Physics Innovations Centre for Excellence in Teaching and Learning

Compilation of final reports on Open University Physics Innovations CETL projects

e-Assessment

Compiled by Sally Jordan

June 2010

Reports from the πCETL e-Assessment Group

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An assessment strategy for the twenty-first century?

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Compilation of papers and reports on Open University piCETL projects: Assessment

Introduction

The papers and reports in this compilation reflect the diversity of work related to assessment that has taken place in the Physics Innovations Centre for Excellence in Teaching and Learning (piCETL) at the Open University. Much of this work has centred around the use of electronically submitted tutor-marked assignments (eTMAs) and interactive computer-marked assignments (iCMAs). A third focus has been on a change in the assessment strategy of our level 3 physics and astronomy modules.

The purpose of this compilation of papers and reports is to share some of our findings. However, rather than just stating conclusions, we wanted to provide ideas and tools that others would be able to adopt for their own use. So, where questionnaires have been used in evaluation, these are included, as is a guide for associate lecturers on marking and commenting on electronically submitted tutor-marked assignments (eTMAs) using a tablet PC (page 32), a guide for students on the use of interactive computer-marked assignments (iCMAs) (page 68) and a guide to good practice in the academic authoring of OpenMark iCMA questions (page 74).

Reviews of the literature (e.g. Black and Wiliam, 1998) have led to the identification of conditions under which assessment appears to support and encourage learning. These have been developed into a number of frameworks to be used by practitioners in developing and auditing assessment practice (e.g. Gibbs and Simpson, 2004; Nicol and McFarlane Dick, 2006). Not surprisingly these frameworks share a number of common themes, linked to assessment's power to engage and motivate students and the role of feedback in helping students to improve. However, the provision of feedback does not in itself lead to learning. Sadler (1989) reports the 'common but puzzling observation that even when teachers provide students with valid and reliable judgments about the quality of their work, improvement does not necessarily follow'. Sadler argues that in order for feedback to be effective, action must be taken to close the gap between the student's current level of understanding and the level expected by the teacher. In taking this view he is aligning himself with Ramaprasad (1983), going beyond a definition of feedback as purely the transmission of information from teacher to learner, to one in which the information must be used to alter the gap. This is in line with the scientific definition of feedback as a cyclical process, in which a change in one parameter leads to a change in the initial conditions.

If students are to be able to act on feedback provided, it needs to reach them quickly. The first two sections of the compilation focus, respectively, on the use of eTMAs and iCMAs, in each case with the intention of enabling students to receive feedback in time for it to be useful. Using eTMAs and iCMAs can also save paper, the administrative costs of manually recording scores, and the inconvenience of posting bundles of paper between the student, tutor, University and back to the student. E-assessment is the natural partner to e-learning, and it is an anachronism to continue to expect students to submit assignments on paper in the 21st Century and in a distance-learning university that is increasingly looking to global markets. Perhaps most significantly, eTMAs are popular with our existing students, with more than 90% of students choosing to submit TMAs by this method when studying the introductory interdisciplinary science module *Exploring Science*, where students can choose to submit either paper or electronic TMAs. However, in Physics and Astronomy and other symbolically-rich disciplines, there are particular challenges in expecting students to prepare their work electronically and expecting associate lecturers to mark and comment on this work also in an electronic format. These difficulties centre around the need to enter equations, graphs and diagrams and, for the associate lecturers, the need to correct work at the place where an error has been made. A number of piCETL projects have led the way in investigating (for tutors) the use of PDF annotator on a Tablet PC, and the loan of a number of tools to assist students with their production of eTMAs.

Interactive computer marked assignments (iCMAs) enable tailored teaching feedback to be provided instantaneously, and students can use this to amend their answer and so to learn. iCMAs have proved popular with students and appear to be effective in increasing retention. Student responses to iCMA questions have been analysed both to study the ways in which students engage with assessment of this type, and to learn more about common student misconceptions. In the case of the analysis of student responses to summative *Maths for Science* iCMA questions, increased understanding of science students' mathematical misconceptions has led to changes in the teaching of basic mathematical skills across a range of modules and to another piCETL resource, the *Maths Skills* ebook (Jordan, 2009).

Assessment has been identified as the 'single biggest influence on how students approach their learning' (Rust et al, 2005). Much has been written about assessment's summative, formative and diagnostic functions, distinguishing 'assessment of learning' from 'assessment for learning' (and, recently, 'assessment as learning'). Some of the distinctions have been blurred throughout the Open University's history, with the grading of and commenting on tutor marked assignments (TMAs) tellingly referred to as 'correspondence tuition', despite the fact that in the past, TMAs have usually contributed to the student's final score. It does not follow that a practice is valid or sustainable just because it has been used for many years and, as Stuart Freake says in the subtitle of the first paper in the fourth section of this compilation, 'the times they are a-changin'. This section describes a move towards an assessment strategy in which summative TMAs are replaced by regular short formative TMAs and iCMAs, with the aim of helping students to pace their learning, freeing staff time to provide direct support for students and allowing modules to be presented more frequently and flexibly without prohibitive additional costs.

The penultimate report in this compilation describes the Physics Assessment Resource, a database of previously used assessment items, designed to facilitate production of similar items in the future. PAR includes details of questions and markschemes. Where questions are in summative use, concern over security currently limits the resource's usefulness. However PAR also provides statistics on question performance and details of problems encountered when a question has been used in the past, so it has great potential as a method for providing better assignments at the same time as saving effort.

The 'Marking on the go' project also arose from a desire to give students accurate and timely feedback, in this case by encouraging tutors at the residential school for SXR208 *Observing the Universe* to record, on a PDA (a hand-held computer), each of their group's performance in the observatory rather than relying on impressionistic marking at the end of the night. This method of recording performance has now been adopted as the norm at all SXR208 residential schools.

This compilation is restricted to piCETL projects whose primary focus is on assessment, but there are links to several other piCETL projects. In particular screencasts of solutions to TMA questions have been produced (Stansfield and Freake, 2008) and associate lecturer time, freed from TMA marking, can be spent in supporting students, perhaps using Elluminate. In addition, assessment has such an important role to play that there is much related work going on in the other Open University Centres for Excellence in Teaching and Learning, and elsewhere. The authors of the reports in this compilation are grateful for the support and encouragement of many people in the Open University Department of Physics and Astronomy, the OpenCETL and especially in piCETL. Funding from piCETL and indirectly from the Higher Education Funding Council for England is also gratefully acknowledged.

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References

Black, P. and William, D. (1998) Assessment and classroom learning, *Assessment in Education*, 5(1):7-74.

Gibbs, G. and Simpson, C. (2004) Conditions under which assessment supports students' learning. *Learning and Teaching in Higher Education,* 1:3-31.

Jordan, S (2009) The *Maths Skills* ebook: final report. *Electronic Resources for Teaching & Learning in Physics and Astronomy, Physics Innovations CETL.*

Nicol, D.J. and Macfarlane-Dick, D. (2006) Formative assessment and self-regulated learning: a model and seven principles of good feedback practice, *Studies in Higher Education,* 31(2):199-218.

Ramaprasad, A. (1983) On the definition of feedback, *Behavioral Science*, 28:4-13.

Rust, C., O'Donovan, B. and Price, M. (2005) A social constructivist assessment process model: how the research literature shows us this could be best practice. *Assessment & Evaluation in Higher Education*, 30(3):231-240.

Sadler, D.R. (1989) Formative assessment and the design of instructional systems, *Instructional Science*, 18:119-144.

Stansfield, G. and Freake, S (2008) Video screencasts for student support. *E-Tutorials and Learner Support in Physics and Astronomy, Physics Innovations CETL.*

The Open University context and glossary of terms

The UK Open University (OU) was founded in 1969 and first admitted students in 1971. We currently have around 180,000 students (150,000 undergraduates and 30,000 postgraduates), 10,000 of whom have declared a disability of some sort and 25,000 of whom are studying outside the UK. OU undergraduate students are typically (though no longer exclusively) adults, studying part-time alongside other commitments and they have a wide range of entry qualifications from previous higher education qualifications to, literally, none. Many have not studied for many years and so they may be particularly lacking in confidence. The students study at a distance, but the OU's model of supported distance education means that they are usually supported by a tutor. This tutor will provide occasional tutorials (face to face or using a range of synchronous and asynchronous electronic communication technologies) and be available to support student learning by telephone or email; however a substantial part of the tutor's contracted time will be spent in grading and providing feedback on 'tutor-marked assignments' (TMAs). The fact that this task is described as 'correspondence tuition' reflects the importance that is placed on the feedback provided by tutors to their students in this way; this is particularly important in a distance-learning organisation, where many students never meet their tutor and opportunities for informal feedback are extremely limited.

Open University students may be taking a single 10-point course (module) or working towards a degree, certificate or diploma. The work of piCETL (The Physics Innovations Centre for Excellence in Teaching and Learning) has impacted especially on physics and astronomy modules and some more general science modules, as listed below. This list is followed by a glossary of some of the acronyms used in this report.

Undergraduate modules

S154	*Science starts here*	10 CATS point level 1 module
S104	*Exploring science*	60 CATS point level 1 module
S194	*Introducing astronomy*	10 CATS point level 1 module
S197	*How the Universe works*	10 CATS point level 1 module
S207	*The physical world*	60 CATS point level 2 module
S282	*Astronomy*	30 CATS point level 2 module
S288	*Level 2 practical science* (working title) 30 CATS point practical science module, to be presented from 2012	
S382	*Astrophysics*	30 CATS point level 3 module
S383	*The relativistic Universe*	30 CATS point level 3 module
S357	*Space time and cosmology*	former 30 CATS point level 3 module
S381	*The energetic Universe*	former 30 CATS point level 3 module
SM358	*The quantum world*	30 CATS point level 3 module
SMT359	*Electromagnetism*	30 CATS point level 3 module

SXR103 *Practising science* 10 CATS point level 1 residential school module
SXR207 *Physics by experiment* 10 CATS point level 2 residential school module
SXR208 *Observing the Universe* 15 CATS point level 2 residential school module
SMXR358 *Quantum mechanics: experiments, applications and simulations*
10 CATS point level 3 residential school module
SMXR359 *Electromagnetism: experiments, applications and simulations*
10 CATS point level 3 residential school module
SXP390 *Science project course: radiation and matter*
30 CATS point level 3 project module

Postgraduate modules

S809	*Imaging in Medicine*	60 CATS point masters module
S819	*Radiotherapy and its physics*	60 CATS point masters module
S829	*Further material in medical physics*	10 CATS point masters module

Glossary of acronyms

AL	associate lecturer (part-time tutor)
CM	course manager
CMA	computer-marked assignment
CT	course team (the group of responsible for the running of a course)
CTC	course team chair
eTMA	electronically submitted tutor-marked assignment
iCMA	interactive computer-marked assignment
PT3	assessment summary form (returned to student with their TMA, with summary comments from their tutor)
SST	student support team (also used for 'science staff tutor', a regionally based academic and line-manager of associate lecturers)
TMA	tutor-marked assignment

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Electronic marking of physics assignments using a Tablet PC

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Abstract
Producing and marking assignments electronically has advantages for both students and academic staff. However, marking and commenting on electronic assignments requires a simple and efficient method for annotating students' scripts. We report here on a pilot project that provided associate lecturers for a Level 2 Open University physics course with Tablet PCs and appropriate software that enabled them to input handwritten annotation, including equations and diagrams, to files containing students' assignment solutions. Surveys of ALs' views indicated that this method of electronic marking is effective and acceptable to students and to a large majority of ALs. It could be used to streamline assignment handling and marking procedures in campus universities as well as in distance learning contexts.

Introduction
The majority of Open University courses include summative tutor marked assignments (TMAs), which are submitted by students at intervals during the presentation of a course. The TMAs are marked by associate lecturers (ALs, also known as tutors), who are based in different locations around the country and are each responsible for a group of about 25 students. The traditional method of producing and marking TMAs is paper based: a student writes their answers to the assignment questions on paper (or word-processes them and prints them out), they use the postal system to mail the assignment to their AL, who marks and comments on the assignment by annotating the student's script. The AL sends marked assignments to the Open University in Milton Keynes, where the marks are recorded in a database, a sample of scripts are copied so that each AL's marking can be monitored, and the scripts are then posted back to students. This system involves shuffling large quantities of paper around the country and there are delays, expense and inconvenience associated with the postal system, with the transcription of marks and with the copying of assignments for monitoring. Now that OU students and ALs are expected to have access to a computer and the internet, some of the delays, costs and inconvenience can be reduced by handling TMAs electronically.

The OU has developed a system for handling electronic tutor marked assignments (eTMAs), and is encouraging course teams and students to use this system wherever possible. The eTMA system allows students to submit electronic files containing their assignments over the internet to a file handling system on a server in Milton Keynes. ALs download the eTMA files for their students from the server, mark and comment on the eTMAs offline, and then return the marked scripts over the internet to the server in Milton Keynes, where marks are automatically recorded in the appropriate database and a sample of scripts is made available for monitoring. Students can then download their marked assignment from the central server. This system has many advantages for students, ALs and the OU over the paper-based assignment system that relies on the post office for moving the assignments around the country.

One advantage is that the eTMA system in principle allows ALs to give more rapid feedback to students following the cut-off date for the assignment than does the paper-based system. Gibbs and Simpson[i] established a list of conditions under which assessment effectively supports learning. A key finding of this work was that it is essential that "feedback is timely in that it is received by students while it still matters to them and in time for them to pay attention to further learning or receive further assistance".

However, the benefits of rapid feedback could be more than offset if a longer time were required for ALs to mark eTMAs to the same standard as paper TMAs, so that the quality and quantity of feedback provided to students were reduced. Assignments for physics and astronomy courses generally involve large amounts of mathematical notation, equations and diagrams, and when marking eTMAs, ALs need to be able to insert equations and diagrams, and the time required to do this is generally the major issue. Keyboard and mouse based tools, such as equation editors and drawing programs, are much more time consuming than annotating a paper script with a pen. The pilot project described in this report was set up to investigate ways in which ALs could mark physics eTMAs easily, and could incorporate equations and diagrams just as they would if they were marking a paper assignment.

The project
In March 2006 the Physics Innovations Centre for Excellence in Teaching and Learning (πCETL) at the Open University agreed to fund a pilot project to investigate the use of Tablet PCs by ALs for marking assignments. All of the ALs who were tutoring a Level 2 physics course, S207 *The physical world*, were invited to participate in the project, and 19 of the 24 ALs agreed to take part. The participating ALs were provided with a Tablet PC (Toshiba Tecra M4), with appropriate software installed to enable them to add handwritten annotation to a student's eTMA file. The following year (2007) all ALs for the course participated in the electronic marking project. Students were informed about the benefits of using the eTMA system, but they had the options of submitting assignments electronically or on paper.

Marking procedures with the Tablet PC
ALs had a number of options for marking and commenting on eTMAs using the Tablet PC.

Ink annotation of a pdf file using PDF Annotator
We wanted to allow students to produce assignments using whatever application they found convenient, but wanted ALs to be able to use a single application for marking. We therefore recommended that ALs used pdf format for marking. The Tablet PCs were sent out with PDF Creator[ii] installed, and this application creates a 'virtual printer' that can convert into pdf format any student file that can be opened and printed from the AL's Tablet PC. The AL simply opens a student's assignment file – which requires that an appropriate application is installed on the Tablet PC – selects Print and chooses PDF Creator as the printing device. 'Printing' the file then produces a pdf version of the file, rather than printing out on paper. PDF Creator allows the user to combine a number of different files into a single pdf file.

The AL then opens the pdf file from the PDF Annotator[iii] application. With the computer in the tablet configuration, the pdf file can be annotated by writing on the screen with the tablet pen in exactly the same way that a paper assignment would be annotated with a conventional pen, but with the advantages that it is straightforward to:

- change pen colour and line width – so it's possible to colour code different types of comments;
- erase or correct comments;
- move or resize comments;
- save comments as macros that can then be inserted easily elsewhere in the same document or in other documents;
- insert blank pages for additional comments, or to append files (such as specimen answers).

When the AL has finished marking, they 'melt' the annotation so that it becomes a permanent part of the document, they save the file in pdf format and follow the standard procedures for returning the eTMA to the OU server. The student downloads the marked assignment from the server and opens the file using Adobe Reader. An example of a page from a marked assignment is shown in Figure 1.

PDF Annotator also allows simple text to be keyed into a text box. However, mixing keyboard entry and tablet pen entry is not particularly easy, since it involves switching back and forth between using the laptop configuration and using the tablet configuration. Switching between the two configurations of the screen takes about 15 seconds, which is not an unreasonable overhead, but the switchover is somewhat clumsy. An alternative procedure used by some ALs is to connect a USB keyboard to the Tablet PC, so that both keyboard entry and tablet pen entry are possible in the tablet configuration.

Ink annotation using Microsoft Word
A large majority of the eTMAs were submitted by students as Word documents, and so a second option for eTMA marking is for ALs to use the Ink tools available in the Tablet PC version of Word 2003, which was installed on these computers. The Ink Annotation tool can be used to write with the tablet pen anywhere in an open Word document, and, as with PDF Annotator, it is possible to change pen colour and line width, to erase ink marks, and to reposition and resize comments. It is also possible to use the Ink Comment tool to insert comments in the margin. This is similar to using the normal Insert Comment feature in Word, except that the comments are handwritten in a balloon in the margin using the tablet pen, and these comments can include equations and diagrams. As with PDF Annotator, it is possible to switch back and forth between using the keyboard to enter simple text in the laptop configuration and using the tablet pen to enter equations and figures in the tablet configuration. When the AL has finished marking the script, the file is saved in .doc format for return to the student via the eTMA system.

Ink annotation using Windows Journal
A third way to mark eTMAs with a Tablet PC is to convert the student's file to a Windows Journal file and then to annotate this file using the tablet pen. As with PDF Creator, Windows Journal installs a virtual printer with which any printable file submitted by a student can be converted to a Windows Journal file (.jnt), and this file can then be annotated in much the same way as a pdf file is annotated using PDF Annotator. This option was not suggested to the physics ALs, and none of them apparently discovered or used this method, but this was the approach used by Fisher[iv] in another Open University Tablet PC trial with a technology course.

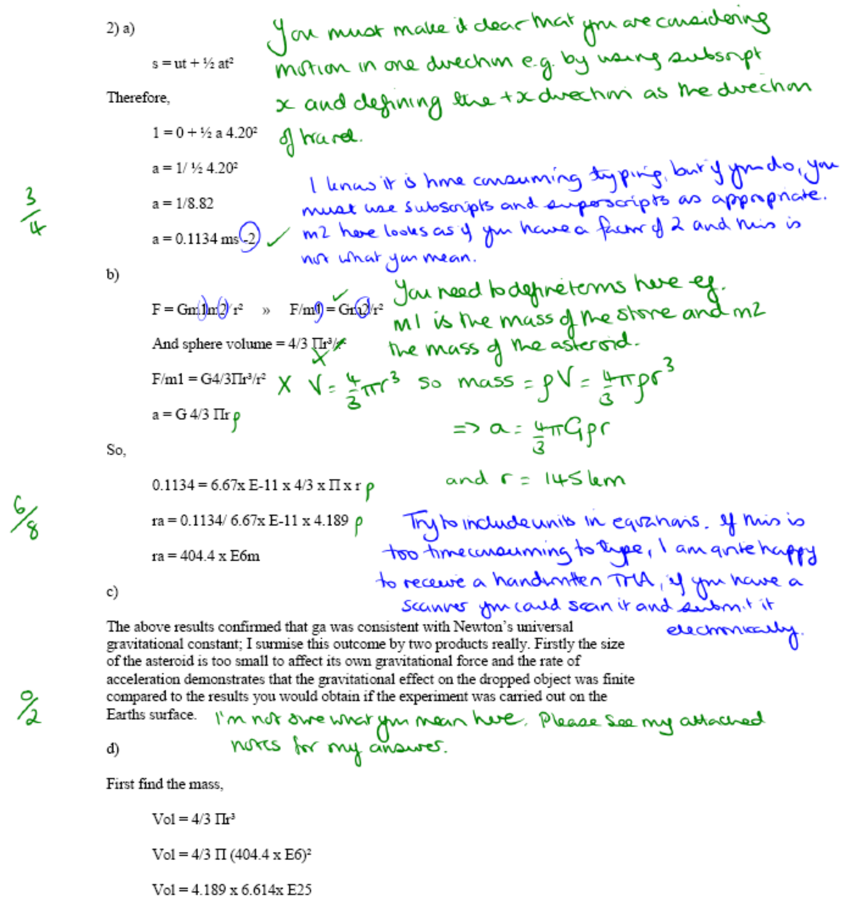

Figure 1: An example of a tutor's annotation on a page from an assignment. The tutor's comments would be much clearer to a student viewing a coloured image on their monitor.

Evaluation
After completion of the 2006 presentation of S207, a brief questionnaire was emailed to the ALs who had participated in the pilot project, and 15 of the 19 participants responded. A more comprehensive questionnaire was emailed at the end of 2007 to the 24 ALs involved in that year's presentation, and 23 of them responded. For both years, information about the number of paper TMAs and eTMAs marked by each AL for each of the course assignments was obtained from the assignment handling database.

Percentage of eTMAs submitted electronically The percentage of the total number of TMAs that were submitted electronically grew steadily during the project, as shown in Figure 2, and reached 40% by the end of 2007.

