TAKING AN ELECTRONIC MATHEMATICS EXAMINATION FROM HOME: WHAT THE STUDENTS THINK

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ABSTRACT
The Open University's Science department produced a short course in Mathematics. Its aim was to assist science undergraduates in obtaining the key skills required in order to progress through higher level science modules. This course lasted ten weeks. Prompt feedback about the examination results was of prime importance, in order that students may make informed choices about future science module selection. The urgency of posting these examination results prompted the development of the compulsory examinable component being delivered online, via a website. This in itself is not novel, but what is innovative, is the fact that students were given feedback if they could not solve the problems. Making use of this feedback resulted in marks being deducted. For example, if a question was answered immediately correctly then full marks were awarded. If the question was answered using only one lot of feedback, then one mark was deducted and so on. Altogether only three lots of feedback were permitted per question. This paper discusses the findings from both questionnaires and telephone interviews conducted with the first tranche of students who sat the electronic examination. The students' perceptions of the examination process were analysed, together with their usage of the feedback support system. The usability and upload time for submission is also reported. These factors are also discussed with respect to interface and question design, together with the feedback structure. These findings will assist the construction of a set of recommendations regarding the development of electronic examination systems. More importantly, if electronic examinations are to be used for distance education students, then the nature of the feedback given to students about their actions in such environments deserves careful consideration.

KEYWORDS
Online examination, feedback, mathematics for science, evaluation

INTRODUCTION

The implementation of computer assisted summative assessment is being investigated at both school and university level in the United Kingdom. In fact a paper-less examinations project is being conducted by CCEA (The Northern Ireland Council for the Curriculum, Examinations and Assessment) and Edexcel (one of school examinations boards for England and Wales), to deliver school examinations online. The two main advantages of administering examinations in this way which are cited by this project are the processing of the examinations and the nature of the examination itself. The processing is quicker and more efficient but also the data on candidate responses can be held on the computer item by item. This can lead to a much more detailed feedback on question performance. An argument proposed by Shermis et al (2001).

The examination too can be improved by taking advantage of the multimedia facilities offered by computers. This in turn would facilitate the inclusion of science experiments being performed, historical figures being interviewed and hence a wider range of skills and knowledge could be assessed than is currently possible under the present examination conditions. This increased interest has been well documented by Bull and McKenna (2000) who also highlights areas that merit further investigation such as the reuse of such questions.

The Open University as a distance learning institution has similar interests in computer assisted assessment and throughout its short history, has embraced the use of new technologies in supporting student learning. Computer marked assignments consisting of multiple choice questions together with tutor marked assignments have provided the core of assessment for our courses for a number of years. There is now a move like the school examination boards towards synchronous examinations and a mock examination was sat by students on a part-time post graduate distance education computing course in 2001 at the Open University. Thomas et al (2002). These researchers have found completing a synchronous examination in their own home can be a positive experience for many students.

Another course at the Open University i.e. The *Maths for Science* curriculum aimed to take Thomas et al findings one step further by offering a web-based examination to students in their own homes one step further by offering immediate feedback and assistance to students when they submit their individual answers to the set questions. This system drew on the findings from the interactive self-assessment questions initially devised for an undergraduate science course, Discovering Science' (Whitelock 1998), which offered differing levels of feedback when the student could not answer a given question. For a similar finding from a mathematics context, see Pitcher et al (2002). The *Maths for Science* system differed in that it provided immediate structured feedback (based on the notions of scaffolded learning as proposed by Vygotsky) to the student, but did not tell them the marks allocated for their response. This was only be revealed at the end of the online test.

The *Maths for Science* system was built to deduct marks according to the amount of feedback given when answering a question. It was anticipated that the provision of partial marks for second and third attempts would encourage students to attempt questions that they might otherwise have ignored through lack of confidence or incomplete knowledge. Again, at its simplest the system would award 100% of the marks for a question to students who answered correctly on their first attempt, 65% of the marks to students whose first attempt was wrong and who received feedback that helped them answer correctly on their second attempt, and 35% to students whose first two answers were wrong but who answered correctly on their third attempt after receiving feedback twice. All students received final feedback explaining the correct solution to the question.

