has had a number of positive effects:

- The time spent preparing and marking exams has been reduced to a least a sixth of the original time, and this may be put to more productive use.
- There will be an improvement in retention rate providing a cost benefit to the institution.
- Access to the degree programme can be improved, because students can use time released from other courses, due to prior learning, to spend on maths.
- The course can cope with students from diverse backgrounds as the students can work at their own pace.
- Students on average spend less time on assessment and thus gives them more earning capacity.
- Students can no longer avoid tackling topics they find difficult or they don't understand. They have to gain at least a pass mark in each topic.
- Students get immediate feedback on their results.
- Students prefer to tackle their assessment in this manner.

The main drawbacks appear to be:

- The students can take too long preparing for the assessments and reach the end of the class time without having completed them.
- The lecturers have to move quickly between topics when giving help.
- CAA, at present, only gives credit for the final answer.

Overall the introduction of CAA into the first year maths course has provided real benefits to the staff, students and institution, with few drawbacks, most of which can be overcome.

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