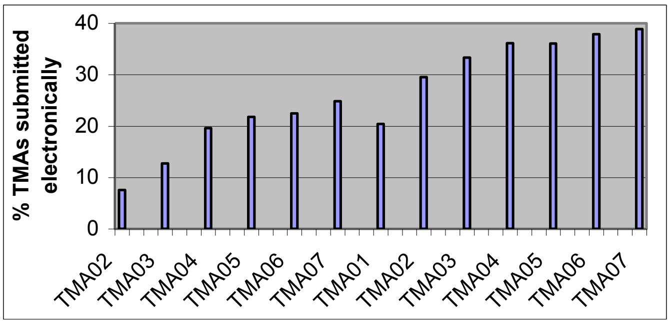

Figure 2: Percentage of TMAs submitted electronically for each assignment during 2006 (shown on the left) and 2007 (shown on the right).

Format of the eTMA files submitted ALs reported that (70%) of the eTMAs submitted in 2007 were word-processed, including the equations and diagrams. About 20% were largely word-processed, but with equations and/or diagrams produced by hand, and scanned images inserted into the document. The other 10% of eTMAs were completely handwritten and then scanned. Most of the eTMAs (83%) were submitted as Word .doc files, but small percentages were submitted in other word-processor formats, as pdf files or as image files.

Marking procedures used by ALs In 2007 the ALs were approximately equally split between those who converted files to pdf format and then marked using PDF Annotator, and those who marked using Word. Most of the ALs who opted to use Word for marking did not receive any files in other formats, and this may have been because they specifically asked students to submit eTMAs as .doc files. A variety of approaches were used when marking in Word; most ALs used both keyboard and tablet pen entry, but a couple opted not to use the Tablet PC and used a conventional computer for inserting text boxes and comments (using Track Changes). None of the ALs used the Windows Journal application.

Difficulties in learning how to use the marking system ALs were asked whether they had problems learning how to use the Tablet PC or the associated software. Even though the only information that they had received was the standard user manuals for the computer and the software, there were few reported problems. A few tutors said they would have appreciated more guidance on the conversion of files to pdf format and on the use of PDF Annotator, and one commented that the use of the Print File command in PDF Creator to produce a pdf file was counterintuitive. A couple of ALs thought there should be explicit guidance about how to insert pages into a script for additional comments. During 2007 we produced a document that provided guidance on the use of the Tablet PC for marking and this was distributed to all participating ALs. This document will be available in future years for ALs who are new to this method of marking.

Ergonomic considerations Six tutors said that it took them some time to find a comfortable way to mark using the Tablet PC. Three of them found that it was difficult to use the Tablet PC while wearing varifocal glasses, and two of them overcame this problem by using single prescription lenses while marking. Two ALs worked with the Tablet PC on their laps and another found that they had to use a lower working surface. One AL found using the Tablet PC so uncomfortable that he minimised use of it in the tablet mode by connecting an external monitor, keyboard and mouse to the Tablet PC and only using pen input for equations or diagrams that could not be copied or referred to. In future it would be appropriate to provide some 'ergonomic' advice as part of the guidance to ALs on the use of the Tablet PC for eTMA marking.

Advantages of using the Tablet PC The ALs were asked about the advantages of using the Tablet PC for electronic marking compared with paper marking, and the main points they mentioned were:

- the ability to annotate eTMAs in the same way that they would annotate paper TMAs;
- the ability to erase comments, or to revise them; they were pleased that they did not need to use correction fluid or to cross out comments; they thought their comments were often more considered, since they could be changed if necessary after reading a later part of the answer;
- no longer needing to contend with the piles of paper associated with conventional TMA marking; also, the pages can't get out of order;
- the ability to copy and paste comments between different TMAs;
- comments could be more legible – though it may be necessary to write more slowly, or to rewrite comments;
- the ease of inserting relevant parts of the specimen answers;
- several ALs said that eTMA marking requires less time than conventional marking;
- automated addition of marks avoids errors;
- improved turnaround time, particularly for students outside the UK;
- avoids use of the paper-based mail delivery system; it is easier to upload marked eTMAs than to post paper TMAs; eTMAs can be accessed anywhere that there is a broadband connection;
- AL retains copy of assignment on their computer for reference.

Ongoing problems and disadvantages of using the Tablet PC for marking In addition to the ergonomic considerations noted above, the main ongoing problems and disadvantages mentioned were:

- some ALs found that it took longer to mark assignments electronically;
- converting files to pdf format was tedious;
- it was difficult to trawl through pages to get an overview to ensure that the comments were appropriate, or difficult to lay out pages and compare several scripts to ensure consistency;
- it was inconvenient to switch between different students' files when marking each question as a batch;
- it was not as convenient as paper for marking while waiting in the car;
- ALs found that switching between laptop and tablet modes was inconvenient; some ALs avoided this inconvenience by using an external keyboard connected to a USB port on the Tablet PC;
- it is not possible to cut and paste in PDF Annotator;
- the reliability of electronic submission (compared with postal submission) meant that many students delayed eTMA submission until just before the deadline.

Student feedback The small amount of feedback that ALs received from students who submitted eTMAs was positive, with most of the comments about the quick turnaround and the ability to submit right up to the cut off time. However, some students did also comment on the clarity and legibility of the comments that ALs made in the returned file.

Overall views about marking eTMAs compared with marking paper TMAs In 2007, eleven of the 23 ALs expressed a preference for marking eTMAs and eight ALs either said explicitly that they were equally happy with paper TMAs and eTMAs or expressed no preference. Only four ALs indicated a preference for paper marking, and three of these had marked very few eTMAs. Almost all of the ALs were very positive about the pilot project. There were some reservations from those who found that eTMAs took longer to mark – this needs to be reviewed when ALs are more familiar with using this method of marking. A more detailed report on the electronic marking trial can be found on the πCETL website.[v]

Future work

In 2006, about 17% of assignments submitted to ALs taking part in the project were eTMAs, and this increased to 32% in 2007. The main reason that the majority of S207 students prefer paper submission is that they lack the IT skills to incorporate equations and diagrams into a word-processed TMA and/or find that producing an eTMA is unacceptably time-consuming. During the 2007 presentation, another πCETL project attempted to increase the number of students submitting electronically by offering students the loan of either a scanner or a digital pen. These systems allow the student to write their assignment answers on paper, but then to convert it to a digital format that can be submitted via the eTMA system.

In 2008 we have extended the electronic marking project to two Level 3 physics and astronomy courses.

Electronic marking with campus-based students

The OU project investigated the use of electronic marking in a distance-learning context, where a major benefit of electronic marking is that electronic transmission of assignments eliminates dependence on the postal service. This particular benefit is not relevant for campus-based students, where paper assignments can be placed in appropriate pigeonholes, but there would still be benefits from using an electronic system that recorded submission and return dates for assignments, that stored marks, and that kept copies of all marked assignments. Academics would also benefit from the elimination of piles of paper assignments, from the ability to download, mark and return assignments anywhere that they have an internet connection, and from all of the other advantages of marking electronically discussed earlier. It would be straightforward to provide campus-based students with access to scanners that could convert handwritten assignments into a single pdf file, so that lack of skills with using word-processing software, equation editors and drawing packages would not disadvantage them.

A πCETL project at Leicester University[vi] is going much further, and investigating a paperless degree. So not only are assignments being handled electronically, but also all course materials are provided electronically.

Conclusion

This S207 pilot project has shown that a Tablet PC provides an effective and acceptable method of marking physics assignments electronically – from the viewpoints of both the ALs and the students. ALs used two main methods of electronic marking – annotating pdf files using PDF Annotator and using annotating doc files using Word – and the choice was a matter of personal preference. However, it must be recognized that although Tablet PCs provide a good way of marking physics assignments, their capital cost may inhibit their widespread use for marking Open University assignments.

Acknowledgements

We gratefully acknowledge the contributions of Jonathan Underwood, who set up and ran this pilot project at the Open University until he moved to University College London, and of the associate lecturers who participated in the project and whose feedback was used as the basis of this report. This project would not have been possible without the funding and support provided by πCETL, which in turn is funded by the Higher Education Funding Council for England.

References

[1] Gibbs, G. and Simpson, C. (2004) Conditions under which assessment supports student learning, *Learning and Teaching in Higher Education*, Issue 1, 3-31.

[2] Chinery, P. and Heindörfer, F., PDF Creator software, free download from http://www.pdfforge.org .

[3]. Grahl Software Design, PDF Annotator software, http://www.GRAHL-software.com .

[4]. See COLMSCT website: Fisher, W., A critical review of the use of enabling technologies www.open.ac.uk/colmsct/projects/wendyfisher.

[5]. See πCETL website: Freake, S., Use of Tablet PCs to mark physics assignments www.open.ac.uk/picetl/projects/etmamarking.

[6]. See πCETL website: Symons, S., Paperless degree project www.open.ac.uk/picetl/projects/paperlessdegree.

The use of Tablet PCs for marking Level 3 physics and astronomy assignments

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November 2008

Abstract

Marking and commenting on electronic tutor marked assignments (eTMAs) requires a simple and efficient method for tutors to annotate students' scripts. We have previously reported on a pilot project that provided associate lecturers (ALs) for a Level 2 physics course with Tablet PCs and appropriate software that enabled them to input handwritten annotation, including equations and diagrams, to files containing students' assignment solutions. Following the success of that pilot project, Tablet PC marking of eTMAs has been extended to two Level 3 physics and astronomy courses. An online survey of ALs at the end of the 2008 presentations of these two courses indicated general acceptance of this method of marking eTMAs, though the ALs were equally divided in their preferences for electronic or paper marking.

1 Introduction

The Open University introduced electronic submission of tutor-marked assignments over ten years ago, and the current version of the system has been in operation since 2001. Use of the system has grown rapidly over the last few years, and in 2007 just over 380 000 eTMAs were submitted, and about 80% of OU courses allowed students to submit their assignments electronically. However, only 50% of science courses allowed electronic submission, and the proportions are much lower than this for physics and astronomy courses and for mathematics courses.

Assignments for physics and astronomy courses generally involve large amounts of mathematical notation, equations and diagrams. Many of the students studying these courses have the skills required to incorporate equations and diagrams into a word-processed file and have been submitting print outs of their word-processed TMAs to their ALs. Many other students could scan a handwritten TMA, combine the resulting image files into a single document and submit this electronically. However, until 2006 none of the physics and astronomy courses allowed students to submit eTMAs because of the difficulties associated with marking and commenting. ALs need to be able to insert equations and diagrams on students' answers, and the time required to do this is the major issue. Keyboard and mouse based tools, such as equation editors and line drawing programs, are much more time consuming to use compared with annotating a paper script with a pen, and it is not reasonable to expect ALs to mark eTMAs with such tools.

In 2006 the Physics Innovations Centre for Excellence in Teaching and Learning (πCETL) set up a project to investigate whether a Tablet PC was an effective tool for marking physics eTMAs. The ALs for a Level 2 physics course (S207 *The Physical World*) were each provided with a Tablet PC and appropriate software, and students were given the options of submitting their assignments either electronically or on paper. The ALs had a number of possible methods for marking the eTMAs they received. The recommended method was to use the PDF Annotator application (Grahl Software Design), which was pre-installed on the Tablet PCs. This allowed ALs to insert handwritten ink marks and comments in a pdf file containing a student's answers, just as they would on a paper TMA. This circumvents the need to use equation editors or drawing packages for marking. Students could submit their eTMA in a variety of file formats; as long as the AL had the appropriate software to open a student's file, they could use the PDF Creator application (Chinery and Heindorfer), also pre-installed on the Tablet PC, to convert the file to pdf format and then mark using PDF Annotator. However, the majority of students produced their eTMAs using Microsoft Word, and submitted doc files, and ALs then had the option of marking these assignments using ink tools available in Word. At the ends of both the 2006 and 2007 presentations of S207, the ALs were asked to provide detailed feedback on their experience of eTMA marking, and the results of these evaluations were reported earlier (Underwood and Freake, 2007). The feedback indicated that Tablet PCs provide a method of marking eTMAs that is effective and acceptable to students and a large majority of ALs.

As a result of the success of the trial of Tablet PCs for marking Level 2 eTMAs, in 2008 the use of Tablet PCs was extended to two Level 3 courses. We report here on the 2008 project and on its evaluation.

2 The Level 3 physics and astronomy eTMA marking project

The Level 3 courses involved in the marking project in 2008 were a physics course (SMT359 *Electromagnetism*) and an astrophysics course (S381 *The energetic Universe*). Each course includes four TMAs, and these are submitted at approximately two-monthly intervals between March and September. The numbers of students registered for these courses were 316 for SMT359 and 276 for S381, and the numbers of ALs tutoring the courses were 13 and 12, respectively. Since the eTMA marking project was set up after the ALs had been appointed, their participation in electronic marking was optional, and 11 of the 13 SMT359 ALs and 11 of the 12 S381 ALs agreed to take part. The participating ALs were provided with a Toshiba Tecra Tablet PC, with appropriate software installed to enable them to add handwritten annotation to a student's eTMA answers. They were also provided with a set of notes about the use of the Tablet PC for eTMA marking (Freake, 2008), which were based on experience gained and feedback received from the S207 trials in 2006-7, and a copy of the report on the 2007 trial (Underwood and Freake, 2007). They were encouraged to participate in the OU's regionally-based training sessions on using the eTMA system and/or to study the eTMA training guides for ALs.

Students were informed about the eTMA marking project via the course websites at the beginning of the course, and told about some of the benefits of using the eTMA system. It was made clear that student use of the eTMA system was optional, and that they should not spend a lot of time producing their TMA in electronic format at the expense of studying the subject matter of the course. Advice was provided about scanning handwritten assignments to produce a single file for electronic submission. They were told that not all ALs were able to participate in the eTMA marking project, and that if they wanted to submit eTMAs they should ask their AL whether eTMA submission was possible and what formats were acceptable for their eTMA files. It was left up to individual ALs to decide how much encouragement they gave to students to submit their assignments electronically.

3 Evaluation

After completion of the 2008 presentations of SMT359 and S381, the ALs were asked to complete an online questionnaire (Freake, 2008) about their experience of marking eTMAs, and 20 of the 22 participants responded. In addition, information about the numbers of paper TMAs and eTMAs marked by each AL for each course assignment, and about the average marks for each set of assignments, were obtained from the assignment handling database

Number of eTMAs submitted The proportions of assignments that were submitted electronically to participating ALs were 37% for SMT359 and 51% for S381. In both cases there was an increase in the proportion submitted electronically during the year, from 33% to 41% for SMT359 and from 47% to 53% for S381 (see Figure 1). Looking at the data in a different way, for SMT359, 36% of the students registered at the start of the course submitted at least one eTMA; the equivalent figure for S381 was 53%. There are very significant differences between the eTMA submission rates for the two courses, with the probability of this occurring by chance less than 0.0001. In comparison, the proportion of TMAs submitted electronically for S207 in 2008 was 46%, and this proportion was reasonably steady during the year. Note that S207 ALs were not asked to participate in the online survey, since they had provided feedback after the previous two presentations of the course.

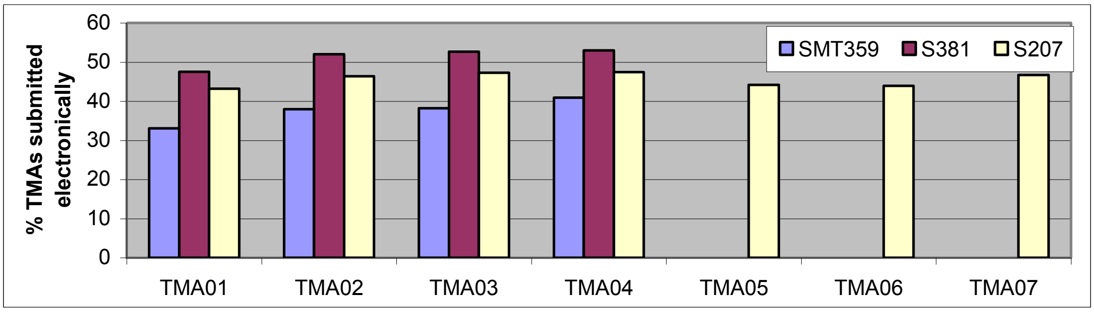

Figure 1
Percentage of TMAs submitted electronically for each assignment of SMT359 and S381 during 2008, and also for S207.

There was a wide variation in eTMA submission rates for different tutor groups. Figure 2 shows the numbers of ALs for each course receiving different percentages of assignments as eTMAs. Two of the 23 participating ALs for the Level 3 courses received less than 20% of their TMAs electronically and three received more than 70% as eTMAs. There was a similar wide spread in the distribution for S207.

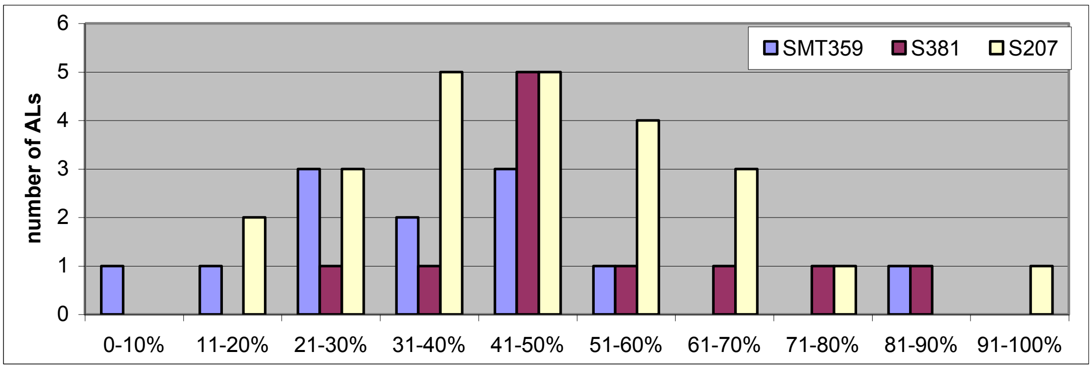

Figure 2
Number of ALs receiving different percentages of eTMAs in 2008 for SMT359, S381 and S207.

One possible explanation for this large variation between the submission rates of eTMAs by different tutor groups is that ALs varied in their stance towards eTMA submission. ALs were asked about this in the survey, and most of them (10/19) said that they took a fairly neutral stance, indicating advantages and disadvantages of e-submission, but also indicating that they were happy to accept either form and it was up to individual students to decide. Seven of the tutors were more encouraging about use of eTMAs, and two strongly encouraged their students to use eTMAs. There is evidence that ALs who encouraged students to try the eTMA system, or who indicated a personal preference for electronic marking received a higher percentage of eTMAs: for SMT359, the two ALs who strongly encouraged e-submission received 66% of TMAs electronically and two who encouraged it received 51% electronically, whereas the seven who said they had been more neutral only received 28% electronically. For S381, the six ALs who encouraged e-submission received 54% eTMAs, whereas those who said they were more neutral received 43% eTMAs. An AL who received 86% of TMAs electronically had told students that "*I had a strong preference for eTMAs, and asked them to at least try one (not compulsory though)*".

Of course, pushing students too hard to submit eTMAs could be counterproductive, and could lead to increased drop out by students who do not want to use the eTMA system. However, there is no evidence that this is happening. One measure of retention is the total number of TMAs submitted to an AL as a percentage of the number expected if all students who submitted the first TMA went on to submit all of the subsequent assignments. The correlation between this retention figure and the percentage of assignments submitted to an AL as eTMAs was very small; for SMT359 the correlation coefficient was -0.08 and for S207 it was -0.05, which indicates that there is no significant dependence of retention on eTMA submission rates for these courses. For S381, a tutor withdrew midway through the course and his students' later TMAs were marked by other ALs, so meaningful retention data cannot be extracted.

About 10% of the students who submitted one or more eTMAs reverted to paper submission for a subsequent TMA. In some cases the reversion was temporary – a student on holiday with no access to a computer, for example – but in other cases students decided that paper submission was quicker or more straightforward, or they had difficulties with using the eTMA system. However, the fact that about 90% of students who tried the electronic system continued to use it is an indication of their preference for this way of working.

Average marks for eTMAs and paper TMAs Several ALs commented on differences between average marks for their students who submitted eTMAs and those who submitted paper TMAs. However, the small numbers of students in each AL's group mean than little statistical significance can be attributed to these observations. When average marks are determined at the course level, then we find that for SMT359 the mean eTMA mark for all ALs was 76.1, compared with a mean of 73.8 for paper TMAs, and for S381 the mean for eTMAs was 70.7, compared with 71.7 for paper TMAs. For S207, the eTMA mean was 77.0, and the paper TMA mean was 73.4. At present we do not have marks for individual assignments, so we have not been able to test whether these differences are statistically significant. Any significant differences might be evidence for differences in ability levels of students submitting via the different routes or differences in ALs' marking standards for the two types of TMA, so further investigation of these marks would be useful.

Format of the eTMA files submitted ALs reported that about 62% of the eTMAs were word-processed, including the equations and diagrams. About 12% were largely word-processed, but with equations and/or diagrams produced by hand, scanned and images inserted into the document, and another 26% of eTMAs were completely handwritten and then scanned. Just over half of the eTMAs (52%) were submitted as Microsoft Word files, 43% were submitted as pdf files, and there were small percentages submitted as image files, as rtf files or in alternative word processor formats (e.g. OpenOffice or Star Office). Word files were used more frequently for S381 eTMAs than for SMT359 (57% vs 45%) and pdf files were used less frequently (37% vs 51%).