The feedback included in the system is relevant to both student learning and the grading process. The proposed system for *Maths for Science* integrates the assessment into the teaching and learning feedback loop, which provides a new level of discourse advocated in Laurillard's teaching model. (Laurillard 1993)

Maths for Science is a short course worth then credits, as opposed to a long course which is worth sixty credits. In order to achieve a degree with honours at the Open University a student must achieve three-hundred and sixty credits. *Maths for Science* was designed to prepare students to achieve a required mathematics standard in algebra in order to progress in their further science studies. The maintenance of short courses is a resource heavy exercise, and online delivery would potentially help to cut down on the amount of human resource time required to process results and awards. Unlike long Open University courses short courses are intended for students to enhance their own study skills in particular areas, and therefore no benefit would be gained from cheating.

The purpose of the study reported in this paper was to discover whether the *Maths for Science* online examinations were successful in terms of providing a usable and acceptable assessment procedure for students and that this modus operandi, which provided a practice examination environment with detailed feedback, supported the learning experience.
Therefore the investigation set out to understand the following factors:

- Issues relating to the usability and therefore validity of the online examination environment.
- Students' keep toward the administration of online examining and their resulting study strategies.
- Recommendations for the design and implementation of future online examination environments with respect to sustaining student confidence in the examination system and their own mathematical ability.

THE MATHS FOR SCIENCE COURSE AND EXAMINATION

All students on this *Maths for Science* course were studying at a distance with a set of structured course materials. They had no tutorial support. These materials were sent in August 2002. This course material 'pack' comprised of a CD-ROM containing the Java software required to run the online examination application, hardcopies of directions for installing the software, and instructions for accessing and completing the online examination. Also included were the main text *Maths for Science* book, the Study guide, Supplementary Question Books 1 and 2, the Course Handbook, and details of the telephone advice line service. The main topic the students were studying was Algebra. They were required to practice the manipulation of equations in similar operations that would be required for scientific calculations. They were also trained to express both large and small numbers to the power of ten, together with re-expressing answers with respect to a range of significant figures. These being the skills the students needed to progress with their undergraduate Science studies.

The *Maths for Science* online examination software was designed to be used by students in their own home via the Internet. A Java framework was used to develop the questions with added communications. JRE v1.3 was deployed and only one browser was supported and that was Internet Explorer. The students were given access to two web based examinations, a 'practice' examination, and an 'End of Course Assessment' (ECA). The ECA formed the examinable component of the course. The practice assessment examination website was available for the duration of the course which started in September 2002 and lasted until November 2002. The real examination was available between 18 October and 12 November as shown in figure 1.

The practice assessment was available for the duration of the course, and the ECA was accessible for a period of two weeks toward the end of the course presentation period. During this two-week period the students were allowed to access the ECA online. Both examinations comprised of forty one maths questions that spanned ten 'chapters' of the set course text.

The score obtained from the ECA determined whether the student passed or failed the course. This in turn would make a difference to the science courses they could select for future study. The students' aim was to rehearse with the practice examination for as many times as they wished. They were then restricted to only one attempt at the final ECA. For both the practice and the final examination the format was identical. This meant that three attempts were permitted for each question before the correct answer was given.

Potentially three separate sets of feedback would have appeared on the screen if the question was continually answered unsuccessfully. If the student typed in the correct answer then the onscreen feedback stated that the answer submitted was correct and the student was then allowed to go on to the next question. The examination also allowed the student to 'pass' on a question in order to move on to the next question, in which case marks were lost for the unanswered question. Unfortunately this version of the examination did not allow candidates to return later to a passed question.

THE ONLINE EXAMINATION

The *Maths for Science* homepage which was accessed via the student's web browser was the student's first encounter with the online examination environment. It gave the student access to the practice examination and the 'end of course assessment' examination when it became available. This page also provided up to the minute information about any developments within the implementation of the course for the duration of its presentation.