Difficulties in learning how to use the marking system The SMT359 and S381 ALs were provided with a set of notes/guidelines about using the Tablet PC for marking eTMAs. These were based on feedback provided by S207 ALs about their experience with eTMA marking in the previous two years. Most of the ALs found these notes useful (7 very useful, 7 useful, 4 moderately useful and 1 of little use), and none of them reported problems learning how to use the Tablet PC for marking. A few minor additions to the notes were suggested, and these will be incorporated in the 2009 version.

Ergonomic considerations Six ALs made comments on ergonomic issues associated with the use of Tablet PCs for eTMA marking. One tutor said it was difficult to find a comfortable position for marking, and eventually propped the Tablet PC on a bookstand with an external keyboard and mouse at one side. Another found that lying on the sofa with his knees drawn up and Tablet PC on his thighs worked well. A third said that he could write on the Tablet PC easiest with it at 45 degrees, with the lower part on his lap and the upper part on a table edge. Two ALs found the tablet pen uncomfortable; it was too small for one, who "*would appreciate a better pen next time*", and the other found that their hand ached after marking assignments from holding the pen too hard. Another AL commented that the Tablet PC itself is very poor from an H&S viewpoint. The notes provided to ALs (see previous paragraph) highlighted a number of ergonomic issues, including the need to find a comfortable working position, but did not mention the pen problems. The next edition of the notes will be revised to include additional 'ergonomic advice'.

Marking procedures used by ALs Two-thirds of ALs marked and commented on all eTMAs using PDF Annotator. This meant that they had to first convert non-pdf files (mostly Microsoft Word files) to pdf using PDF Creator. The other third of the ALs marked the pdf files they received using PDF Annotator, but marked Word files using Word. A variety of techniques were used to mark in Word: two ALs used ink annotation alone, three others used ink annotation in combination with either the Comment facility or text boxes or Track Changes, and one AL who had declined the loan of a Tablet PC used keyboard entry only.

Comparison of eTMA marking with paper TMA marking ALs were asked to respond to 10 multiple-choice questions that asked them to compare the two marking methods. Each question used a five-point scale that extended from 'Much less/shorter', through 'About the same', to 'Much more/longer'. On four of the questions, 70% or more of responders thought their marking of paper TMAs and eTMAs was 'about the same', and there was little difference between the responses of SMT359 and S381 ALs: these four items asked about the *number of comments* on the script, the *length of comments* on the script, the *helpfulness of the comments* and their *legibility*. However, about 50% of ALs thought that their *PT3 comments* for eTMAs were longer than those for paper TMAs, and this difference was much greater for S381 than SMT359 (66% vs 27%). The longer PT3 comments are presumably a consequence of the fact that the electronic PT3 will expand to accommodate as much as an AL wants to enter.

About 75% of the ALs thought that eTMA marking was *more complex* than marking paper TMAs, and 50% thought eTMA marking was *more stressful*. There was a large difference between the views of ALs for the two courses; 91% of SMT359 ALs thought eTMA marking was more complex compared with 55% for S381 ALs, and 73% of SMT359 ALs found eTMA marking more stressful, whereas only 22% of S381 ALs thought it was more stressful and 44% thought it was less stressful.

Another area that was explored was the flexibility and convenience of the two methods of marking. Half of the ALs thought that eTMA marking was less flexible (and 22% more flexible) and 60% thought it was less convenient (30% more convenient), and again there was a difference between the two courses. For SMT359, 60% thought eTMA marking was less flexible and none thought it was more flexible, whereas for S381 38% said eTMA marking was less flexible and 50% said more flexible.

Time required to mark TMAs is another important issue. Overall, 55% of ALs thought it took longer to mark eTMAs than paper TMAs, 35% thought it they took about the same time, and 10% thought eTMAs took less time. The SMT359 results were more skewed towards eTMAs taking longer to mark: 72% of SMT359 ALs said eTMAs took longer, and none of them thought they took less time. In comparison, 33% of S381 ALs said eTMAs took longer, and 22% thought they took less time.

The aspects of marking that ALs thought *increased* the time required to mark eTMAs included: the need to convert files to pdf format for marking with PDF Annotator; getting out the computer and setting it up; downloading and uploading eTMA files from the file handler; revising comments to make them clearer or more legible; redoing comments that had been accidentally deleted; and fiddling around with the positions of text boxes. Things identified as *reducing* the time required to mark eTMAs included: having everything (students' answers, PT3s, tutor notes, model answers) available in electronic form, so that comments and solutions could be cut and pasted; ability to type the PT3 rather than handwriting it; not having to post marked TMAs to WH.

Advantages of using the Tablet PC The ALs were asked about the advantages of using the Tablet PC compared with paper marking, and the main points they mentioned were:

- the ability to annotate eTMAs by hand in the same way that they would annotate paper TMAs;
- the ability to erase comments, or to revise them; they thought their comments were often more considered, since they could be changed if necessary after reading a later part of the answer;
- comments could be more legible – though it may be necessary to write more slowly, or to rewrite comments;
- hand writing comments is faster than using a keyboard;
- the ease of inserting extra pages for additional comments or for pasting model answers;
- flexibility and ease of use of the electronic PT3 form;
- no longer needing to contend with the piles of paper associated with conventional TMA marking; also, the pages can't get out of order;
- useful to have previous eTMAs and PT3s available for reference, either when a student raises query or when marking subsequent assignments;
- avoids use of the paper-based mail delivery system; it is easier to upload marked eTMAs than to post paper TMAs; eTMAs can be accessed when away from home – anywhere there is a broadband connection.

Disadvantages of using the Tablet PC The disadvantages of using the Tablet PC compared with paper marking that ALs mentioned were:

- the extra time required for marking;
- the hassle of setting up the Tablet PC and downloading and returning eTMAs;
- converting files to pdf format was tedious;
- it was difficult to browse through pages to get an overview to ensure that the comments were appropriate, and difficult to lay out pages and compare several scripts to ensure consistency;
- it was inconvenient to switch between different students' files if trying to mark each question as a batch;
- being tied to the computer for marking;
- the weight and bulk of the Tablet PC.

Extra features that would improve eTMA marking The main suggestions for improvements to the eTMA marking process were:

- improving the 'clunky', 'cumbersome' file handler software that currently 'causes headaches';
- supplying a USB keyboard;
- enhancements to PDF Annotator that allowed more-flexible formatting of text boxes;
- providing MathType for ALs.

Student feedback ALs did not receive much feedback from the students who submitted eTMAs, but what they did receive was generally positive. There were a number of comments about the quick turnaround and some students commented on the legibility and readability of the comments that ALs made in the returned file. The fact that a very large majority of the students who tried eTMAs continued to submit their assignments in this way is a good indication of student satisfaction with this method.

Additional advice for students ALs made a number of suggestions for additional advice that the Course Teams could provide to students about producing their eTMAs. These included:

- more advice about production of eTMAs that include scanned documents, particularly about file size, resolution and legibility;

- emphasizing the requirement to submit a single file rather than a set of image files;
- advice on producing equations, for example, using Equation Editor, MathsType, or equivalent;
- asking students to leave generous margins and space between parts of questions so that there is plenty of space for their tutor to insert comments;
- asking students to submit in pdf format, so that ALs don't have to do the file conversion.

Overall views about marking eTMAs compared with marking paper TMAs The views expressed by ALs were categorized as indicating 'preference for eTMAs', 'preference for paper TMAs', 'happy with either' or 'no preference expressed'.

- Eight ALs preferred marking eTMAs, and comments included:

"*I think it's been a great help to my ability to mark and send comments promptly back to the students.*"

"*Generally I find it much better because of the ability to edit comments.*"

"*Overall I prefer the Tablet PC approach using the annotating pen … being able to write directly on the script is really important.*"

"*I found it a very positive experience. The eTMA marking was easier and faster overall, and I would have much preferred if all my students had submitted eTMAs*."

- Four ALs indicated a preference for paper TMAs:

"[Marking eTMAs] *is a bit more stressful and time consuming but not enough to put me off*."

"*I have a preference for paper TMAs* [because ETMAs take more time]."

"[Need for access to computer] *makes eTMA system slightly less convenient*."

"*Marking on paper is easier and less time consuming (to my surprise)*."

- Two AL indicated that they were happy with both eTMAs and paper TMAs, and five did not express a preference.
- Three ALs stressed that the Tablet PC was essential for eTMA marking.

"*If we are going to have eTMAs then I think a Tablet PC is essential. It makes all the difference between eTMAs being practicable and not being practicable. I would not be happy marking eTMAs on these courses without one.*"

"*Without a Tablet PC I would not want to mark a Physics eTMA because of the difficulty and time in writing out and correcting equations and diagrams*."

"*I am perfectly happy with marking either. However, I would not be happy to mark eTMAs if I did not have a Tablet PC*."

ALs were also asked to express their preference for eTMA marking or paper marking using a five-point scale (Strongly prefer paper, slightly prefer paper, about the same, slightly prefer eTMAs, strongly prefer eTMAs). The ALs were evenly split with 45% preferring paper, 45% preferring eTMAs and 10% ranking them about the same. However, the overall data masks a significant difference between the views of ALs for the two courses: 64% of SMT359 ALs prefer paper TMAs and only 27% prefer eTMAs, whereas for S381 the proportions are reversed, with 22% preferring paper and 66% preferring eTMAs.

Hints and advice for colleagues ALs were asked if they had any helpful hints or advice that they would like circulated to their colleagues. The main suggestions were:

- buy a USB keyboard; this makes it easy to mix ink comments and text boxes on the script, and easy to complete the PT3 form, without having to reorient the screen of the Tablet PC;

- mark some paper TMAs first; with paper scripts it is easier to mark a batch of answers to a particular question to get used to the marking scheme; it can be complicated to have files for a number of students open on screen at the same time;
- ergonomic advice that has already been mentioned in an earlier paragraph;
- and the comment: "*it's worth the pain*".

Monitoring The e-monitoring system appeared to work well from the viewpoints of the monitors and those being monitored. Several ALs commented on the quicker return of the monitoring report, and some appreciated the absence of extra piles of paper to file away. Some of the assignments that were monitored were paper TMAs that had been scanned by the assignment handling office, presumably because no eTMAs were available for a particular tutor and particular assignment, and a monitor suggested that colour scans would make it easier to distinguish the tutor's comments on an answer. Another monitor noted their surprise that a large proportion of ALs chose to annotate eTMAs with red ink, even though a wide range of ink colours is available.

Other uses made of the Tablet PC Two thirds of the ALs used their Tablet PCs for other purposes besides marking SMT359 and S381 eTMAs. Other OU uses included marking eTMAs for other courses that they were tutoring (Y161, S104, S207, S250, S283), preparing material for tutorials and presenting material at tutorials by connecting to a data projector, and preparing screencasts for SMT359. Three ALs had used their Tablet PC for teaching/research purposes at other educational institutions.

Other comments The final question allowed ALs to add any additional comments about the trial. Most of the specific comments have been included in earlier paragraphs, but about half of the ALs volunteered very positive comments about their experience and there were no negative comments. Here are some selected comments.

"*I am sure that marking eTMAs was easier with this equipment. And I enjoyed taking part in the trial*."

"*I think a Tablet PC, as distinct from a non-Tablet PC, is essential to the success of this trial*."

"*Thanks very much for conducting the trial! I feel I and my students have benefitted from the experience.*"

"*Very glad to have taken part in it!*"

"*The eTMA system in general seems to work very smoothly.*"

"*Was very useful and an interesting experience*."

4 Discussion of results

The overall picture that emerges from the AL feedback is that Tablet PCs provide an acceptable way of marking physics and astronomy eTMAs, with a fairly even split between those who prefer to mark eTMAs and those who prefer to mark paper TMAs. There are differences between the two courses: S381 ALs are much more favourably disposed towards eTMAs than SMT359 ALs, they provide more encouragement to students to use the eTMA system and they receive a higher proportion of assignments electronically. These differences are likely to be due to a combination of factors, which could include:

- S381 requires less extensive use of mathematical equations and complex notation in TMA solutions than does SMT359.
- S381 requires students to make more use of a computer than does SMT359; it includes activities that involve use of spreadsheets, accessing an image archive, finding information from the web and studying various multimedia packages.
- S381 ALs have better ICT skills, or are more willing to adopt new technology.

- S381 students have better ICT skills, or are more willing to adopt new technology.

However, it is not clear which of these might be most significant, and we have no evidence to support the statements in the last two bullet points.

The majority of ALs for each course believe that the comments they made on eTMAs were 'about the same' as their comments on paper TMAs, and the remainder thought that they made more comments, longer comments, more-helpful comments and more-legible comments on eTMAs. Monitors' reports also indicated that there was generally very little difference between the quality of feedback on eTMAs and paper TMAs. However, there was a larger spread of AL opinions about the two marking processes. The balance of opinion was that eTMA marking is more complex, more stressful, less flexible, less convenient and requires more time, and a higher proportion of SMT359 ALs held these views than of S381 ALs. A significant proportion of ALs thought eTMA marking was less stressful, more flexible and more convenient, and these opinions were more widespread among the S381 ALs. Given that ALs had not used the eTMA system and had not used a Tablet PC prior to this trial, the balance of opinion is not surprising. We would certainly expect that after a second year of marking eTMAs, the complexity, stress and time associated with eTMA marking would be reduced.

We anticipate that the proportion of eTMAs for the Level 3 courses will be higher in future presentations since students will be aware at the time they register that e-submission is an option and is encouraged. In addition, a higher proportion of students will have gained experience of eTMAs in previous courses and will want to continue to use electronic submission. The fact that 90% of students who tried the eTMA system did not revert to paper submission is an indication of the appeal of this way of working.

The survey provided some evidence that eTMA submission rates were higher when an AL had encouraged electronic submission rather than taking a neutral stance. It is likely that ALs who prefer eTMAs will give more encouragement to students to submit electronically in the next course presentations that they tutor, and the experience gained in the 2008 presentations will enable all ALs to provide better advice and support to students about eTMA submission. This is also likely to enhance the eTMA submission rates.

Students were provided with information on the course websites about producing an eTMA, and this included advice about reducing the file size for scanned pages and about submitting their eTMA as a single file. However, half of the ALs reported that they had problems with some eTMAs produced with scanners. Some students submitted very large files, and some submitted a set of image files rather than combining the files into a single document. This created extra work for ALs, but generally they were able to advise students how to produce acceptable eTMA files for subsequent assignments. In hindsight it is clear that the advice on the website could have been much more explicit about acceptable file sizes and formats for scanned documents, and appropriate changes will be made to this advice for the next presentations of the courses. These changes should reduce the number of assignments submitted in unsuitable formats and make eTMA marking more straightforward and less time consuming for ALs.

5 Future developments

In 2009 we will extend the use of Tablet PCs for eTMA marking to two more Level 3 physics and astronomy courses, SM358 *The quantum world* and S357 *Space, time and cosmology*. SM358 is presented in alternate years with SMT359, has an initial registration of 300+, and two-thirds of its ALs also tutor SMT359 and will therefore already be familiar with using the Tablet PC for eTMA marking. S357 is presented in alternate years with S381, has an initial registration of 300+, and three of its ALs have used a Tablet PC for marking in other courses. In 2010, S357 and S381 will be replaced by two new astronomy courses, S382 and S383. It is likely that many of the ALs who have tutored S357 and S381 will be appointed to teach the two new courses, and will be able to make use of their Tablet PC marking skills in those courses.

Feedback from SMT359 and S381 ALs has suggested a number of enhancements that could be made to the notes about eTMA marking that are provided for ALs and to the notes about producing and submitting eTMAs that are provided for students. Both sets of notes will be revised and made available to ALs and students of SM358 and S357 at the start of the 2009 presentations. In particular, the student notes will be modified to include more specific advice about scanning handwritten assignments and combining scanned images into a single document.

During 2008 three of the SMT359 ALs and a Walton Hall member of the course team used Tablet PCs to produce screencasts of solutions to all of the TMA questions, solutions to half of the questions for the 2006 exam paper, a 20-minute presentation giving advice about the examination, and screencast presentations to enhance some of the e-tutorials (Stansfield and Freake, 2008). Preliminary data about the use of these screencasts by students is very positive and an online survey of students is being carried out in November 2008, the results of which will be available on the πCETL website early in 2009. We anticipate that other physics and astronomy course teams will wish to make similar uses of screencasts for student support, thus gaining additional benefits from providing Tablet PCs for ALs.

The ALs' Tablet PCs could also prove very useful in synchronous e-tutorials provided using the Elluminate system. Physics and astronomy courses are undertaking a number of trials of the Elluminate system in 2009, ranging from large group tutorials down to sessions for individual students. The ability to use a Tablet PC to write on the Elluminate whiteboard could greatly enhance these tutorial sessions.

Finally, we note that in 2010 the support for the Level 3 physics and astronomy courses will be provided by student support teams (SSTs). In view of the success of the eTMA Tablet PC marking trials, and emerging applications for Tablet PCs for producing screencasts and for communicating equations and diagrams in Elluminate tutorials, it will be important to provide Tablet PCs for all of the ALs in these SSTs. Consideration also needs to be given to how the use of Tablet PCs can be extended to other subject areas in the University that have similar challenges in communicating complex notation and diagrams.

6 Conclusion

This πCETL project has demonstrated that a Tablet PC provides an effective and acceptable method of marking physics and astronomy eTMAs – from the viewpoints of both the ALs and the students. For S207 and S381, about 50% of students are now submitting assignments electronically, with a somewhat lower proportion for SMT359, and it is highly unlikely that this could have been achieved without equipping the ALs with Tablet PCs.

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References

Chinery, P. and Heindörfer, F., PDF Creator software, free download from http://www.pdfforge.org .

Freake, S. (2008) *Marking and commenting on eTMAs using a Tablet PC*, guidance notes provided for ALs in January 2008, http://www.open.ac.uk/cetl-workspace/cetlcontent/documents/477b89dab4f06.doc

Freake, S. (2008) *πCETL Tablet PC eTMA marking trial: AL questionnaire 2008*, http://iet-intranet.open.ac.uk/docs/about/cir/survey/questionnaires/8565.htm

Grahl Software Design, PDF Annotator software, http://www.GRAHL-software.com.

Underwood, J. and Freake, S. (2007) *The use of Tablet PCs for marking physics experiments*, project report, http://www.open.ac.uk/cetl-workspace/cetlcontent/documents/477b8b6489921.doc

Stansfield, G. and Freake, S. (2008) *Video screencasts for student support*, http://www.open.ac.uk/picetl/activities/details/detail.php?itemId=4874c09b259de&themeId=460260f480f84

πCETL Tablet PC eTMA marking trial

AL questionnaire 2008

We have just completed the first year of using Tablet PCs for marking eTMAs for Level 3 Physics and Astronomy courses, and the course teams and the πCETL would like to know your views about marking TMAs in this way.

We would like to know the full spectrum of ALs' opinions about using Tablet PCs for marking, so please let us have your comments, however critical they may be!

We would therefore be most grateful if you would spare the time to complete this online survey. We estimate that this will take about 20 minutes of your time.

Thank you in advance,

Stuart Freake
Tablet PC marking trial coordinator for πCETL

Details:

Name: ______

Course: SMT359 ○ S381 ○

1. How many students were you allocated initially?

____ students

2. How many of your students used the eTMA system for each of the TMAs?

TMA01: ____ students

TMA02: ____ students

TMA03: ____ students

TMA04: ____ students

3. How many of your students submitted at least one eTMA?

____ students

4a. Did any of your students submit some eTMAs but then revert to paper submission for some or all of the later assignments?

- ◯ Yes
- ◯ No - please go to question 5

4b. If 'Yes', approximately how many students?

[ ] students

4c. If 'Yes', what reasons did they give?

Please state here:

5. Please indicate what you said to your students at the beginning of the course, or during the course, about e-submission of TMAs. Did you take a neutral stance, or emphasise advantages of the eTMA system, or discourage electronic submission, or not mention it explicitly?

Please state here:

6. Please indicate the APPROXIMATE percentages of eTMAs that were produced in the following ways:

[ ] % - Word-processed, including equations and diagrams

[ ] % - Word-processed text, with handwritten equations and/or diagram

[ ] % - Handwritten

7. Please indicate the APPROXIMATE percentages of eTMAs that were submitted in the following file formats:

% - Microsoft Word

% - Other word processor formats (Star Office, OpenOffice, etc)

% - PDF

% - RTF

% - Image files

8. Did any students appear to have difficulties producing files within the size limitation? If so, please indicate why. ***(Initially the limit was 2Mb, but for later TMAs it was increased to 3Mb so that students who were scanning handwritten pages had a bit more leeway.)***

Please state here:

9. How useful were the guidance notes about marking with the Tablet PC?

Not useful

Of little use

Moderately useful

Useful

Very useful

10. How could the guidance notes be improved?

Please state here:

11. What was your general approach to marking eTMAs? ***(e.g. did you convert the document to PDF and use PDFAnnotator to mark, or did you adopt a different approach? If you marked in Word, did you use Track changes/ Comments/ text boxes/ ink?)***

a) When a Word-readable document was submitted?

b) When other formats were submitted?

12a. Did you use a keyboard for text entry when annotating eTMAs?

- Yes
- No - please go to question 13

12b. If 'Yes', did you use the Tablet PC keyboard or an external keyboard?

- Tablet PC keyboard
- External keyboard

13. Did you cut and paste sections of the model answers into the eTMAs?

- Yes
- No

14. What problems or difficulties (if any) did you experience when using the Tablet PC and accompanying software? ***(Any tips on overcoming problems that might help new ALs would be useful)***

Please state here:

15. Do you put more or fewer COMMENTS on an eTMA than a paper TMA?

- ○ Many fewer
- ○ Slightly fewer
- ○ About the same
- ○ Slightly more
- ○ Many more

16. On average, are your COMMENTS ON THE SCRIPT longer or shorter on an eTMA than a paper TMA?

- ○ Much shorter
- ○ Slightly shorter
- ○ About the same
- ○ Slightly longer
- ○ Much longer

17. On average, are your PT3 COMMENTS longer or shorter for an eTMA than a paper TMA?

- ○ Much shorter
- ○ Slightly shorter
- ○ About the same
- ○ Slightly longer
- ○ Much longer

18. In general, do you think your comments are more or less HELPFUL on an eTMA than a paper TMA?

- ○ Much less
- ○ Slightly less
- ○ About the same
- ○ Slightly more
- ○ Much more

19. In general, do you think your comments are more or less LEGIBLE on an eTMA than a paper TMA?

- ○ Much less
- ○ Slightly less
- ○ About the same
- ○ Slightly more
- ○ Much more

20. To what extent is marking eTMAs more or less COMPLEX than marking paper TMAs?

- ○ Much less
- ○ Slightly less
- ○ About the same
- ○ Slightly more
- ○ Much more

21. To what extent is marking eTMAs more or less STRESSFUL than marking paper TMAs?

- ○ Much less
- ○ Slightly less
- ○ About the same
- ○ Slightly more
- ○ Much more

22. To what extent is marking eTMAs more or less FLEXIBLE than marking paper TMAs?

- ○ Much less
- ○ Slightly less
- ○ About the same
- ○ Slightly more
- ○ Much more

23. To what extent is marking eTMAs more or less CONVENIENT than marking paper TMAs?

- ○ Much less
- ○ Slightly less
- ○ About the same
- ○ Slightly more
- ○ Much more

24. Overall, how does the TIME REQUIRED to deal with an eTMA compare with the time required for a paper TMA?

- ○ Much less
- ○ Slightly less
- ○ About the same
- ○ Slightly more
- ○ Much more

25. Compared with marking paper TMAs, what contributes most to...

... reducing time required for each eTMA?

... increasing time required for each eTMA?

26. What were the main ADVANTAGES for you of using a Tablet PC to mark and annotate eTMAs compared to marking and annotating on paper?

Please state here:

27. What were the main DISADVANTAGES for you of using a Tablet PC to mark and annotate eTMAs?

Please state here:

28. What are your overall views about marking eTMAs for Level 3 Physics and Astronomy courses compared with marking paper TMAs?

Please state here:

29. Which method of marking TMAs do you now prefer for the Level 3 Physics and Astronomy course that you tutor?

- Strong preference for marking paper TMAs
- Slight preference for marking paper TMAs
- Equally happy with marking paper TMAs and eTMAs
- Slight preference for marking eTMAs
- Strong preference for marking eTMAs

30. Please note any extra features that you would like to see developed for the Tablet PC and the associated software that would help the electronic marking process?

Please state here:

31. What feedback did you receive from your students about the eTMA system, and particularly about the form of the electronic marking and annotation on the returned scripts?

Please state here:

32. Do you have any suggestions for additional advice that the Course Team could provide to students about producing eTMAs?

Please state here:

33. Do you have any helpful hints or advice about use of the Tablet PC for eTMA marking that you would like to be circulated to your colleagues?

Please state here:

34. Do you have any comments to make about the e-monitoring system, either from the viewpoint of someone who was monitored or from the viewpoint of someone who did the monitoring?

Please state here:

35. Has the Tablet PC proved useful to you for other applications besides marking eTMAs for Level 3 Physics and Astronomy courses? ***(You might like to comment on any use you have made of the Tablet PC for other OU applications or for home or work applications, and the extent to which you have used the tablet configuration as opposed to the simple laptop configuration.)***

Please state here:

36. Are there any other comments regarding this trial that you would like to make?

Please state here:

Many thanks for taking the time to complete this questionnaire. We will send you a copy of the report that summarises the views of ALs early next year. Please submit your responses by clicking on the button below.

Submit

If you have any technical problems accessing or submitting this questionnaire please email: The OU ELSA Team.

Marking and commenting on eTMAs using a Tablet PC

(Version 6.2, December 2008)

These notes describe three methods for marking eTMAs using a Tablet PC. They are based on ALs' experiences of using Toshiba Tecra Tablet PCs for marking physics and astronomy eTMAs as part of a trial funded by the Physics Innovations Centre for Excellence in Teaching and Learning (πCETL). You may discover other ways in which a Tablet PC can be used for marking eTMAs – or other methods of marking physics and astronomy eTMAs that do not require a Tablet PC. If you have any additional tips that you would like to share with colleagues, please post them on the AL FirstClass forum for your course, and we will incorporate them in updated versions of this document.

This document does not discuss the interaction of ALs with the eTMA system itself, since this is covered by the generic information and training materials provided by the OU. If you have not previously marked eTMAs, it is strongly recommended that you work through these materials and attend one of the eTMA training sessions provided at your regional centre.

Learning how to use the Tablet PC

If you have not used a Tablet PC, then you may wish to use some of the on-screen training materials that are provided with the Toshiba Tecra. These include an introductory tutorial, which you can access from Start / All Programs / Get Going with Tablet PC, and more detailed online training, which you can access from Start / All Programs / Tablet PC / Tablet PC Tutorials.

A few points that ALs have suggested should be mentioned up front:

Ergonomic considerations

Marking eTMAs involves a lot of time working with a computer, so you should spend some time initially finding a way of working with the Tablet PC that you find comfortable.

(a) Writing position. Writing on the screen may be uncomfortable because it is a few centimetres above the surface of your desk. Possible solutions include:

• using a book beside the Tablet PC to support your forearm at the level of the screen;

• using a lower work surface than your normal desk (or a higher chair);

• working with the Tablet PC on your lap, while sitting (or even reclining) on a sofa;

• working with the bottom edge of the Tablet PC resting on your lap and the top resting at an angle against your desk;

• working with the Tablet PC propped on a bookstand, with an external keyboard and mouse at one side.

(b) Viewing the screen. As with all computer screens, it is necessary to choose a position for the screen that avoids reflections from windows, lights, etc. Several wearers of varifocal glasses have said that they prefer to use single-prescription reading glasses when working with the Tablet PC.

Marking an eTMA

There are a number of methods of marking eTMAs using a Tablet PC. The method we recommend is to use PDF Annotator to make handwritten comments (Method 1, below), and this can be done irrespective of the file formats that students submit. A large proportion of eTMAs are submitted as Microsoft Word files, and these can be annotated by hand using the Ink Annotation and Ink Comments tools that are available when running Word on a Tablet PC (Method 2). If you have a strong preference for keyboard entry of annotation, you may wish to use Word text boxes and comments for annotating students' work (Method 3).

Method 1: using PDF Annotator

This method involves using the PDF Annotator application **(**Grahl Software Design, http://www.GRAHL-software.com **)** to mark a pdf file containing a student's answers. The annotated pdf file is then saved in pdf format and returned to the eTMA system. Students can view the annotated files using Adobe Reader.

If you use this method, you should encourage students to submit their eTMAs as single pdf files, if possible. Alternatively, if they submit in any format that you are able to open and print on your computer, you can convert their file to pdf format using the PDF Creator application (free software available for download from http://www.pdfforge.org).

Both PDF Creator and PDF Annotator are pre-installed on the Tablet PCs provided by πCETL.

(a) Using PDF Creator to produce a pdf file from any file that can be printed. (This process can be omitted if a student submits an eTMA as a pdf file.)

- Open the file containing the TMA answer using a computer with the PDF Creator application installed. (Installing PDF Creator sets up a virtual printer on a computer, and printing the student's eTMA with this virtual printer creates a pdf file of the assignment.)

- Click on File / Print, and in the print dialogue window select PDF Creator from the drop down list of printers, and then click on OK.

- In the PDF Creator dialogue window that then opens you have the option of adding/changing information about the pdf file, but that should not be necessary. Uncheck the box 'After saving open the document with the default program', unless you intend to mark this TMA immediately *and* you have set PDF Annotator as your default program for opening pdf files (see section (c) below for instructions about how to do this). Click on Save.

- In the Save as dialogue window, ensure that the folder where you wish to store the pdf file is displayed in the Save in: area . It is simplest to use the same folder as for the student's original file. You have the option of changing the name of the file, but it is probably best to keep the same name as the original file (- it will have a .pdf extension to distinguish it). Click on Save to create the pdf file.

(b) Producing a single pdf file from two or more files.

We encourage students to submit their solutions to a TMA as a single file, and the notes for students about producing an eTMA on the course website give advice about doing this. If a student produces a large number of image files for scanned images, they should be encouraged to combine them into a single pdf file or to paste them into a single Word file.

If a student has submitted their eTMA as several files zipped together, then you may wish to combine them into a single pdf file. In this case, open the first file, click on File / Print, and in the print dialogue window select PDF Creator from the list of printers, and then click on OK. In the PDF Creator dialogue box that opens, click on the Wait-Collect button (rather than clicking on Save).

The PDF Creator – PDF Print Monitor window opens, showing the file with 'Waiting' status.

Open the second file and print using PDF Creator as before. The file automatically goes into the 'waiting' list in the PDF Creator – PDF Print Monitor window, which can be displayed by clicking on its tab in the task bar at the bottom of the screen. Repeat this procedure for each of the files that are to be combined into a single pdf file.

Display the PDF Creator – PDF Print Monitor window, and highlight all of the files you wish to combine into a single document. Then select Document / Combine from the menus, followed by Document / Print. In the PDF Creator window, click on Save, and in the Save as dialogue window select the folder where you want to store the file and give the combined file a suitable name. Then click Save to create the pdf file.

You will probably find it convenient to produce pdf files for all of the eTMAs you have received before you start to mark them.

(c) Marking and commenting using PDF Annotator

Making PDF Annotator the default pdf viewer You may find it convenient to make PDF Annotator your default program for viewing pdf files on the Tablet PC. This can be done by right-clicking on the icon for any pdf file, and selecting Open With / Choose Program, then highlighting PDF Annotator in the list of programs in the Open With dialogue window and checking the box 'Always use the selected program to open this kind of file', and clicking on OK. (Making Adobe Reader the default pdf file reader can be done in a similar way.)

Selecting the screen orientation The default orientations for the display are Primary Landscape (bottom of display at hinged edge of screen) in the laptop mode and Primary Portrait (hinge at the right of the display) in the tablet mode. Most ALs prefer a portrait orientation of the display for marking eTMAs because this allows almost a full page of an eTMA to be displayed full size. The orientation is easily changed by tapping on the 'Change tablet and pen setting' icon at the right of the task bar, selecting Properties and then selecting the Display tab. The orientation of the display can then be selected from the drop down menu.

To set a particular display orientation as the default orientation when the screen is rotated to the tablet mode, tap on Start / All Programs / TOSHIBA / Tablet PC / Rotation Utility, then select the required default orientation from the drop down list for 'When in Tablet PC mode'.

Opening the pdf file for an eTMA If you have made PDF Annotator your default pdf file viewer, simply tap on an icon or file name of the pdf file for a student's eTMA and it will be opened with PDF Annotator. If another program is your default pdf file viewer, either right-click on the icon or file name of the pdf file, and select Open with PDF Annotator, or start the PDF Annotator program and open the appropriate file from within the program.

Annotating a pdf file Ensure that the File, Page, Pen, View, Text and Custom Pens toolbars are displayed by tapping on View / Toolbars / Customize and checking all of the boxes displayed under the Toolbar tab.

You can use the tablet pen to annotate the pages on screen in the same ways that you would use a normal pen when marking on paper.

- The buttons on the Pen toolbar and/or the Custom Pens toolbar can be used to select the ink colour and the line width. The Customize pens button on the right of the Custom Pens toolbar allows you to specify 12 different colour/linewidth combinations for pens, each of which can then be selected with a single click of a button on this toolbar.

- An eraser can be selected from the Pen toolbar to remove ink annotations. The eraser mode can be set (via Extras / Settings / Eraser) to either erase the whole of a pen stroke that is pointed at or only the ink that the eraser is moved over.

- The Select Ink tool (lasso button on the Pen toolbar) can be used to draw a loop to surround an ink annotation, which can then be dragged or resized, and can be cut or copied and pasted elsewhere in the same file or another file.

- You can insert a text box by tapping on the Text button (spanner with letter A) on the Pen toolbar, and then tapping at the point in the document where you want to place the text box. Material can be entered into the box using the Tablet PC Input Panel, which can be opened by tapping on the icon at the left of the task bar. The Panel provides three methods of text entry. Selecting the On-Screen Keyboard (bottom icon at the left of the Panel), allows you to tap on each character in turn. The Writing Pad (top icon) will convert handwriting in printed text; the conversion appears to be quite robust, and it is straightforward to correct any errors. The third option is the Character Pad (middle icon at the left of the Panel), which requires each character to be handwritten separately. However, it is much simpler to input material using an external keyboard plugged into a USB port.

The font and size of the inserted text can be selected using the Text toolbar, and the colour selected using the Pen Colour button on the Pen toolbar. All of the text in a box has to be the same font and the same colour, though these attributes can be different in different boxes. Unfortunately this means that you cannot mix roman, bold and italic in a text box, nor mix Symbol font with another font.

- The Insert Image tool on the Pen toolbar can be used to insert an image from a file stored on your computer.

- Ink comments, text boxes and images can be saved as macros that can then easily be inserted elsewhere in any document. To save a macro, use the Select Ink tool to select the appropriate ink comment, or tap on an inserted text box or image to select it, and then choose Edit / Save As Macro from the menus. Up to 12 macros can be saved in this way.

- A comment that has been saved as a macro can be inserted into a file by choosing Edit / Insert Macro and selecting the required macro from the drop down list that is displayed. The macros can be listed in a convenient order on the menu by selecting Extras / Settings / Macros and moving specific macros up or down the list, as required, and unwanted macros can be removed using the Delete button. Macros can also be inserted into a pdf file using the keyboard shortcuts Ctrl+F1 to Ctrl+F12.

- A blank page for additional comments can be inserted *before* the page that is currently displayed by choosing Edit / Insert Page from the menus.

- A blank page can be appended *after* the page that is currently displayed by choosing Edit / Append Page from the menus. Inserted or appended pages can be removed by choosing Edit / Delete Page from the menus. *Note that it is not possible to restore a deleted page, so care is needed to avoid deleting a page of a student's answer.*

- Parts of another pdf file (e.g. a file containing Specimen Answers) can be pasted into a student's eTMA file. The required part of the Answer file is copied using Adobe Reader, and this is done by opening the pdf file with Adobe Reader (version 8 is now available from the Adobe website), selecting the Snapshot Tool button (camera icon) on the toolbar (or alternatively choosing Tools / Select & Zoom / Snapshot Tool from the menus), and then selecting the required area by using the tablet pen to drag the pointer from the top left to bottom right of the required area; this copies the selected area to the clipboard. Returning to the PDF Annotator window, the copied material can be pasted into the student's answer, and moved and resized as appropriate. This copying process works best when the source material is copied and pasted at the actual size required in the final document, since enlarging or reducing the pasted pdf insert degrades the image quality. Small insertions, such as an equation or a diagram, can be located in white space alongside the student's answer, but large chunks of Specimen Answer need to be pasted into an appended page. Material from the Specimen Answers that spans two pages will have to be pasted in two parts since it is not possible to use the Snapshot Tool to select material for copying from more than one page. (NB using the Select (arrow) tool to highlight material for copying from a pdf file only works with plain text, since the symbols, formatting, etc. are not preserved when the material is pasted into PDF Annotator.) Pdf inserts can be saved as macros, as described above.

- Any material that is copied and pasted from the Specimen Answers can be annotated by hand in the normal way.

- A complete pdf file (such as the Specimen Answers) can be appended to the end of an eTMA file by choosing Edit / Append Document from the menus, and then selecting the appropriate pdf file in the Open dialog. Individual pages can be deleted from the appended file by tapping on the page, and then choosing Edit / Delete Page from the menus, and this means that only the pages appropriate for a particular student need be included.

It is not possible to open two pdf files in the same PDF Annotator window, but you can have two or more PDF Annotator windows running simultaneously (by opening each file by tapping on its icon). This allows you to annotate a student's answer in one window, and annotate the Specimen Answers in a second window, and as you are marking you can switch back and forth between the two files (and the PT3 window) using the buttons on the task bar. On completion of marking and commenting you can save the annotated specimen answers and then append them to the annotated student answer file (as described in the previous paragraph). However, it may be better to simply zip together the annotated version of the student's answer file and the Specimen Answer file.

- When you have finished marking and commenting, select Edit / Melt all annotations from the menus in order to make all of your marks and comments 'permanent', and then save and close the pdf file and the PT3 entry window. Annotation cannot be removed after it has been melted, though additional annotation can be added.

Method 2: using ink in Word

If an eTMA is submitted as a Word-readable file, you may prefer to mark and annotate the file using the ink options available in the Tablet PC version of Word 2003 and in later versions of Word. However, note that if you use Comments or Ink Comments, their location and appearance on a student's PC will depend on the version of Word that they have installed and the settings chosen (see Appendix 2 of the *Using the eTMA System* workbook). If this causes problems, you could convert your annotated file to pdf format using PDF Creator. If you use Word 2007, you could save the annotated answer file as a pdf file.

Opening the eTMA file With the Tablet PC in the tablet configuration, open the eTMA file with Word. Display the toolbars for Ink Annotations, Ink Comment, Drawing and Reviewing by selecting View / Toolbars from the menus and checking in turn the appropriate boxes.

There are two methods for inserting ink marks and comments into the document without changing the formatting of the student's answer.

(a) Using Ink Annotations to insert ink marks anywhere on the page of a Word (or other Microsoft Office) document that is displayed on the screen.

- You can select a pen colour and line width using the dropdown list beside the pen button (first button on the left of the Ink Annotations toolbar); this allows selection of standard colours of ball point pen, felt tip pen or highlighter. For a wider selection of colours and line styles, use the separate drop down lists of colours and line styles on the same toolbar. You can then write marks and comments anywhere in the displayed document. Can drop down list be customized?

- Select the Eraser button on the Ink Annotations toolbar to remove unwanted ink. Is erase mode adjustable?

- To switch off the ink or the eraser, tap on the Stop Inking or Stop Erasing buttons that appear on the Ink Annotations toolbar when a pen or eraser has been selected.

- If more space is required to insert additional feedback for a student, a blank page can be inserted in the student's answer file by tapping at the beginning or end of a page, and choosing Insert / Break / Page Break / OK from the menus. (Note that this does result in the renumbering of the student's pages.)

- Material can be copied from another file (e.g. a Word file containing the Specimen Answers) and pasted in the normal way into the student's script at an appropriate place, either at the end of a question or at the end of the script. A complete file can be inserted by tapping at the appropriate place in the student's eTMA, and choosing Insert / File from the menus, browsing to the appropriate file in the Insert File dialog box and tapping Insert. To maintain the student's layout on the pages (though not the page numbers), you can insert page breaks before and after the inserted material. You may prefer to insert additional material, such as Specimen Answers, at the *end* of the students eTMA file. Alternatively you could leave this material in a separate file and zip this file with file containing the annotated answer for return to the student. Any material inserted from the Specimen Answers can be annotated in the ways described above.

- Note that care is needed to ensure that the student's answer is not displaced relative to ink annotations by the subsequent insertion of additional space for annotation earlier in the answer.

(b) Using Ink Comments to add handwritten comments. This is much less flexible than using ink annotation, since comments would typically be written in balloons in the right margin. However, ink comment balloons do provide a neat way of distinguishing different comments, and they can be used alongside ink annotations.

- The location of ink comments can be selected using the Tools / Options / Track Changes dialogue: for example, selecting Use Balloons: Always and selecting Margin: Right will enable you to insert handwritten comments in balloons in the right margin. If you intend to use the Ink Comment facility, with balloons in the right margin, then it would be worth asking students to leave a wide margin on the right of their answer. However, note that the student's view of these comments will be determined by the settings for comments on their computer, as described in the *Using the eTMA System* workbook. Possible problems here can again be avoided by returning the annotated file in pdf format.

- To insert a handwritten comment, tap at the point in the document to which the comment will be tied. Then tap on the Ink Comment button on the Reviewing toolbar, or choose Insert / Ink Comment from the menus.

- A balloon appears in the right margin, linked to the appropriate point in the document, and marks, comments, equations or diagrams can be written inside the balloon. The balloon will get deeper if the pen writes close to the bottom of it.

- A separate eraser button appears on the tool bar when an Ink Comment is highlighted, and tapping on this allows the comments to be deleted or revised.

- An Ink Comment balloon can be removed by tapping on it and then tapping on the Reject Change / Delete Comment button on the Reviewing toolbar.

- Care is needed to ensure that Ink Comments don't cover up annotation in the margin.

Method 3: using Text Boxes and Comments in Word

This method is essentially the standard method for marking eTMAs using Word, as described in the *Using the eTMA System* workbook and the *Guide to eTMAs for Associate Lecturers*. It allows insertion of comments, marks and other annotation via the keyboard if you prefer this method to handwriting your comments, and does not require use of the Tablet PC. Of course, equations and diagrams are more difficult to insert using this method than by handwriting with the ink tools.