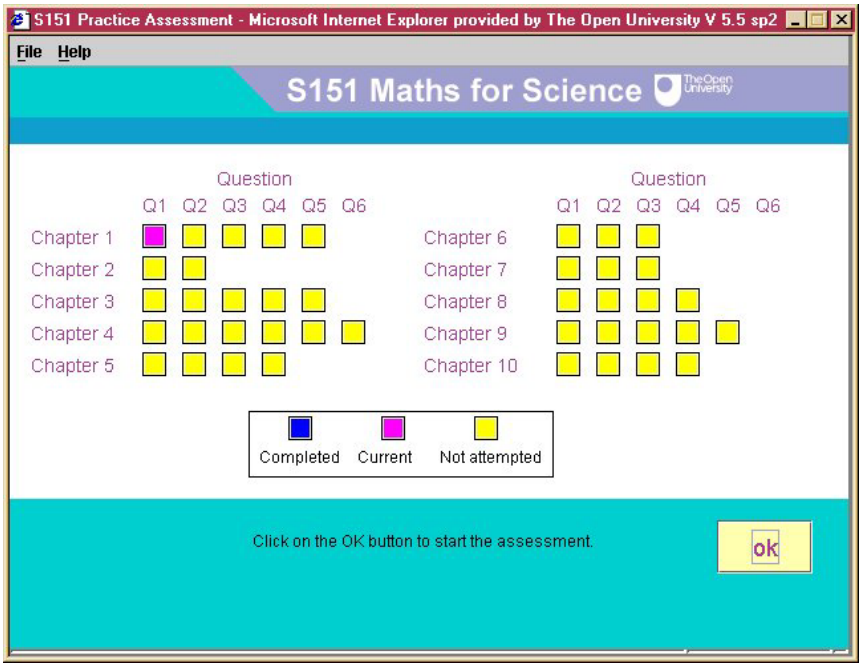

Figure 1. Practice Assessment entry page

Once the student decided to enter the practice assessment from the courses homepage, the screen in figure 1 appeared. This screen displayed a record of which questions the student completed or attempted. It therefore provided a record of work completed to date. The student could enter the practice examination as many times as desired. However, all the questions could only be accessed in a linear sequence which meant that the student must finish the examination before s/he could return to the beginning. They were then permitted to work through the sequence again. When a question was answered for the first time incorrectly then the student was told quite simply that they were wrong. A message appeared stating 'Your answer is incorrect'.