Opening the eTMA file With the Tablet PC in the laptop configuration, open the student's eTMA file in Word, and display the Reviewing toolbar (click View / Toolbars / Reviewing) and the Drawing toolbar (click View / Toolbars / Drawing).

- To insert text annotation on the document, click on the Text Box button on the Drawing toolbar, then click on the document at the point where you want the top left corner of the text box to be located and drag the pointer to the location of the bottom right corner. Then key in the appropriate text. The text box can be resized or moved if necessary, and the font size, colour, etc. can be selected in the normal way to make the text clearly distinguishable from the student's answer. You can select a Fill Colour for the box and a Line Colour for its border using buttons on the Drawing toolbar, or can opt for No Fill and No Line.

- To insert a marginal comment tied to a particular point in the answer, click at that point and click on the Insert Comment button on the Reviewing toolbar (*not* the Ink Comment button); then type your comment in the marginal balloon.

- The location of comments can be selected using the Tools / Options / Track Changes dialogue: for example, selecting Use Balloons: Always and selecting Margin: Right will enable you to insert text comments in balloons in the right margin. If you intend to use the Comment facility, with balloons in the right margin, then it would be worth asking students to leave a wide margin on the right of their answer. However, note that the student's view of your comments will be determined by the setting for comments on their computer, as described in the *Using the eTMA System* workbook. Possible problems here can again be avoided by returning the annotated file in pdf format.

- To highlight part of the text, click on the Highlight button on the Reviewing toolbar, and click and drag the pointer over the material to be highlighted. The colour of the highlighting can be chosen using the down arrow beside the Highlight button.

- Additional pages or material from separate files can be inserted as described in Method 2.
- It is also possible to use the Track Changes facility to delete material from the student's answer and to insert material. However, many ALs prefer to leave the student's answer unchanged, and to add their own annotation on top of this.

Combining methods 2 and 3

You can combine Methods 2 and 3, so that you use the keyboard for simple text insertion and the tablet ink facility for equations and diagrams. There are two ways to do this.

(a) Switching back and forth between the laptop and tablet configurations for the screen. It only takes about 15 seconds to change the screen configuration, so it is possible to use the keyboard for insertion of simple text comments with the screen in the laptop configuration, and then change to the tablet configuration – with the Word file still open – to use ink annotation for equations and diagrams. However, there are concerns that the hinge mechanism for the screen may not withstand frequent switching back and forth between modes.

(b) Using an additional keyboard connected to a USB port of the Tablet PC. If you have a USB keyboard that you can plug into the Tablet PC, then you can use the computer in the tablet configuration, and can use the additional keyboard for text entry and the tablet pen to write on the screen when you wish to insert equations and diagrams.

Additional points about eTMAs submitted as Word files

- If you want to fix the annotation in a marked TMA to ensure a student sees exactly what you have written and to avoid possible incompatibilities in software, save the annotated file in pdf format using the PDF Creator virtual printer, and return the pdf version to the eTMA system.
- If a student submits an eTMA as a Word file (or OpenOffice, StarOffice), and you prefer to mark with PDF Annotator, then you can convert the file to pdf format using PDF Creator. However, you could gently encourage the student to submit subsequent eTMAs as pdf files – the student notes explain how this can be done with the PDF Creator application (freeware).
- If a student produces an eTMA using Word 2007, then they can be asked to save and submit either as a .doc file so that you can mark with Word 2003 on the Tablet PC, or as a pdf file so that you can mark with PDF Annotator.

Completing the PT3 Entry

It is not possible to complete the PT3 Entry by annotating the form using the tablet pen – this has to be done via text entry, and there are a number of ways to do this while marking with the Tablet PC.

- If you have an external USB keyboard, it is straightforward to switch back and forth between tablet pen annotation in the student's answer window and text entry in the PT3 Entry window.
- You could switch between using the tablet configuration for marking and the laptop configuration for PT3 entry. This is probably only practicable if you wait until you have marked all of the questions for a student before filling in the PT3.
- Marks and text can be entered in the PT3 using the Tablet PC Input Panel, opened by clicking on its icon at the left of the task bar. This gives you the options of using the On-Screen Keyboard, the Character Pad or the Writing Pad for text entry. If your handwriting is reasonable, then the Writing Pad may be your best option.

Advice to students

In the advice we give students about eTMA production and submission, we stress a number of points, but past experience shows that some students overlook or ignore this advice. In particular, we suggest that students should do the following.

- Leave large margins around answers, generous spaces between parts of answers, and start each answer on a new page. This should plenty of space for their tutor's comments.
- If scanning handwritten solutions, ensure that file sizes are not excessive and that image quality is sufficiently clear for their tutor to mark without difficulty. Students have been told that the absolute limit on file size that the eTMA system will accept for courses that are part of the Tablet Pc marking project is 3 MB, but they should aim to keep the size to less than 2 MB.
- Scanned images should be combined into a single file, either pdf or doc format, and not submitted as separate files for each page.
- Submit a dummy TMA00 to the eTMA system, so their tutor can check on the suitability of the method that a student is using, and they can check that they can view the comments that their tutor makes.

You may wish to reinforce some of these points in your communications with students.

Some final points

- You can return eTMAs as soon as you have marked them; the eTMA system will not make them accessible to students until after the cut-off date.
- It should not be necessary to return a student's original eTMA file as well as the annotated eTMA, though there is no harm in returning both. The student will have retained a copy of the original file, and it should be easy for a monitor to distinguish your annotation from the student's work.
- If there is a problem with opening or reading a student's eTMA file, then you should ask them to resubmit it. In some cases it may not be possible to resolve the problem and you can request a paper version. If you mark the paper version and return it to Walton Hall, this should over-ride the record of the eTMA that was submitted (though this may take some time).

An extract from a tutor marked assignment annotated on a Tablet PC using PDF annotator
Produced by Pamela Budd with thanks to an anonymous student

Therefore when combining the two equations:

$$v = \frac{L}{\frac{\theta}{\omega}}$$ ✓

Simplified as;

3/3

$$\boldsymbol{v} = \frac{\boldsymbol{\omega L}}{\boldsymbol{\theta}}$$ ✓ good

b) The probable speed of the aluminium molecule is given by;

$$v_{mp} = \sqrt{\frac{2kT}{M}}$$ m

or we could use

$$v_{mp} = \sqrt{\frac{2RT}{M}}$$

Where

K = 1.381 x 10^{-23} *JK*$^{-1}$ *= Boltzman constant*

T = 900° C =1173K Temperature of the beam

M = 0.0270 kg mol^{-1} molar mass of aluminium ✓

Applying these numbers to our equation;

$$v_{mp} = \sqrt{\frac{2 \times 1.381 \times 10^{-23} \times 1173}{0.0270}}$$

$$\boldsymbol{v_{mp} = 1.095 \times 10^{-9}\ \mathrm{ms^{-1}}}$$

{Name be careful of the value for m:

The mass *m* of a mole is 0.0270 kg mol^{-1} ÷ 6.02 × 10^{23} atoms mol^{-1}
= 4.48 × 10^{-26} kg.

7

Hence $v_{mp} = (2kT/m)^{1/2}$

$= (2 \times 1.38 \times 10^{-23}\ \mathrm{J\ K^{-1}} \times 1173\ \mathrm{K} / 4.48 \times 10^{-26}\ \mathrm{kg})^{1/2}$

$= 850\ \mathrm{m\ s^{-1}}$. }

The rotational speed ω of the disc is given by;

$$\omega = \frac{v_{mp} \times \theta}{L}$$

↗ π/6 – we usually work in radians here – angular speeds usually have units rad s⁻¹

Where
L = 0.262 m   Θ = 30º and $v_{mp} = 1.095 \times 10^{-9}$ ms^{-1}

5/8

$$\omega = \frac{1.095 \times 10^{-9} \times 30}{0.262}$$

ω =**3.54x10^{-4} ms^{-1}**

{The angle is $\theta = 30° = 30° \times \pi$ rad / 180° = π/6 rad.

The spacing is L = 262 mm = 0.262 m.

The rotation speed is $\omega = v\theta/L = 850\ \mathrm{m\ s^{-1}} \times \pi/6\ \mathrm{rad}/0.262\ \mathrm{m}$
$= 1700\ \mathrm{rad\ s^{-1}}$.}

c) First the most probable speed for the silver beam is;

$$v_{mp} = \sqrt{\frac{2kT}{M}}$$

again be careful of m

Where K = 1.381 x 10^{-23} JK^{-1} T = 900° C =1173K M = 0.108 kg mol^{-1}

correct method – propagated errors

3/3

$$v_{mp} = \sqrt{\frac{2 \times 1.381 \times 10^{-23} \times 1173}{0.108}}$$

$$v_{mp} = 5.477 \times 10^{-10}\ \mathrm{ms^{-1}}$$

– see * on next page for alternative approach.

Rotation speed is given by;

$$\omega = \frac{v_{mp} \times \theta}{L}$$

Where

8

Embedding mathematical content and figures in electronic assignments

Jimena Gorfinkiel

Background

The aim of this project was to trial equipment that would assist students on the second level physics course S207, *The physical world,* in producing their tutor marked assignments (TMAs) electronically. The Open University has, over the last few years, set up the facility for submitting course assessment work electronically. Electronic submission has several administrative advantages and can also benefit students by reducing the return time (that is, the time between the date the students submit their TMA and the date they are sent the corrections and comments by their tutor) thus enhancing the formative aspect of TMAs. Reducing return time is particularly important in a fast paced and wide ranging course like S207, where students could well be studying a very different field of physics by the time their marked TMAs are returned to them. In addition, more and more students expect to be able to use the computer for all activities related to Open University study.

The main problem faced by physics and maths students when producing electronic versions of their coursework is the difficulty of inputting equations and figures. There is, of course, software available to do both of these things to outstanding quality. However, it is impractical to expect our students to invest the time required to learn to use it: our students normally have limited time available for their studies and this time should be spent on achieving the learning outcomes of the course. Text editors like Word or OpenOffice have a facility for inputting equations. This facility is relatively easy to use, but rather slow and time consuming as it requires the user to click every symbol that needs to be included in the equation. Other software, like LaTex, can be extremely efficient and produce excellent quality documents. However, there is a steep learning curve with LaTex as users need to remember (and type) the command for each symbol, or combination of symbols, they want to use. For students who are proficient in the use of a text editor that allows for the inclusion of equations, the longer time that it takes to type as opposed to writing down an equation may be compensated by the time saved erasing an overwriting electronically. This is probably also the case if they are proficient in the use of graphical software, for which the situation is similar: a variety of software and freeware is available, but learning to use it takes time and for many students it is not necessarily a skill that will be of use to them in the future, particularly since not all of them go on to study further highly numerate courses.

There was, therefore, a perceived need for equipment that would allow the students, with minimal time-investment, to produce an eTMA (electronic TMA) of good enough quality for the tutor to be able to mark it electronically.

During the 2006/07 and 2007/08 presentations of S207, students were given the opportunity of requesting the electronic equipment listed below. The equipment was chosen in the hope it would fulfill the following requirements:

1. Easy to install.
2. Easy to use, without the need to spend long hours becoming familiar with it.
3. Enable students to produce a document that can be easily read and marked by their tutor.
4. Allow students to generate a modestly-sized file (3 Mb), as the university poses restrictions on the size of the file that can be submitted to the eTMA system.
5. Allow the student to generate a single document (rather than, for example, one electronic file per TMA page); this could be achieved by means of collating the files using different software.

The equipment

During the first year of the trial (2007) students were offered the following equipment:

- CanoScan scanner: a fast scanner that allows colour and black and white scanning. The software provided with this scanner enables users to generate, relatively straightforwardly, a single pdf document.

- LogiTech io Pen: this system can be used to handwrite TMA answers, including equations and figures, with a special pen on special paper (also provided). Information is stored in the pen and then downloaded to a computer via a USB connection. Users can't see on the screen what the document looks like while they are writing it (though they can see it on the paper). On the other hand, they don't need to be close to a computer to write their TMAs.

- PC Notes Taker: this system can be used to handwrite TMA answers, including equations and diagrams, with a special pen and a sensor that clips to a sheet of paper and is connected to a USB port on the computer. Information about the pen's movements is transmitted to the computer and displayed on screen while students write normally on standard paper.

During the second year of the trial (2008) the PC Notes Taker was replaced by the following:

- DigiMemo notepad: this system can be used to handwrite TMA answers, including equations and diagrams. It consists of a support pad for normal paper and a special pen. The information is stored in the support pad and is then downloaded to a computer via a USB connection. There is the option of writing on the pad while it is connected to the computer, thus allowing the user to see in real time how the electronic files for their eTMA will appear.

The substitution was made on account of the previous year's experience: as would emerge in the trials, some of these electronic pens are very good for writing text, but not precise enough for drawing 'quantitative' graphs. Users of the PC Notes Taker had also pointed out a problem when using a ruler to draw diagrams. The equipment relies on the pen sending a signal to the sensor clipped at the top of the paper. When using a ruler, the hand holding it can block the communication between pen and sensor thus preventing the equipment from storing information on what is being drawn.

All the equipment provided had a further advantage: students would always have a paper version of their TMA to send to their tutor if they had any problems with the electronic file produced.

Students were provided with relatively detailed information on how to use the equipment to produce an electronic file per TMA page and then collate all these into a single file.

Of all the equipment, the scanner was seen as the 'low-tech' option and therefore the most appropriate for students with little computer experience who wanted to produce their eTMA in one go. Nevertheless, all the equipment could be used to write equations or draw figures and graphs that could then be included in a word-processed TMA. No advice was given on how to do this, but we assumed that students who could use a word-processor and wanted to try this option, would find a way to do it.

The trial of this equipment was run in parallel with that of tablet PCs. These were provided to the tutors of this course to facilitate the marking of eTMAs (see report by Stuart Freake).

The trials

Around 500 students take part in each presentation of S207. During the 9-month long course they have to submit 7 TMAs, about one TMA a month. Each of these normally comprises four or five long questions that in many cases require students to draw diagrams and/or figures and in almost all cases involve writing and operating with several equations. The TMA answers can fill up to 20 pages depending on how much the student writes, spacing, etc.. During the trials, the course started in February and finished in October. Even before the beginning of the trial some S207 students were using text editors to produce eTMAs. However, the number of students submitting eTMAs was small.

We expected the trial to be of interest to two different groups of students:

- Those comfortable with typing text and the basic use of a text editor (like Word or OpenOffice), for whom it would provide a tool to produce equations and figures in electronic form to be included in their documents
- Those with little computer experience, who would use the tool to produce a complete TMA

The first trial was carried out in 2007. Since not all tutors were using their tablet PCs for electronic marking, we asked them to volunteer to contact their students with information about the trial. In this way, only tutors who were keen on electronic marking would, hopefully, receive an increasing number of eTMAs. Tutors were given some information about the trial and the equipment and were provided with a standard letter to send to the students. This letter invited students to '*volunteer to take part in an Open University project, supported by πCETL (Physics Innovations Centre of Excellence in Teaching and Learning), to examine the ways in which technology can be used to embed mathematical content in assignments in such a way that it can be usefully annotated and commented upon'.* The letter also stated that:

> *Participation in the project will not advantage or disadvantage you, in terms of your study of S207. However, we hope that if you choose to participate, you will find it easier to produce eTMAs and this may enhance your enjoyment of the course. Participation in the study is likely to involve some small amount of extra time in getting familiar with the equipment and you should not volunteer for this if you anticipate that finding time for study of S207 will be a problem.*

Students were sent this information in March and were told that they would receive the equipment in late April. This meant that students would have already submitted TMAs 01 and 02 by the time they got the equipment and would only have 2-3 weeks to produce TMA03. For this reason, it was expected that students would use the equipment to produce TMAs 04 to 07.

The initial take up was not very encouraging: only 24 students signed up for the trial, of around 400 still actively involved in the course (it is not unusual for 10 to 20 % of students to drop out early on). For this reason, it was decided that a demonstration would be carried out during one of the SXR207 residential school weeks. (SXR207, *Physics by experiment,* is a one week residential course in which students do experiments related to the physics they have learnt in S207. The course is not compulsory for S207 students, but around half of them attend it). This took place towards the middle of July 2007 and involved the students being able to try out the LogiTech io Pen and the PC Notes Taker. As a consequence, an additional 7 students signed up for the equipment trial.

Students willing to participate had to fill in a form indicating their preferred device. Unfortunately, no one requested a scanner and since this may well have been because people already had one, we decided to send out only the electronic pens (Logitech io Pen and PC Notes Taker).

The students who initially signed up were sent the equipment in early May together with a guide to producing the eTMA in the form of a single document; those who signed up in July received the equipment and guide in early August. The guide provided some general guidelines, as well as some specific information on the installation and use of each of the electronic devices. It also described in detail how the files generated should be collated to produce a single Word or pdf file. As no one-to-one technical help could be provided, we created an on-line forum specifically for trial participants where they could exchange information and help each other.

The second trial was carried out in 2008. At the beginning of the February presentation of the course, a message was posted on the course website starting with the following paragraph:

> *Would you be interested in submitting your TMAs electronically, but are not sure how to produce them? Whether you are happy typing the text but don't know how to include the equations and figures or you would actually want help in producing a whole TMA, we may be able to help.*

They were also told that:

> *The OU computing Helpdesk does not have access to the hardware or software you will be sent. Therefore, they are unlikely to be able to help with problems specific to it. A Sub-forum within the OUSA S207 FirstClass forum will be available for you to post queries and exchange information with other students using the equipment.*

For this year's trial students were able to use the equipment for all TMAs if they wished. All the information regarding the trial and equipment was included in a web-page ("piCETL electronic pen and scanner trial") directly linked from the Course's website. This included information on the trial, its background and the equipment on offer, the request form and three documents (one for each device) giving instructions on how to produce a single file eTMA using the electronic equipment. Whereas in the previous year the information provided assumed the student would want to produce the whole eTMA (text, equations and figures) using the equipment, this time we made it clear that it was also possible to use it to produce electronic files containing equations and figures that could then be inserted into a text-processor document. Again, students were given a second chance of signing up to the trial (this time around April) and a discussion forum was also provided for participants to exchange information and queries. Some 22 students participated in the trial in 2008.

The students' responses

Towards the end of the course's presentation, after the date of the exam, a questionnaire was sent to participating students. The questionnaires varied slightly in 2007 and 2008 to take into account the different equipment as well as some of the issues that had arisen during the first trial.

Of all participants, 14 returned the completed form in 2007 and 11 did it in 2008. It should be noted that some of theses did not attempt to use the equipment. The on-line forums were not very active and did not provide us with much information on how the students got on with the equipment.

The questionnaires were design to provide the following information:

1. whether students had found the equipment useful
2. how long it had taken them to feel comfortable with it
3. whether they had encountered any serious problems
4. whether, if the student had previously submitted an eTMA, the equipment was a better tool to produce it than what they were using before

The following tables summarize the information provided by the students:

Key:

NT: PC Notes Taker
LP: Logitech io Pen
CP: CanoScan scanner
DM: DigiMemo notepad
E: equations
F: figures
W: whole TMA
Y, N, M: yes, no, maybe, respectively

PEN	Which TMA?	Used for?	eTMA before ?	Overall satisfied ?	Likes eTMAs ?	Would use pens in future?	Time (in hours)		Problems (P) and comments (C)
							install	familiarize	
NT	4-7	EF	N	Y	Y	Y	1-2	0.5-1	P: accuracy of detailed diagrams ; missing bits mean redoing diagrams C: diagrams and equations would have taken ages using word processing package
LP	4-7	EF	N	Y	-	Y	1	0.5-1	C: mistakes can be erased; can add colour; used for notes P: digital paper hard to get; converting software not good.*
NT	7	W	N	Y	Y	N	1-2	<0.5	Would prefer to type
LP	7	W	N	Y	Y	Y	<1	<0.5	P: More than 25 pages C: relative ease to produce collated document
LP	4	W	N	N	Y	M	2-4	0.5-1	Would prefer to **scan.** Problems with converting equations and scientific terminology into text *
NT	4	EF	Y	N	Y	N	<1	>1	Slower than previous method Tutor complained about graphs Equations off centre, subscripts and superscripts not in place Takes too long to draw diagrams and insert them
NT	-	-	N	N		N	1-2	-	Installed and tried Not accurate enough for detailed diagrams Thinks scanning is better

SUMMARY STUDENT RESPONSES 2007 (Continued)

PEN	Which TMA?	Used for?	eTMA before ?	Overall satisfied ?	Likes eTMAs ?	Would use pens in future?	Time (in hours)		Problems (P) and comments (C)
							install	familiarize	
LP	5	W	Y	Y	Y	Y	1-2	0.5-1	(doesn't say what he used for previous eTMAs) Best for equations and graphs Sent both paper and eTMA!
NT	-	-	Y	Y	Y	M	>4	-	Problems with filing and not very clear when you write. Filing problem prevented them from sending anything
NT	-?	-	N	N	N	N	-	-	Not submitted eTMAs before because it takes too long eTMAs take longer to produce than paper ones; only advantage not having to post them P: it's difficult to erase. Process introduces mistakes
LP	4	W	Y	N	Y	M	1-2	<0.5	Used word processor before Pen is slower; tutor found TMA very clear P: difficult to edit a downloaded page; pen too chunky
LP	4-7	EF	Y	Y	Y	-	<1	0.5-1	Previously used Microsoft equation editor P: converter (to text) not good * Saves time over using equation editor
LP	-	-	Y	N		Y	1-2	N/A	Couldn't get it to work Used MATHTYPE and word
LP	5-6	EF	Y	Y		Y	<1	-	Used word processor. Pen is faster and easier. P: difficult to draw lines using ruler C: fast an easy to use If lots of maths on TMA, would probably do them by hand.

* The installation package for the Logitech io Pen included software to convert handwritten text into typed one. We did not mention this to the students, but several of them felt this was a tool they wanted to use. Unfortunately, as this type of software tends not to recognize non-standard symbols, the students were disappointed with the outcome. It was never our expectation that students would use this option.

SUMMARY STUDENT RESPONSES 2008

PEN	Which TMA?	Used for?	eTMA before ?	Time taken to become familiar	Satisfied overall?	Likes eTMAs ?	Would use in future		Problems (P) and comments (C)
							TMA	equipment	
LP									Did not use. Found Visio easier to use for drawn. Found having to use special paper restrictive
CS	2-7	whole TMA	N	<1	Y	Y	Y	Y	Produced single document with scanner software Sent the pages in upside down for the first two submitted "Without your idiots guide to operating the scanner I would have been struggling" BEST: Sending the TMA on-line without having to go to the post office. Also speed: says if comments arrive very late she is on something else in the course WORST: none
CS	2-7	whole TMA	N	<1	Y	Y	Y	Y	Produced single document with scanner software No comments from tutor No problems producing TMA Would definitely continue using equipment BEST: The assurance that the TMAs are received and the posting is instantaneous. Environmentally friendly. WORST: Maybe the slight blurring of the graphs when scanned
LP									Did not use at all. Problem with installing software and thought would need to get special paper herself. No time to contact me.

SUMMARY STUDENT RESPONSES 2008 (Continued)

PEN	Which TMA?	Used for?	eTMA before?	Time taken to become familiar	Satisfied overall?	Likes eTMAs ?	Would use in future		Problems (P) and comments (C)
							TMA	equipment	
LP	2	Whole TMA	Y Latex / StarOffic e	1-2 and 30 min to 1hr to collate pages into single doc	N	Y	Y	maybe to use for figures	Pen is more difficult and slower to use and produces less clear documents. BEST: made including figures and graphs much easier. But thinks would be difficult to cut and paste figs. into another document. Possibility of editing and improving many times. WORST: collation into single document long and monotonous. Decided to revert to previous method. Says eTMAs take longer than hand written ones would
CS	2-7	whole TMA	N	<1	Y	Y	Y	Y	Produced single document with scanner software the scanner did not scan some default colours used by Excel '07, MS Vista complained but software worked. Scanner a bit slow Need to re-scan whole if error found ** BEST: TMAs could be submitted right up to the deadline rather than have to post early. Also had instant confirmation that TMA had been received. WORST: it would have been nice to write directly onto electronic paper, *e.g.* Tablet PC.
DM	2-7	whole TMA	Y word processor ; graphs tables scanned	<1 and 30 min to 1h to collate	Y	Y	Y	Y	Easier and faster than previous method and made including equations and figures easier BEST: individual lines in equations and pictures, can be moved and scaled with DM software allowing you to remove, edit or re-format work. WORST: compatibility of the file format the DM creates which makes it hard to edit the files in preferred word processor, Open office.

SUMMARY STUDENT RESPONSES 2008 (Continued)

PEN	Which TMA?	Used for?	eTMA before?	Time taken to become familiar	Satisfied overall?	Likes eTMAs ?	Would use in future		Problems (P) and comments (C)
							TMA	equipment	
DM	2 but submitted paper	Whole TMA	Y Word processor	<1 did not know how to collate	N	Y if mostly text	Y	N would use word processor	Was careful to draw graphs and diagrams in one go and not to move the paper, but were not reproduced the same as drawn – parts of work were moved out of place or appeared a different shape. Made several attempts. BEST: If accuracy was higher, it would be a faster way of producing equations than word-processing. WORST: accuracy More difficult and time consuming. Less clear Equations take a long time to be produced Would go for eTMAs in future as will do biology and answers are mostly textual)
DM	none (gave up on TMA03)	whole TMA	Y scanned after giving up		N	Y 100% better	Y	N	Did 80% of the job well, but difficult to get the other 20% correct. Equipment more difficult and slower BEST: easy to write the basic information out and very portable and easy to use. “Really neat idea”. WORST: could not get editing to work so “that was a show stopper really!” (claim she therefore could not edit) Found scanning directly into OO very fast (interesting further comments)
DM	none			<1					Return equipment very early on stating accuracy is very low and it would take too long to correct the files produced

** The software provided with the scanner allows you to create a single pdf file, but pages must be scanned in the right order. It does not provide the facility for removing a page and inserting a corrected version. However, there is freeware available (pdf creator) that would allow students to do this. For example, if the student has saved each page in whichever format it has been produced, these can be collated together again in any desired order. Alternatively, the student can generate a new pdf file by ‘printing’ the current one in sections and inserting the new page between these sections. These are not quick 'click-delete-insert' process, but is probably faster than having to re-scan all the pages.

Of the 14 students who returned the questionnaire in 2007, 8 had tested the LogiTech io Pen and 6 the PC Notes Taker. We extracted the following general information:

- 4 students did not use the equipment and of the 10 who did, 6 used it to produce only 1 eTMA. Of the latter, only two were students who requested the equipment in July and therefore only had time to produce a single TMA
- 6 students had submitted eTMAs before but 8 hadn't
- Half of the students who used the equipment employed it to produce the whole eTMA, whereas the other half used it only for figures and/or equations.
- 8 students were happy overall with the pens, whereas 6 were not
- 6 students stated that they would use the pen for a future course if it were provided, 3 stated that they may use it and 5 said that they would not use this equipment again.

It seemed clear from the students' answers that producing graphs with the PC Notes Taker was problematic. This impression was confirmed when re-testing the equipment a posteriori in 'real' conditions (i.e. producing not a drawing or a sketch but a graph where the lines had to start, end, and/or meet at quantitatively determined points). The Logitech io Pen seemed to fare better, with students reporting far fewer problems.

The response from students who used the equipment to generate only equations and figures seems to have been more positive. Three of them used the equipment for all TMAs 4 to 7. Interestingly, two of these students reported not having submitted eTMAs before. It would seem that having provided them with a tool to generate an electronic version of the figures and equations enabled them to use word-processing skills they already had. The only student who responded negatively among those using the equipment for equations and figures, was using the PC Notes Taker and complained about the subscripts and superscripts not being in place.

The time the students spent installing and familiarizing themselves with the equipment seems entirely reasonable, except for a student whose basic computer skills were perhaps too limited even for a simple installation (s/he seems to have problems saving and retrieving the electronic files produced by the pen).

Of the 11 students who returned the questionnaire in 2008, 4 had tested the LogiTech io Pen, 4 the DigiMemo notepad and 3 the CanoScan scanner. We extracted the following general information:

- 4 students did not use the equipment to produce an eTMA (although some of them tested it) and of the 7 who did, 2 used it to produce only 1 eTMA (although one of these submitted a paper version of it because s/he didn't know how to collate the electronic files into a single document)
- at least 4 students had submitted eTMAs before
- All students who used the equipment employed it to produce the whole TMA
- 4 students stated that they were happy overall with the equipment
- 5 students stated that they would use the equipment for a future course if it were provided and one said they may use it but only to generate equations and figures.

All the students who replied made positive comments, even those who answered that they would not use the equipment again. Those who used the scanner produced all TMAs (2 to 7) with it, although none of them had submitted an eTMA before. They seemed to be the most satisfied with the equipment tested.

Student using the DigiMemo notepad seemed less satisfied with the equipment (although it was initially thought a better option than the Logitech io Pen). Interestingly, the only person (among the students who answered the questionnaire) who used the Logitech io Pen seemed not to have actually liked it.

The people who had submitted eTMAs before were less positive (although one did find it better than using a word processor) than those who hadn't. It is interesting that none of the people who replied in 2008 used the equipment to produce figures and/or equations only, when this had been suggested in the initial message posted on the course website. Even so, a couple of them mentioned that they felt that including figures was easier and better than having to scan them in.

Some conclusions

The take-up for these trials was lower than expected on both years. This could be due to unsuccessful or inadequate advertising, or lack of time on the students' part that made them decide they could not afford to spend any time learning to use the equipment. It is also possible that many felt they had already found an efficient way of embedding equations and figures in their eTMAs. However, although the number of students submitting eTMAs has increased from 2006, when electronic submission was first made available to students, there is still a non-negligible proportion that chooses not to submit electronically, thus losing out on its advantages. In 2007, fewer than 10% of the students submitted TMA02 electronically, but by the last TMA (TMA07) almost 40% used the eTMA method (the majority of them were produced with Word). In 2008, the ratio was stable, at around 45% of students submitting electronically, still lower than is desirable. (The increase in the number of electronic submissions of the early TMAs is possibly due to tutors being more supportive and encouraging of electronic submission as they get more comfortable with the process of marking eTMAs using the tablet PCs. It may also indicate a growing number of computer literate students). It is reasonable to assume that in many cases where students do not submit electronically, it is because they have not found, or can not think of, what would be for them, an efficient way of producing an eTMA.

As mentioned earlier, an important concern is the time students spend generating their eTMAs: ideally, producing an electronic version of their coursework should not incur a significant time overhead. Students' answers were divided on whether the equipment tested saved them time over their previous method. Of course, this will very much depend on the student's computer skills, typing speed, etc., but it is clear that for a student who is comfortable typing, reverting to handwriting the text part of their TMA will probably take more time.

It is difficult to draw many general conclusions from this trial as the numbers were small and there are many other factors influencing the behaviour of students in this area. Since the take-up was so small, it might have been instructive to survey the students who produced none, or very few, of their assignments electronically. However, some information was gained regarding the specific equipment used in the trials. The PC Notes Taker was clearly not a good tool, as the quality of the graphs produced was too poor. The DigiMemo notepad was less well received than expected, with the one student who actually generated an eTMA with it stating that producing a good quality figure was very time consuming. The Logitech io Pen seems a reasonable option as no complaints were made about the quality of the figures and graphs produced with it. This is possibly a good choice for the more computer literate students, especially if they are interested in producing just the equations and figures for the TMA. Unfortunately, the io Pen is no longer being produced by Logitech, but equipment making that use of similar technology will probably produce graphs of the same quality.

The 2008 students who used the scanner produced all their TMAs with it. These are people who hadn't submitted eTMAs before, so it is clear that for them the option of scanning was satisfactory and effective. The time overhead incurred when scanning a TMA is relatively short. The quality of eTMAs is good and it is also the one requiring the cheapest equipment. The disadvantage is that it does not allow for electronic editing; if a mistake is found the student has to either re-write the page or erase and overwrite the area where the mistake is present. In both cases the page needs to be re-scanned and somehow inserted into the existing document. This is not a straightforward procedure and it would be extremely useful for the students to have a very simple way of removing/deleting and inserting pages in an existing pdf document. An option would be to suggest students insert the pages (as image files) into a word document. This would simplify the process of deleting and re-inserting a page, but at the cost of having to make the scanned images (of the TMA pages) slightly smaller to make them fit into a Word document page. Nevertheless, scanning seems undoubtedly the most successful option: students provided with scanners submitted all their TMAs electronically and reported few problems. It is, however, a relatively 'low-tech' option that students who are comfortable typing may find unsatisfactory. For the 2008 October presentation of S207 students were provided with guidance as to how to scan their handwritten TMAs and submit them electronically.

To summarize our findings: not all the digital writing equipment tested made it possible for the students to produce the sort of graphs that physics students need to include in their work to an acceptable quality. The Logitech io Pen seemed to fare significantly better than the PC Notes Taker or the DigiMemo notepad. Users of the scanner were also very satisfied with it and this is the equipment that seems to produce the best results. It is the option we would recommend to the 50% of students who are still submitting paper versions of their course. However, the scanner is not necessarily the best solution for all students, and many of them will look for a more high-tech alternative.

Acknowledgments

Stuart Freake provided very helpful advice and support, particularly in testing some of the equipment and helping with the written material (invitation letters, “How to” guide, end-of-trial questionnaires, etc.) that was sent to the students. Michael Watkins, Course Manager for S207, also provided valuable support, most significantly helping with some of the administrative tasks.

<u>**Questionnaire for S207 students participating in the Picetl electronic pen and scanner trial**</u>

Please take a few minutes select the appropriate answer and include any relevant information. Please notice that some parts of some questions are specifically for users of a particular device (these start with '***For……users only'***). If you requested a device but **did not use it** to produce your eTMA, we would still like to hear from you. You do not need to answer the questions, but let us know why you didn't or couldn't use the device. Please use additional sheets if necessary.

Which equipment did you use?
- ☐ DigiMemo Notepad
- ☐ Logitech io Pen
- ☐ CanoScan scanner

Did you find the installation of the associated software difficult?
- ☐ No
- ☐ Yes. Explain briefly what the problems were.

For which of the TMAs did you make use of the electronic equipment to enable e-submission?
- ☐ TMA01
- ☐ TMA02
- ☐ TMA03
- ☐ TMA04
- ☐ TMA05
- ☐ TMA06
- ☐ TMA07

Which parts of the eTMA did you produce with the equipment?
- ☐ Whole eTMA
- ☐ Equations and Figures
- ☐ Only figures
- ☐ Only equations

For DigiMemo andLogitech users only: did you find it difficult to produce graphs of appropriate quality and precision?
- ☐ No
- ☐ Yes ***(Please explain what the problems were)***

Approximately how long did it take you to familiarize yourself with the use of the equipment before you used it to produce an eTMA?
- ☐ Less than 1 hour
- ☐ Between 1 and 2 hours
- ☐ Between 2 and 4 hours
- ☐ More than 4 hours

For DigiMemo andLogitech users only: Assuming you collated the electronic files into a single document for submission and considering your last eTMA, how long did this take you?
- ☐ Less than 30 minutes
- ☐ Between 30 minutes and 1 hour
- ☐ More than 1 hour
- ☐ I did not collate the files

For Canoscan scanner users only: Did you collate the electronic files into a single document for submission?

- Yes, I generated a pdf file using the software provided with the scanner
- Yes, I zipped them using software available on my computer
- No, I didn't

Had you submitted an eTMA before using the piCETL equipment?

- Yes
- No ***(Please explain your main reason(s) and then go to question 13)***

How did you produce your previous eTMA?

- By scanning a handwritten TMA
- By using a word processor
- Other. Please explain:

Did the piCETL equipment make it easier or more difficult to produce an eTMA than your previous method?

- Easier
- About the same
- More difficult

Did it make it faster or slower to produce an eTMA than your previous method?

- Slower
- Faster

Were the eTMAs you produced with this equipment clearer than those produced with your previous method?

- Yes, clearer
- About the same
- Less clear

For DigiMemo and Logitech users: Did the equipment make it easier to include figures/graphs and equations?

- No, it didn't make it easier
- It made including graphs easier
- It made including equations easier
- It made both easier

Please note any comments that your tutor made about the clarity and readability of the eTMAs you produced with the piCETL equipment.

Please note any specific problems or difficulties you had when you produced eTMAs with the the piCETL equipment.

Overall, did you find the equipment useful for producing an eTMA?

- Yes

☐ No

What is the best aspect of it?

And what is the worst aspect?

Overall, do you think eTMAs are better than traditional paper TMAs? Please explain why.

☐ No
☐ Yes

If you have a choice of submission methods in your next course, will you opt for eTMAs?

☐ Yes
☐ No

Assuming that you had access to the piCETL equipment, would you use it to produce eTMAs for your next OU course?

☐ Yes
☐ No
☐ Maybe

If you answered No or Maybe, please summarize your reasons for not wanting to use the equipment for eTMAs in your next course.

If you didn't find the equipment useful, would you be interested in finding another method to produce eTMAs more easily than by using word processing software?

☐ Yes
☐ No

Did you use the equipment for anything else besides producing eTMAs? (Even if it was not OU related, we would like to hear about it). Please describe what you used it for.

Thank you for participating in the trial of piCETL digital equipment and for taking the time to respond to this questionnaire.

OpenMark development for S104 and other level 1 courses

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January 2009

Abstract
The aim of this project was to develop the academic and pedagogic basis of the OpenMark eAssessment system and to develop interactive computer marked assignments (iCMAs) for S104 : *Exploring Science*. The OpenMark system, previously used for formative and summative assessment in S151 : *Maths for Science* enables students to be provided with instantaneous, targeted and relatively detailed feedback on their work. iCMA questions were also developed for S154 : *Science Starts Here* and the diagnostic quiz 'Are you ready for level 1 science?'.

Background – why e-assessment?
Reviews of the literature (e.g. Black and Wiliam, 1998; Gibbs and Simpson, 2004) have identified conditions under which assessment appears to support and encourage learning. Several of these conditions concern feedback, but the provision of feedback does not in itself lead to learning. Sadler (1989) argues that in order for feedback to be effective, action must be taken to close the gap between the student's current level of understanding and the level expected by the teacher. It follows that, in order for assessment to be effective, feedback must not only be provided, but also understood by the student and acted on in a timely fashion. These points are incorporated into five of Gibbs and Simpson's (2004) eleven conditions under which assessment supports learning:

- Condition 4: Sufficient feedback is provided, both often enough and in enough detail;
- Condition 6: The feedback is timely in that it is received by students while it still matters to them and in time for them to pay attention to further learning or receive further assistance;
- Condition 8: Feedback is appropriate, in relation to students' understanding of what they are supposed to be doing;
- Condition 9: Feedback is received and attended to;
- Condition 11: Feedback is acted upon by the student.

It can be difficult and expensive to provide students with sufficient feedback (Condition 4), especially in a distance-learning environment, where opportunities for informal discussion are limited. Feedback on tutor-marked assignments is useful but may be received too late to be useful (Condition 6) and it is then difficult for students to understand and act upon it (Conditions 8 and 10), even assuming that they do more than glance at the mark awarded (Condition 9).

One possible solution to these dilemmas is to use e-assessment. Feedback can be tailored to students' misconceptions and delivered instantaneously and, provided the assessment system is carefully chosen and set-up, students can be given an opportunity to learn from the feedback whilst it is still fresh in their minds, by immediately attempting a similar question or the same question for a second time, thus closing the feedback loop. Distance learners are no longer disadvantaged — indeed the system can emulate a tutor at the student's elbow (Ross et al., 2006, p.125) — and 'little and often' assessments can be incorporated at regular intervals throughout the course, bringing the additional benefits of assisting students to pace their study and to engage actively with the learning process, thus encouraging retention. For high-population courses, e-assessment can also deliver savings of cost and effort. Finally, e-assessment is the natural partner to the growth industry of e-learning.

Development of OpenMark iCMAs for S104
S104: *Exploring Science* is the Science Faculty's 60 point level one science course, introducing students to Earth science, physics, chemistry and biology and developing mathematical, communication and practical skills. S104 had its first presentation in February 2008 and since then

has run in two presentations per year, with 1500-2000 students per presentation. The content of S104 draws heavily on its predecessor, S103, but its tuition and assessment strategies are very different. S104's assessment strategy includes the following components:

- Seven tutor marked assignments (TMAs), marked against learning outcomes and with optional eTMA submission.
- Eight interactive computer marked assignments (iCMAs) (summative but low stakes), each containing 10 questions.
- Synoptic component:
    - Written end of course assignment (ECA).
    - Longer iCMA49 (25 questions) with questions ranging across the course .

S104's iCMAs are credit-bearing because the course team wanted students to engage with them in a meaningful way. However their purpose is to provide instantaneous feedback and to help students to pace their study. The iCMA questions use the OpenMark e-assessment system, which enables us to provide students with multiple attempts at each question, with an increasing amount of instantaneous feedback after each attempt. The student can learn from the feedback and use it to correct their answer. Wherever possible the feedback is tailored to the student's misunderstanding.

S104's iCMAs make use of the full range of OpenMark question types, including free text entry of numbers, letters and single words as well as hot-spot, drag and drop, multiple-choice and multiple-response. We have also included a few questions requiring free-text answers of up to a sentence in length (Jordan and Mitchell, 2009). Examples of the question types used in S104 are given in Appendix 1 and further information about OpenMark is given on the OpenMark Examples website (http://www.open.ac.uk/openmarkexamples/index.shtml), produced by Phil Butcher.

Each S104 iCMA opens to students approximately two weeks before they are due to start reading a particular book of the course. Initially the iCMAs closed 1-2 weeks after students were due to move onto the next book, which led to each iCMA cut-off date being after the cut-off date for the TMA assessing the same book. This resulted in many students not starting the iCMA until after they had completed the TMA and moved on to the next book, so it was felt that the pacing function of e-assessment was not being used to the full. From the 09B presentation, iCMA cut-off dates will be just two days after the students are timetabled to move onto the next book, with the TMA due dates a further two days later.

OpenMark sits within Moodle and scores are reported to the student and their tutor via StudentHome and TutorHome respectively. S104 has its own 'iCMA Guide' (reproduced in Appendix 2a) and associate lecturers are given additional advice via the S104 Tutor Forum on FirstClass (Appendix 2b).

Each presentation of S104 uses 105 questions (10 each for iCMAs41-48 and 25 for iCMA49), with some re-use of questions between presentations. Wherever possible at least five different variants of each question are provided, to act as an anti-plagiarism device, and sometimes more variants are provided to enable the same basic question to be used, for example, in iCMA43 on one presentation of the course and iCMA49 of the following presentation. Each OpenMark question was written by an academic member of the Course Team, programmed by an LTS media developer and checked by both the academic author and an experienced consultant.