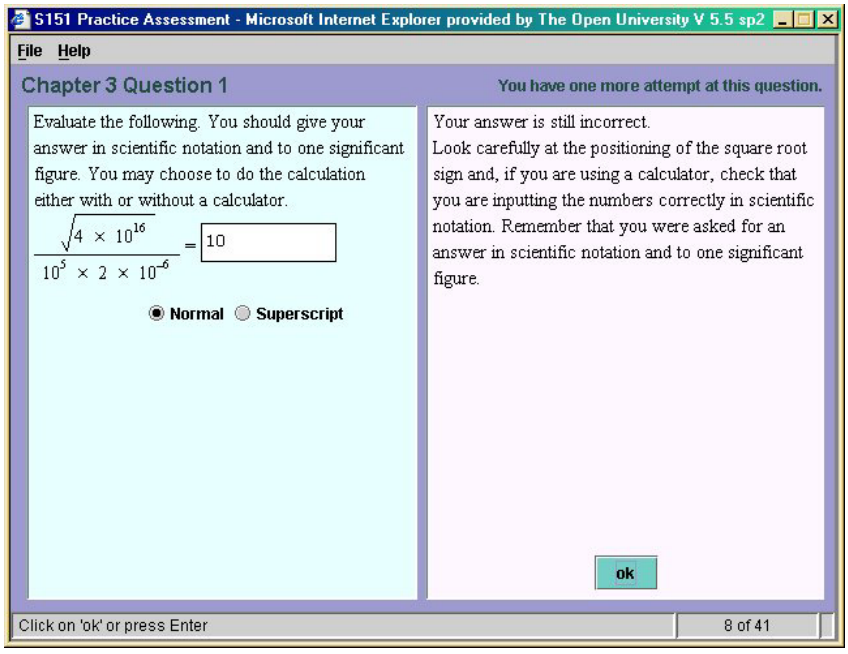

Figure 2. Chapter 3, Question 1, second attempt feedback

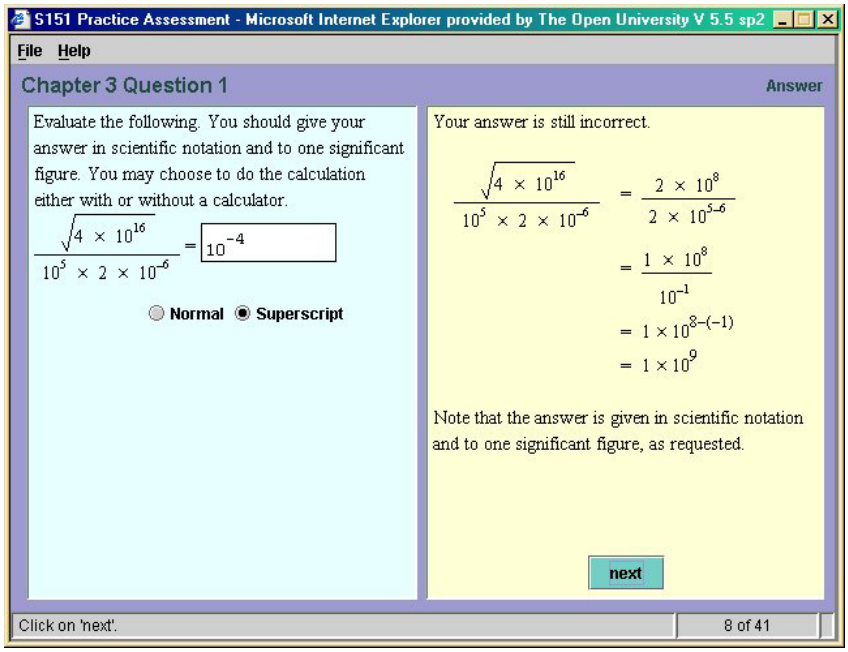

Figure 3. Chapter 3, Question 1, second attempt feedback

Upon the submission of a second wrong answer, the student was given feedback so that they could revise their response as shown in figure 2. Hence the students received a text message similar to the one below:
'Look carefully at the positioning of the square root sign and, if you are a calculator, check that you inputting the numbers correctly in scientific notation. Remember that you were asked for an answer in scientific notation and to one significant figure.'

If the question was answered incorrectly for the third time, then the student was told that their answer is incorrect and the correct solution was displayed. See figure 3. At the end of the assessment, a screen stating the student's score and the breakdown of that score with relation to the number of attempts at the questions appeared. A synopsis of the student scores and the questions attempted was displayed instantaneously at the end of the examination. For the final examination, three types of feedback were possible but students could not go back and repeat any of the questions.

THE PARTICIPANTS

This study involved selecting a sample of students from the first presentation of the *Maths for Science* course which commenced in September 2002. This sample was selected from all areas across the United Kingdom and represented a typical cross-section of students at this level of study with the Open University. In fact one-hundred and ten potential volunteers from two-hundred and thirty nine students were contacted. An invitation to participate in this investigation was sent out to this group via email, and sixteen students volunteered to participate in this study.

The entry requirements for this course made it compulsory for all participants to have access to a Pentium III 450MHz processor or its equivalent. The data from the questionnaire provided information about the students' computer specifications, their perceptions of their own ability in mathematics and their familiarity with the Internet and online security issues.

It was made clear to prospective students that the examination was to be taken online and in the students' own homes. The practice examination was available from the start of the course and students were expected to spend up to ten hours on this. When the ECA became available students could complete it in one or more sittings but no questions could be repeated or reworked. Missed questions

could not be reattempted. It was anticipated that competent students would take up to two and a half hours to finish if everything was completed in one session.

RESEARCH METHOD

Two different research tools were used to understand both usability and work practice issues that arose when students completed this course of study and examination in their own homes. These tools comprised of a questionnaire, administered by email and a follow up telephone interview.

The questionnaire was designed to elicit background information about the students' experience of both the subject matter they were studying and their experience of computer use together with the specification of their machines. These questions were asked because these could all be factors that impinge upon the speed of delivery of the examination and the students' ability to deal with unexpected events together with their confidence in their mathematical ability.

The above data could more conveniently be collected and analysed from an online questionnaire however, information with respect to the topics listed below was more effectively gathered via a telephone interview. The interview was designed to elicit the students' experience of:
The practicalities associated with taking online examinations in the home
How the practice system influenced their preparation for the real examination
The participants' confidence in the system

The course started in September 2002 and the questionnaires were returned mid November 2002, while the telephone interviews were completed by 25 November 2002.

RESULTS

Findings from the questionnaires that had been sent out to the participating students revealed that the eight students who submitted the ECA described themselves as 'average' or 'quite confident' in mathematics. The remaining eight students who did not submit their ECAs described themselves as 'average' or 'not confident' in mathematics. The finding suggests that the students' confidence level was a factor in deciding whether they submitted the online ECA or not.
In fact 80% of the students involved in this study had above the minimum specification requirement for a computer on this course, and were working with faster machines than had been specified. All of the students except for one were competent Internet users. Since the students were taking a first level mathematics course in order to acquire a minimum level of mathematics expertise to progress with further science studies, there was more variation in their levels of mathematical skill.
To summarise this group of students were all competent computer and Internet users. They should therefore be able to tackle any software implementation problems but would provide a more varied response to the examination of their mathematics knowledge in this format as their background experience in this area was more variable.

The telephone interview responses provided information on three key areas under investigation. These were:
Accessing and running the system
An examination of whether the students could download and interact with the examination materials over the period of time during which the examination was available.
Student Experience
An investigation of the strategies adopted by the students in whilst working through the course materials and the online examinations.
Feedback
Did the online feedback during the examination assist them in developing and demonstrating their mathematical abilities?

ACCESSING AND RUNNING THE SYSTEM

In a conventional paper based examination students work through the paper in one invigilated session. They can go back and check through their work, or attempt the questions in any order. In the *Maths for Science* online examination however, the students could complete the examination over a number of session which meant they could go in and out of the examination environment at will. They did however have to answer the questions in a preordained linear order. They needed to be aware of these changes and the course materials were designed to do this. There is evidence that over half the students tried to prepare in this way.

These eager students relied heavily on the arrival of the printed support material to advise them on what to expect. The following comment reveals one student's approach to utilising printed support material:
When I started the course I actually read all the information… because I read this a month previously I'd actually forgotten the information when the tests came online. So it was a case of remembering what to do. I believe it was in the introductory phase where the ECA was actually covered and in the first couple of weeks you read all the introductory information about what exactly you need to do and the aim of the course etc.

Their work with the practice examination revealed to them the differences between online and written examinations. The following student was concerned about not being able to have continued access to the rubric for the examination.

When you sit in an exam room you get yourself all psyched up for doing the exam. You think about what you have done and you doubt yourself and lose all your confidence. With a paper exam you're able to look at the front of the exam paper throughout the exam and see what the guidelines are and the regulations and of course you can't in [an online] test like this.

There should therefore be a set of examination instructions that can be accessed throughout the final examination, i.e. the E.C.A. as and when required. This study also investigated the students' views on whether the online examination enabled them to develop and demonstrate their full abilities. Some students lost faith in their ability as a result of the navigational and submission systems and some found difficulty in coping with the fundamental differences between online tests and written tests.

The above examples illustrate some of the difficulties encountered with adapting to a new type of examination. However over half of the students prepared early enough to sort out any problems and dealt with their misconceptions satisfactorily. Missing a question by mistake caused some problems and the software needs to be changed to deal with this difficulty. The recommendation is that there should be included in a new version of the system a message which asks you again if you mean to miss a question just in case a student pressed this button by mistake. Students acknowledged they did not feel the adrenalin rush when they took the examination and because they were not with colleagues the experience was not the same. The interesting finding was that they did feel less distressed and more relaxed sitting the final examination.

STUDENT EXPERIENCE

This was typical of over half the students from this group who read through their materials before the course.

The practice examination was designed to familiarise students with the online examination environment, and to give students an opportunity to test themselves on this environment before commencing the final ECA. Some students however were more instrumental in their approach to using the practice examination and they did it straight away in order to gauge their ability and inform their revision strategy before working through the course materials. The following quote states how one student used the course materials in tandem with the online practice examination:

The first couple of times I did the practice assessment on the computer I did it in blocks. I did sections then worked through another model and then went back and did a bit more. I learned from the questions more about what they were asking, and took note of that… Before I did the actual assessment, I did the practice one three times straight off, and each time I did it and I got the feedback I wrote down the areas that I was weak on. This was because it gives you feedback at the end the questions you wrote the first, second and third time and I took note of this so that I knew the weak spots and then I worked harder on those bits before I did the end of course assessment. I found this approach really useful.

Everybody used the practice assessment examination apart from one student who said:

I didn't [complete the practice examination] because I'm fine on doing the second one [the ECA]. I have had a look at it. I attempted one or two and decided I'd leave it and do more work. To be honest I hadn't done enough work on the course itself. It made me realise how much more work I had to do. It highlighted problem areas if you like that I needed to concentrate on.

As this short course was taken without tutorial support, the feedback from the practice test was invaluable to students. In fact the interviews revealed three different student strategies for preparing for the online examination.

Strategy number 1 as shown in figure 4 below illustrates how students worked through a chapter of the printed course text book then attempted a chapter on the practice examination. The next chapter in the printed text was studied and the questions from the practice examination attempted and so on. When students who had adopted this strategy went on to attempt the ECA, they referred to the printed text upon receiving feedback and then returned to the ECA once again. These students checked their workings with the printed text in case similar questions appeared further on in the ECA, or where a similar mathematical procedure was required.