A series of workshops was run to train S104 course team members in the authoring of OpenMark questions. These included advice on writing unambiguous questions linked to appropriate learning outcomes, writing appropriate feedback for students, specifying answer matching, ensuring that as many questions as possible are fully accessible (i.e. have versions that can be read by a screen-reader) and checking questions. The basic 'Writing OpenMark questions' workshop has since been repeated for other course teams and a guide 'Good practice in the academic authoring of OpenMark questions' has also been produced. This guide is reproduced in Appendix 3.

Development of OpenMark iCMAs for S154

A bank of 66 OpenMark questions was written in the spring of 2007 for use in various contexts, including the reinforcement and assessment of basic knowledge and skills, especially mathematical skills, developed in the 10 point course S154 : *Science Starts Here* (first presentations October 2007 and March 2008, with 500-1000 students per presentation). An additional 15 new questions were written prior to the October 2008 presentation of S154, supplemented by two free-text short-answer questions first written for S103 and one S104 question reused with the permission of the author. The questions in the bank have been written with up to 20 different variants each, to enable their use in different places (including S154's formative and summative iCMAs, 'Are you ready for level 1 science?' and the iCMA that accompanies the Maths Skills ebook) and also to provide multiple variants in each iCMA in which they are used. In formative use, multiple variants provide students with more opportunities for practice. The examples of different question types given in Figures A1 to A7 of Appendix 1 are all taken from this bank of OpenMark questions and the example of the programming instructions for a question at the end 'Good practice in the academic authoring of OpenMark questions' (Appendix 3) illustrates the way in which each application has its own independent data-sets and reference to the relevant points in the text.

S154 had not initially intended to make summative use of OpenMark questions. However, mounting evidence that students frequently only attempt the first question or two of formative-only iCMAs, led to a course team decision to have two short summative iCMAs, one assessing Chapters 2-4 and one assessing Chapters 6-9. However, the focus of S154 on underpinning mathematical skills means that some students will require a lot of practice so there is also a 'Practice iCMA'. Students are encouraged to engage with the Practice iCMA regularly, with reminders given on the course website every week and at the end of each chapter in the course book.

'Are you ready for level 1 science?'

32 of the questions from the bank of mathematical questions described in the previous section have also been used (with different variants) in the diagnostic quiz 'Are you ready for level 1 science?', which has been available to prospective students of level 1 Science Faculty courses (including S104, S154, SDK125 and Science Short Courses) since 3rd April 2007. These questions are offered alongside 6 questions on English and study skills and a number of advice screens, all written by Linda Fowler.

An OpenMark-based diagnostic quiz has been used because it forces people to engage actively with the questions, rather than looking at the answers before looking at the questions and then assuming that they could easily have obtained the correct answers for themselves. There is some evidence of this sort of behaviour with the printed and .pdf versions of the other Science Faculty 'Are you ready for?' quizzes, and the level 2 courses S207, S205 and S204 have had interactive 'Are you ready for?' quizzes for some time.

The other reason why OpenMark is appropriate for the 'Are you ready for level 1 science' quiz is that it enables people to be guided through a complex maze of possible routes, depending on their aspirations and the amount of time they have available, in such a way that the quiz does not appear too complex or too long to prospective students. 'Are you ready for level 1 science?' is actually three interlinked iCMAs. After a very short 'introductory quiz' students are guided either to a 'basic quiz' (to assess their preparedness for S154, SDK125 or entry level Science Short Courses) or to a quiz that is designed specifically to assess their preparedness for S104. Within the S104 quiz some of the questions (on arithmetical rules of precedence, negative numbers and fractions, decimals, ratios and percentages) are deemed to be 'essential' (these topics are not re-taught in S104) whereas other questions (on topics which are re-taught, albeit sometimes rather briefly, in S104, for example the use of scientific notation) are classified as 'desirable' for S104. Prospective students are advised that they will be able to complete the early books of S104 more quickly if they are already familiar with some of these topics (See Figure 1)

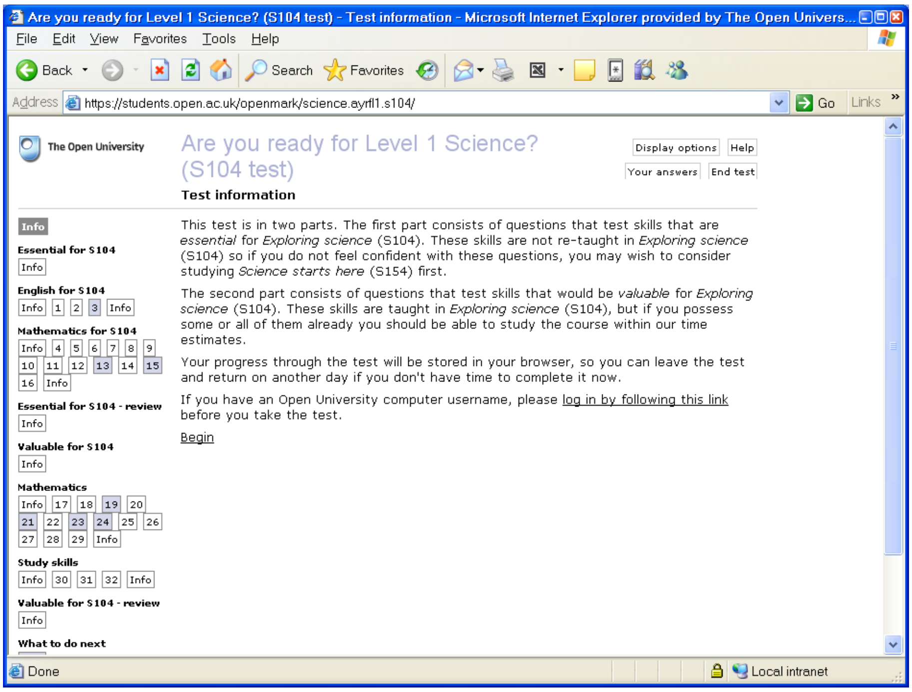


Figure 1 The introduction to the S104 part of 'Are you ready for level 1 science?'

Evaluation

Evaluation of S104 and S154's use of iCMA questions and of the 'Are you ready for level 1 science?' quiz forms part of the larger project 'Investigating the effectiveness of interactive online assessment for student learning', funded jointly by piCETL and COLMSCT (The Centre for Open Learning of Mathematics, Computing, Science and Technology). This project, is seeking to investigate different models of iCMA use and thus to determine:

- The most effective ways in which iCMAs can be used to support students in choosing appropriate courses/programmes of study;
- The most effective ways in which iCMAs can be used to engage students and to support student learning whilst students are studying a course;
- The accuracy and reliability of marking of different types of OpenMark questions.

The project's methodology includes extensive analysis of the data that is captured when students attempt iCMAs as well as more qualitative methodologies such as questionnaires, interviews, focus group discussions and observations in the IET (Institute for Educational Technology) Usability Laboratory. Most of the work on this project will take place during 2009, with reporting in early 2010.

Various aspects of S104's and S154's teaching and learning strategy are also being evaluated by a series of online questionnaires delivered to students as part of the Science Faculty funded IET project 'Evaluation of course components in three new Science courses'.

Preliminary evaluation of 'Are you ready for level 1 science?' shows that it has been very heavily used (with more than 26, 000 people accessing the quiz between April 2007 and January 2009) and popular, though unfortunately only around 50-65% of students on the first two presentations of S104 appear to have used the diagnostic quiz before deciding to study this course.

A feedback question asks prospective students whether they found 'Are you ready for level 1 science?' useful, which course(s) they were considering both before and after attempting the quiz, and whether they had any suggestions for improvement.

Several of the students who took the ‘basic quiz’ obviously found it very easy; some found this reassuring (e.g. in answer to ‘Did you find the quiz useful?’: ‘Yes, I enjoyed it and was pleasantly surprised. it's a long time since I did maths at school!!; ‘Very useful and very reassuring’; ‘It re-ignited a little confidence’) others appeared frustrated (e.g. ‘No. It was far too simplistic’). Analysis of responses to individual questions also indicates that most people have answered these very competently. Most students who took the ‘basic quiz’ were initially intending to take S154, SDK125 or a Science Short Course and very few students changed their mind as a result of the quiz.

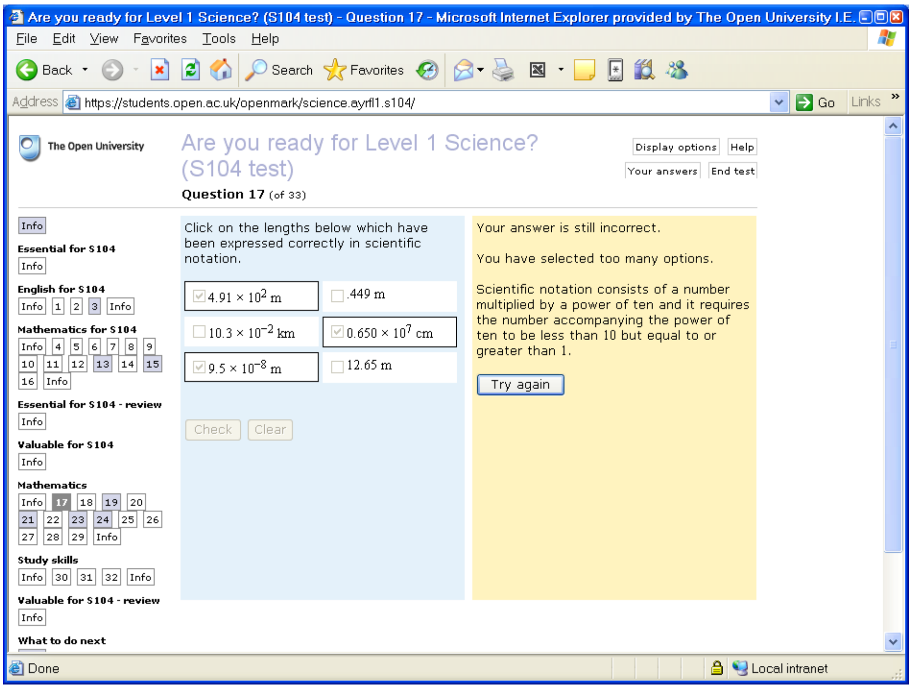


Figure 2 A poorly answered question in the S104 part of ‘Are you ready for level 1 science?’

Responses to the feedback question and analysis of responses to individual questions indicates that prospective students taking the S104 quiz found this more difficult, and in a sense it appears that this quiz is more useful, with some students deciding to start their study with S154 rather than S104 and comments in response to ‘Did you find the quiz useful?’ such as ‘Yes. It confirmed to me that I need to take the preparatory course S154 prior to S104 in 2008. The maths section is my week point, although I feel I only need to brush up on certain areas of it and 154 will do that (I hope).’. However, again, many students were simply assured of their preparedness for the course they were originally intending to study, with comments such as ‘The quiz was very useful. As a 39 yr old who has had little mathematics exposure since the mid 80s, it was refreshing to realise how much I had remembered.’ Responses to individual questions have been far more variable than for the basic quiz, but the questions all seem to have been behaving well. Prospective students are finding the question shown in Figure 2 particularly difficult, which might indicate that we should make the question easier by indicating how many options should be selected, or possibly even remove this question from the quiz, as it is perhaps a little unfair for people who have simply not been introduced to scientific notation before. Scientific notation is briefly retaught in S104 and it is also discussed in the *Maths Skills* eBook.

Acknowledgements
Much of the work described in this report has been carried out in conjunction with colleagues on the S154 and S104 course teams, in particular Linda Fowler, Ruth Williams and Valda Stevens. Development of the OpenMark questions for S154 and ‘Are you ready for level 1 science’ would not have been possible with the assistance of Greg Black (Learning and Teaching Solutions). Phil Butcher (COLMSCT Teaching Fellow and LTS) has provided invaluable guidance on possibilities offered by the rapidly developing technologies.

References

Black, P. and Wiliam, D. (1998) Assessment and classroom learning, *Assessment in Education, 5*, 1, 7-74.

Gibbs, G. and Simpson, C. (2004) Conditions under which assessment supports students' learning, *Learning and Teaching in Higher Education, 1*, 3-31.

Jordan, S.E. and Mitchell, T. (in press) E-assessment for learning? The potential of short free-text questions with tailored feedback. *British Journal of Educational Technology, 40,* 2.

Ross, S.M, Jordan, S.E and Butcher, P.G. (2006) Online instantaneous and targeted feedback for remote learners, In Bryan, C. and Clegg, K.V. (eds), Innovative assessment in Higher Education. London: Routledge, 123-131.

Sadler, D.R. (1989). Formative assessment and the design of instructional systems. *Instructional Science, 18*, 119-144.

Appendix 1 OpenMark question types used in S154, S104 and 'Are you ready for level 1 science?'

All of the questions illustrated are taken from the S154 practice iCMA.