Strategy number 2 (see figure 4 below) illustrates how students referred to the printed text material first. They then attempted the practice assessment, and finally went on to use the ECA in almost linear fashion. These students may have referred to their printed text in between attempting the practice examination and the ECA, however they only used the practice examination once in order to familiarise themselves with the online examination environment.

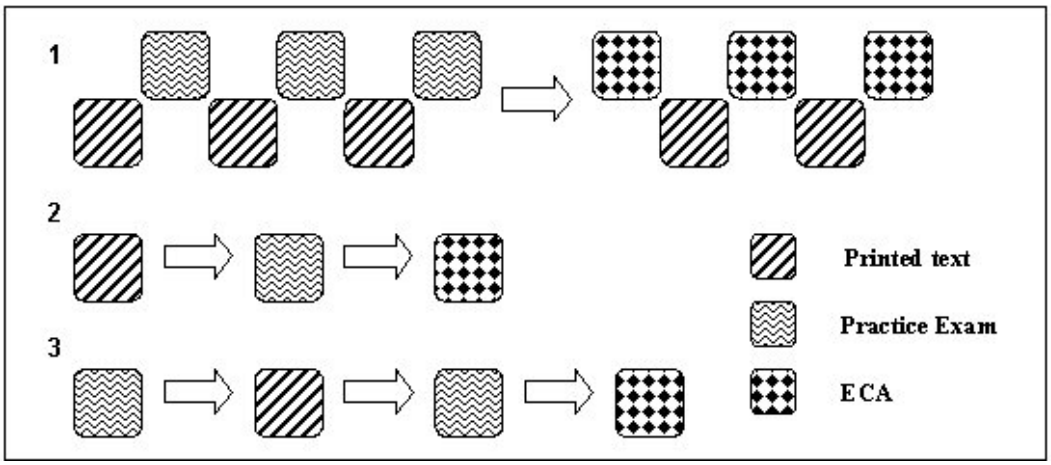

Figure 4. Student strategies for using the online examinations

Strategy number 3 (again see figure 4 above) illustrates how students used the practice examination in order to gauge their current mathematical knowledge, before reading the printed text in order to revise areas which they identified as being weak. These students then attempted the practice assessment once again to make sure they had improved upon their previous score in the areas where they had experienced previous difficulties. They then went on to attempt the ECA.

Students acknowledged changes in their confidence levels as they worked through the tests and on the whole found the feedback very useful. They did not attempt the ECA until they felt confident and some did not reach this condition and take the final ECA. They deferred until the next available online examination which was scheduled to be accessible in January 2003. (See section 'The students' Examination results'. Their expectations during the ECA were based upon their experiences during the practice test. Comments such as the following were made:

I think the actual major worry was pressing the button to submit. And then when you got the feedback you thought 'Oh yes that was stupid why did I do that' or you thought 'ah, I should have done it that way that's what they're actually asking me for'. So the feedback was actually very good because I think there was only question where I got it totally wrong on the practice assessment. Whereas the other ones I thought 'Yes, I know what they're saying now so I can do this' and then I got it right. So the feedback was very good I thought.

The practicalities of using the electronic examination were sorted quickly by three quarters of the sample and so confidence in the examination system doing what it said it would do increased. However the pedagogical changes made with this type of examination that included student feedback on their responses, proved to be an important pedagogical asset. The structure of the course with this practice examination affected the students' decisions about when to take the final examination. Half of the sample interviewed deferred taking this ECA until January 2003. The reasons for this surprising finding are discussed after the following section which reports about the nature of the feedback given to the students.

FEEDBACK

Support during the course essentially came from three sources; the telephone 'helpline', the accompanying documentation and texts, and the on-screen instructions. All students commented that these materials were helpful but their preconceptions were the main problem. They read into the Instructions what they believed to be the case and so only really understood when they experienced the practice examination.

In order to take the tests the students had to follow instructions on how to navigate around the test environments, how to answer the questions, and how to submit their answers. Students sought on-screen support and confirmation of the submission of their answer before going on to the next question. Interview discussions on usability revealed concerns about the framing of information on-screen in terms of what had been expressed 'implicitly' as opposed to what had been expressed 'explicitly'. Comments such as the following were made:

Rather than the word 'pass' there should be another word used …. Or perhaps the word 'pass' should be more clearly defined on the screen for people like me who haven't read the book in depth, I haven't checked to see if it is stressed in any of the handbooks… say if there [had been] a note on the screen saying 'if you press this button you will lose all your marks for this question' or words to that effect, then that perhaps would have stopped me from accidentally skipping a question and losing marks.

Three quarters of the students commented favourably about the feedback given during the course of the electronic examination. In fact it affected their learning strategies (as described in the previous Section, namely 'Student Experience' and their confidence in their own mathematical abilities. One student thought the examination would be a more straightforward multiple choice set of responses. They were delighted with this particular format and state clearly below that it helped them to understand the subject matter better.

I was expecting a multiple choice type of exam, however, with [the practice examination] being more about working out values and putting the correct answer, I thought it was better and it helped to demonstrate the mathematics enabling me to understand it better.

The mistakes students made in typing in their answers i.e. with respect to superscripts, is a common mistake even with paper and pencil examinations. The feedback given by the computer did, however, support them.

I found the feedback useful yes. I made silly mistakes it was quite hard, because I was concentrating on the answer so much that sometimes I omitted the superscript. I wasn't clear about that, but I did grasp it quickly thereafter.

Although the mathematical feedback has been demonstrated to shape the students learning strategies and they were very positive about it, when asked about what changes they would make to the system, they would have liked more feedback from the first incorrect submitted answer. In fact one student states:

The only thing about the feedback, it didn't seem to be very progressive. In so far as the first lot, it would just say you got something wrong.

To summarise, the feedback given to the students about their mathematical progress was valued and shaped their learning strategies. They also stated that it helped them to understand the subject matter better. However confidence in the examination reaching the University when it was finished was in fact a worry. The students would have liked a message stating that it had been received. This is a relatively trivial matter to correct from the software designer's point of view but essential to the students' perceptions of the validity and hence confidence in this type of examination system.

THE STUDENTS' FINAL RESULTS

Eight students out of the sixteen who participated in this evaluation submitted their ECA examinations. Seven of these obtained very high passes and only one student failed. The remaining eight students decided not to submit until the January examination. It was possible to employ this strategy without detriment to starting their next set of science courses because the academic year in the OU does not start until February. It is only then that these students would start the next phase of their undergraduate Science studies. The interview sessions revealed that the students with the weakest mathematical background decided to wait until January 2003 in order to improve and practice their mathematical skills.

Two of these students were very nervous, started the final examination and in the end did not submit because they pressed the 'pass' button by mistake. This meant they could not repeat that question and would automatically reduce their score through omission. One student said:

I just went on and did it and then the first question pressed the wrong button, so that was the end of that really. I didn't see the point in continuing, I considered it, but I know I had one question wrong already to simply press the pass button I didn't think and I wasn't necessarily confident that I would get everything else right in account of that. So I preferred to leave it really.

One student misinterpreted the actualities of the examination format. He thought it was a 'print out and send back' system despite very clear instructions that the examination was web based. This student did not have a computer at home and thought he could print out the examination; work with paper and pencil, and post his results back to the university. He said:

I read about the course and it said that the assignment had to be taken from the Internet. I just assumed being a maths course, it was just a download of pieces of paper and that I would fill in that assignment

and post it off as normal. I thought it was just a way of cutting down on paper-work and postage for yourselves because I automatically assumed that being a Maths course there would be marks, and usually with mathematics it's not necessarily the right answer that gets you the marks but also It's how you got there. This is why I assumed it would be a paper download.

The above scenario caused some problems as the student could not access the Internet at his place of work either because of the company firewalls. This is an important consideration for students who are travelling for their employers and intend using their laptop to take the examination abroad.

The majority of the students who took part in the evaluation were familiar with the format of the Open University system having studied previous courses. There were two main reasons for these weaker students not submitting in November 2002; the first reason being a lack of time to study to the required level of competence to pass the examination. This is an interesting finding which, because of the nature of the feedback given in the practice examination, made this type of information more explicit to the students. The second reason was that two of them experienced certain technical difficulties during the installation of the Java software which was sent to them via a CD-ROM. These latter students contacted the telephone help-desk at the Open University and then their Java software installation problems were quickly remedied by the help-desk staff.

A quarter of the sample interviewed experienced some problems due to differences with their Internet Service Providers. However they got to solve these problems as shown below by (a) logging on at a quiet time and (b) switching from using an external modem to a computer with a built in modem.

I had a couple of problems during the practice assessment, slow servers and things like that. But I did the ECA at nine o'clock at night something like that so the connection was really quite quick. [So what time during the day did you do the practice assessment?] Saturday afternoon. I think it was more connections through my server rather than the OU end of things actually. My server tends to be a bit slow during the weekend.

When I first tried to set it up I was actually using a dial up modem and of course I kept being cut off and it was a bit of a nightmare to be honest. Then I switched to ADSL and that was a lot quicker and you didn't have to worry about being cut off and I must admit it made the process a lot easier.

Some problems with the Internet Service Provider however could not be resolved and this was the main reason for them not taking the final examination. One student said:

The computer is playing up, telephones calls to the provider are unanswered, Freeserve does not connect to the OU Practice Assessment site etc. Disheartened!

These findings indicate the success of the pedagogical feedback given to students since it made them realise that they needed more time to study before they took the final examination. However there can be real technical difficulties with the range of Internet Service Providers and further research needs to be completed in order to solve these particular problems.

DISCUSSION

All the students were willing and able to take a University examination electronically in their own home. As is the case with any new system especially one where the format is very different from any other type of examination the students had previously taken, there are inevitable teething problems. The biggest one was the students own misconceptions about how they thought the system would work. These particular difficulties were mainly overcome by the course printed materials that were sent to the students before the course started. They were also given the opportunity to repeat as many times as they wished the practice assessment. The technical difficulties that were experienced on this front were sorted out by the Open University online help-desk; however, certain problems with individual Internet

Service Providers did raise some issues that merit further investigation. In essence the continuous feedback from the University to the student when they answered a question was successful and there were no substantial complaints about time lag. Where one particular extensive delay occurred, the student logged on to his Internet Provider at a non-busy time. This small-scale study suggests that examinations of this nature are technically feasible and would be welcomed by competent Web users.

One of the most important findings from this study is about how the practice examination with its feedback system, structured the students' learning strategies. For the Open University this was a very short course for students to improve their mathematical skills and would study Science as their main subject. It would not be feasible to offer face to face tutorial support for such a short course but, as with all our text based distance learning materials, they have been written to be followed independently without tutorial support. This finding illustrates that the feedback given by the electronic system encouraged students to apply themselves diligently and with best effect to their studies. They were more able to gauge their level of competence in this mathematical subject and used this knowledge to best effect when deciding which date to sit the examination. In fact this pedagogical process afforded more control to the student and did not force them to go to an examination centre to sit an examination which they knew they would fail. The flexibility that this new method of examination offers the distance learner was indeed commended by the students.

The adoption of a suitable learning strategy not only raised student awareness of their capabilities, but also increased their confidence in making appropriate decisions about how to continue with their studies. The basic mathematical skills which they wished to master are requirements for both level 2 and 3 Undergraduate Science Courses. The immediacy of the feedback from the examination permitted them to make a more informed choice about how to progress their scientific knowledge at University level. Again, more control was given to the student and this finding needs to be followed up with respect to student drop out rates from courses. It could be hypothesised that key skill courses which need to be passed for future undergraduate study would benefit from the pedagogical strategy employed by this *Maths for Science* course and would lead to a decrease in student drop out rate from further main subject studies. The issue relating to student confidence in their individual answers reaching the University was high as they did receive immediate feedback about each of the questions they submitted. However, they were not sure that when they had finally completed all the questions that the whole examination was finally submitted and received by the examination centre. This latter procedure can be made explicit to the students with a simple message that the completed examination was received by the University.

Future investigations will be carried out to understand the student pattern of final examination submission, together with the primary factors that lead to non-submission. Our main findings are encouraging since students who did experience technical difficulty solved their individual problems and developed effective learning strategies for a topic they all found difficult. However the lack of social and motivational dimensions found in sitting examinations on your own at home merit more research. This, of course, was an open text book examination and the format would not be suitable for the more conventional examinations sat by most undergraduates. One encouraging finding is that a course of this nature can be run without tutorial support and the materials afford students an effective level of control over their studies. It would be of value to study the students working through the practice examination and the final examination in the more naturalistic setting of their own home. We would encourage the use of post hoc interviews with subjects from a larger sample pool about motivational factors and confidence levels in the system in order to make fuller recommendations about design issues related to sitting synchronous electronic examinations from home.

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