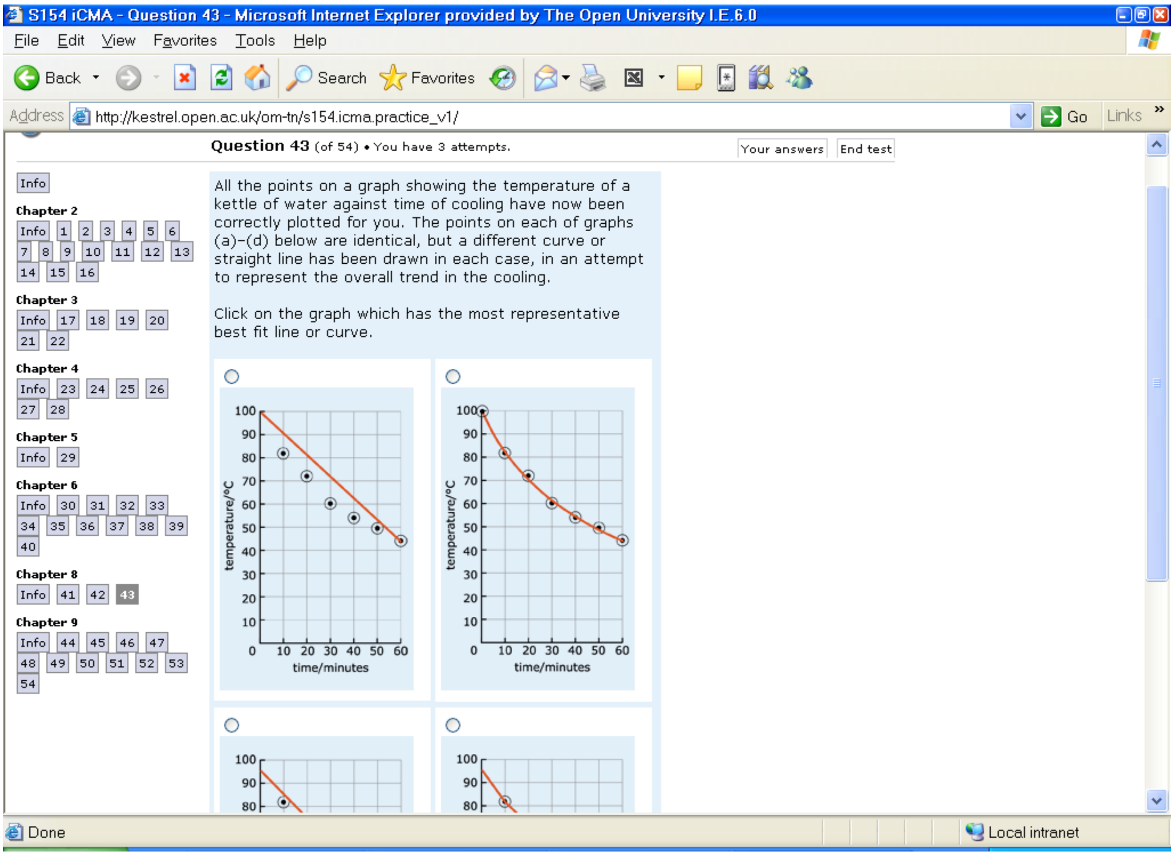


Figure A1 A multiple choice question

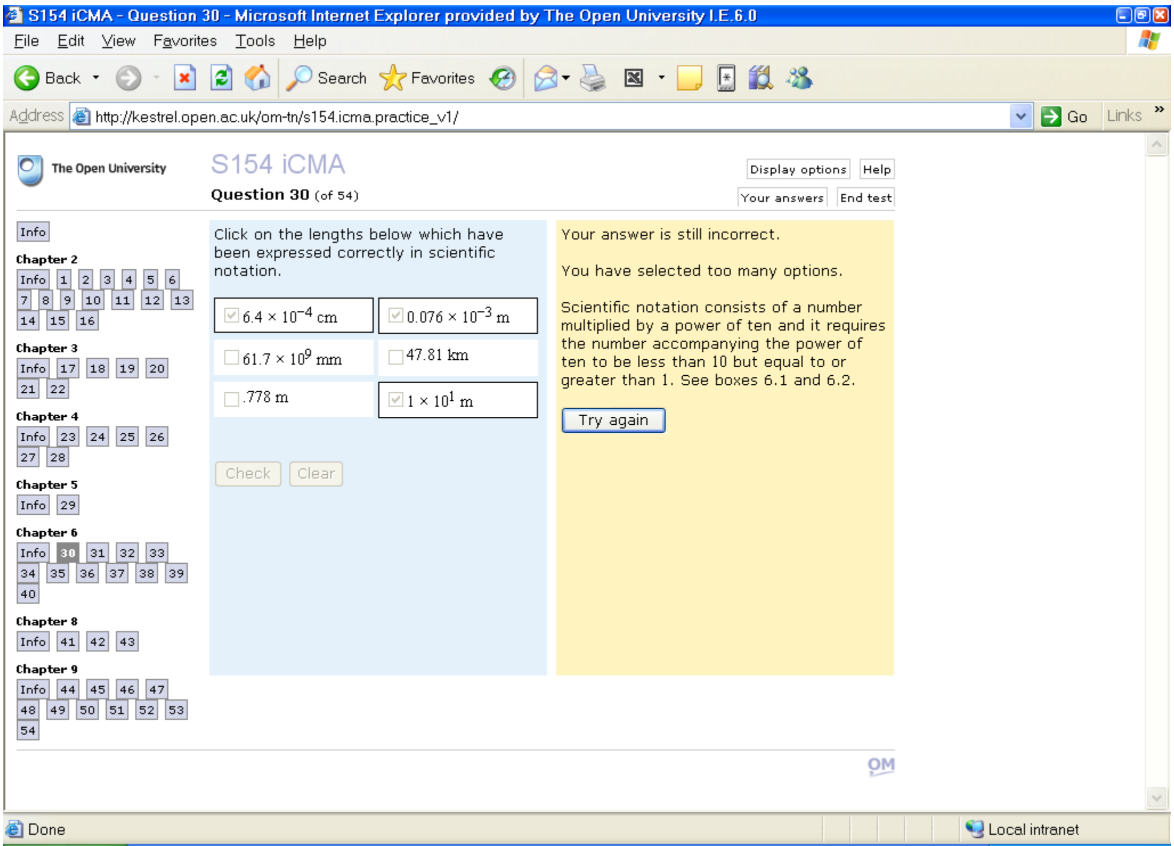


Figure A2 A multiple response question

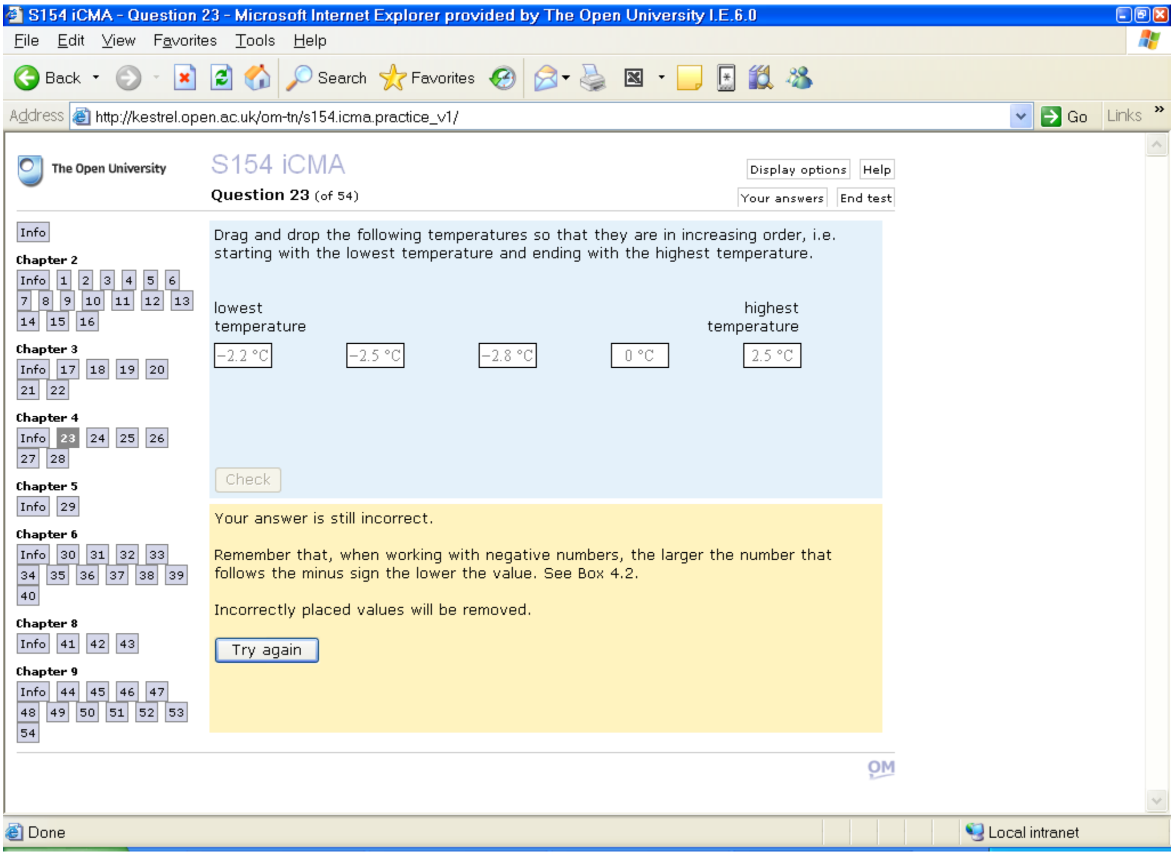


Figure A3 A drag and drop question

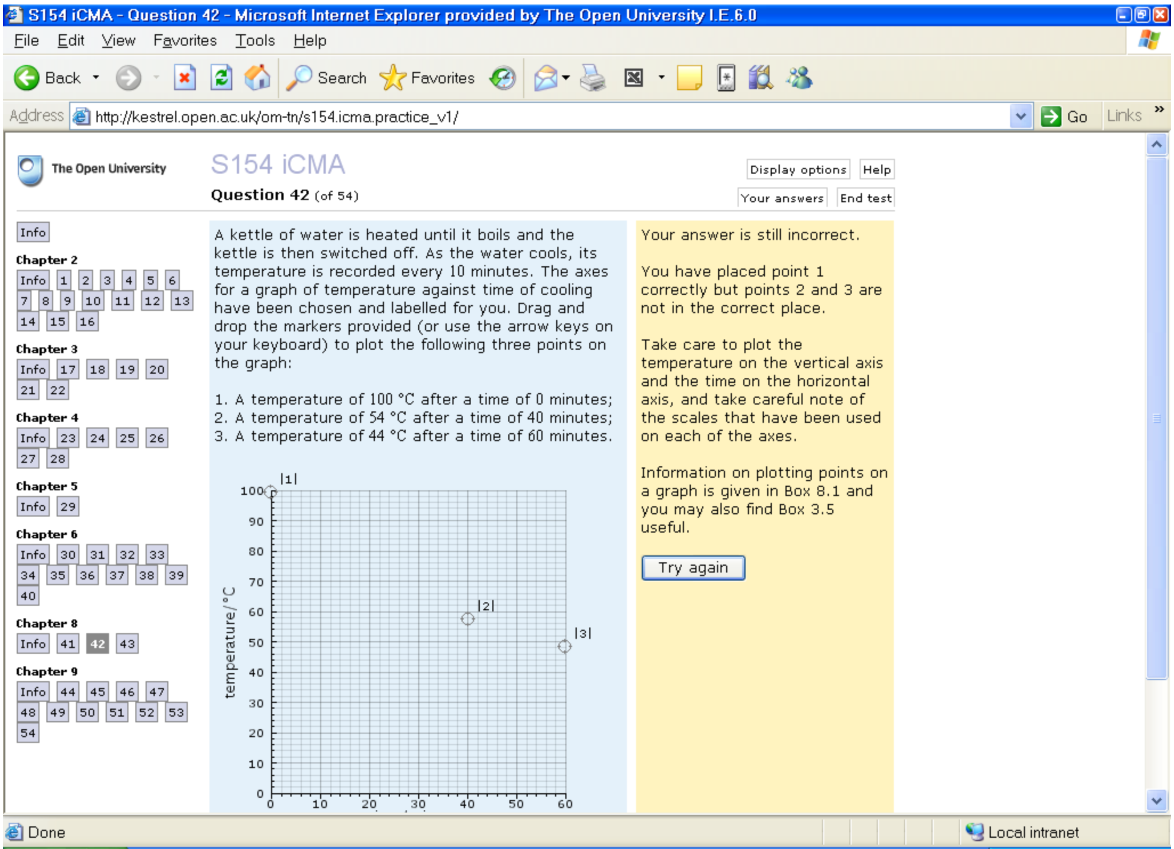


Figure A4 A hotspot question

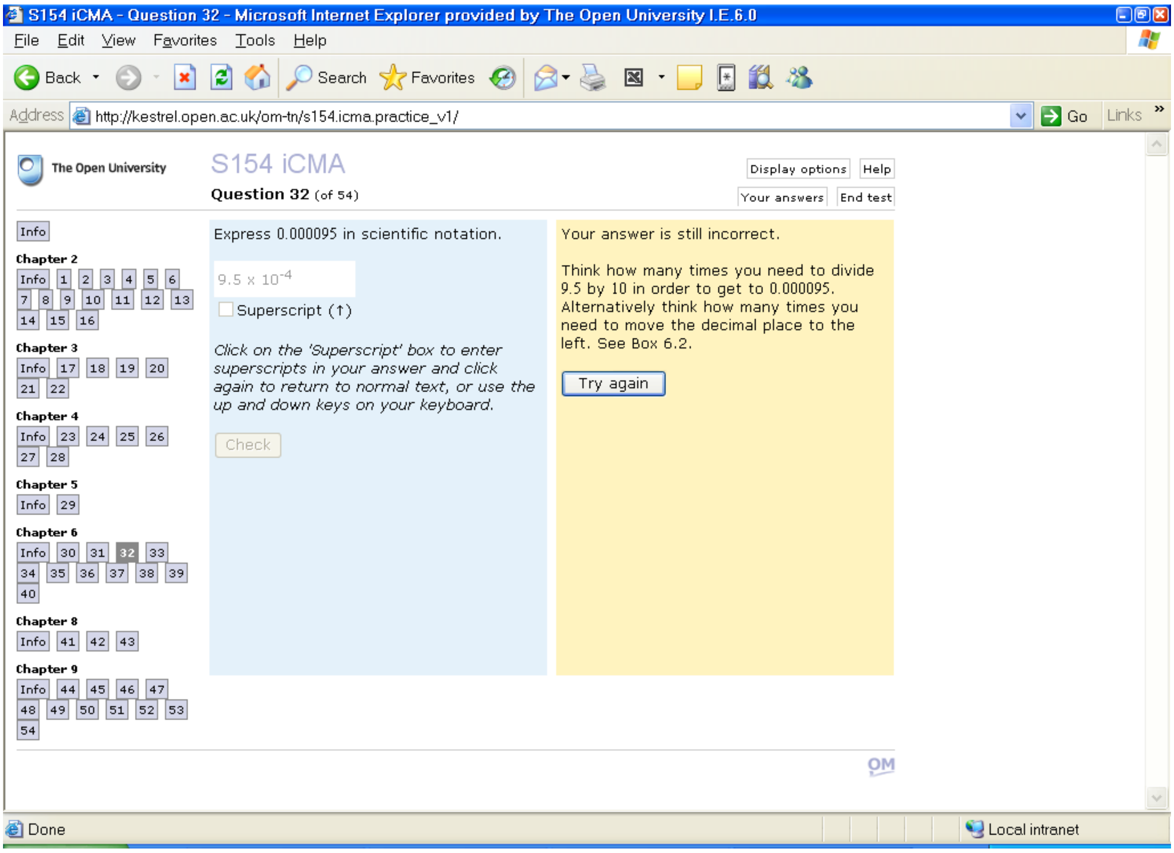


Figure A5 A question requiring numerical input (including a superscript)

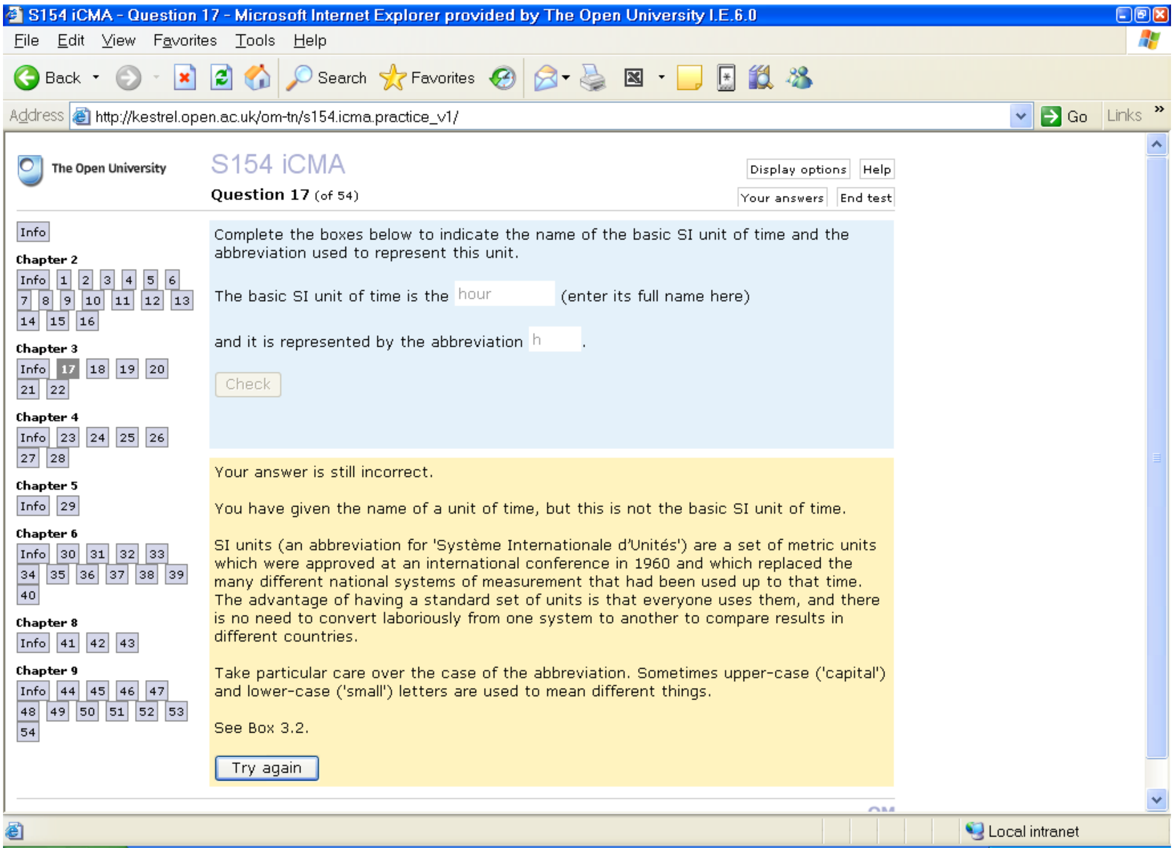


Figure A6 A question requiring simple textual input

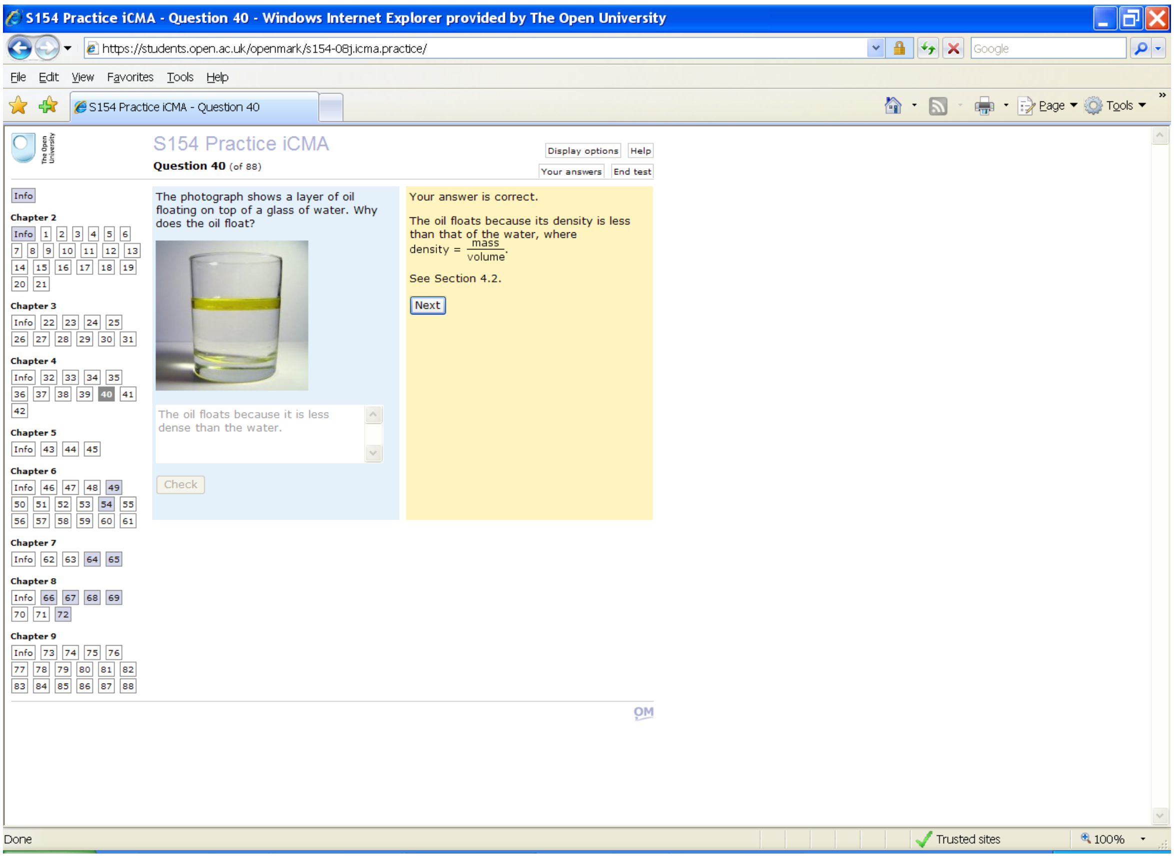


Figure A7 A question requiring an answer in the form of a simple sentence

Appendix 2a The S104 iCMA guide

In addition to the TMAs, S104 includes nine iCMAs (interactive computer-marked assignments). You will be provided with immediate computer-generated feedback on your iCMA answers, so you can use them to help inform you about your knowledge, understanding and skills. Most of the questions allow a second and third attempt at an answer, so you can learn from the feedback provided before having another go.

Each iCMA is available for several weeks and you can spend as long as you wish on the questions within that time. However each iCMA has a cut-off-date (given in the *Study Calendar*). You must submit the assignment on or before the cut-off date, whether or not you have completed it, otherwise your score will not be recorded and will not contribute to your final course score. Your tutor cannot grant you an extension and no late submissions will be accepted.

Note that each iCMA only counts for a very small percentage of your overall course score, so if you make a mistake in entering an answer, or are not able to answer all of the questions, don't worry. The questions are provided primarily so that you can learn from attempting them and from the feedback provided. In particular, iCMA41, which assesses Book 1, only counts for 1% of your overall course score. So each of its 10 questions only counts for 0.1%. If you haven't used iCMAs before, you can use iCMA41 as a means of getting used to the system. If you would like extra practice in using iCMAs before attempting iCMA41, try the *Maths Skills* questions which you can find on the course website (under 'General resources' then 'Maths skills' then 'Practice iCMA').

Instructions for accessing and using the iCMAs

- You can access the iCMAs from the course website.
- You need to be online while you are working on an iCMA, but you can take breaks whenever you like. If you break off from the assignment part way through, when you resume the iCMA you will be taken back to exactly the point where you stopped working and your answers to the questions you have already completed will have been retained, such that you can carry on where you left off.
- The answers to the questions are short and can be entered onto your computer in a straightforward and unambiguous way. However, you will need to do some working for most of the questions, so you should have your calculator and a pen and paper with you all the time you are working on the iCMAs. You may also like to have the S104 course material to hand, for ease of reference. Working online tends to encourage people to guess the answers to questions. We would urge you to resist this temptation; time spent methodically working out each answer is time well spent.
- iCMAs are only supported in the Internet Explorer and Firefox browsers. If you use a different browser your answers may not be recorded correctly, even if they appear to be correct on screen.
- If you would like the text of an iCMA to be displayed in larger font or with a different background colour etc., click on Display options in the top right-hand corner of the screen. (See Figure 1)
- While working through the questions click on Enter answer to check whether your answer is correct, Try again to attempt a question for a second or third time and Next question to move on to the next question. You are advised *not* to use 'Enter' on your keyboard or the 'Back' function on your web browser.

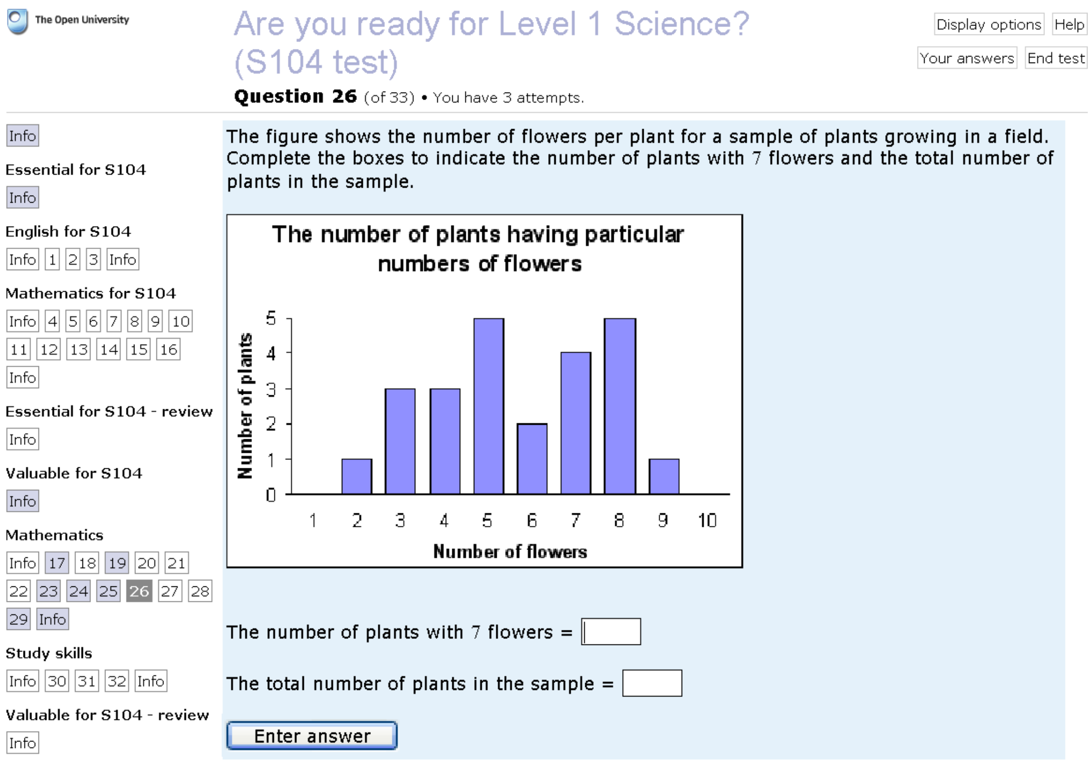


Figure 1 An iCMA question

- A function is sometimes provided to enable you to enter superscripts (such as the ‘3’ in 10^3) or subscripts (such as the ‘2’ in CO_2). If your answer needs a superscript or subscript you must use this function to enter your answer (in the examples, answers of 103 or CO2 would not be marked as correct). However, this function is provided for many questions, whether or not you need to use it in entering the correct answer. To use the superscript/subscript function, click on the box labelled superscript or subscript or use the up or down arrow keys on your keyboard. Click on the superscript or subscript box again or use the opposite arrow key to return to normal text.
- If you need to enter a decimal number, you use a full stop not a comma as the decimal divider, so you should type, for example, 1.23
- Some questions require answers to be expressed as a phrase or sentence. Just type your answer as you would in answering a TMA question. It is best to answer these questions as a single simple sentence rather than in note form or as several sentences.
- If you would like further guidance on how to input your answers to the questions, click on Help in the top right-hand corner of the screen. (See Figure 1)
- The questions will be presented to you in sequence. Most questions allow up to three attempts (the number of attempts is stated at the top of each question). Feedback is provided after each incorrect answer. After you have answered a question correctly, or made three unsuccessful attempts at answering it, you will be told the correct answer and then you will have to move on to the next question.
- It is important that you aim to get the correct answer with a minimum number of attempts – you will obtain more marks for getting the answer correct at your first attempt than at your second, and more marks for getting the answer correct at your second attempt than at your third. For some questions you will obtain partial credit for partially correct answers.
- Although the questions are presented to you in sequence, it is possible to attempt most of them in any order. To move to a different question, click on the relevant question number on the left-hand side of the screen.

- You are strongly advised to attempt all the questions.
- You will not be given exactly the same questions as other students or as your tutor, so if you want to query a point with your tutor remember to make a note of the question you were asked.

When you have completed the iCMA remember to click on the submit button otherwise your mark will not be recorded. The submit button is located at the bottom of the summary screen. If you have worked through the iCMA in order, the summary screen will appear automatically once it is completed. If you have answered the questions out of order then it can be accessed at any time by clicking on End test (in the right-hand corner of the screen). Check that you have completed all the questions that you want to before clicking on submit, since once you have clicked on submit you will not be able to attempt any more questions.

Remember that you must submit the iCMA on or before the cut-off date. Note that the cut-off date for each iCMA in the *Study Calendar* is the *latest* date on which the assignment will be accepted. You are advised to start work on each iCMA in plenty of time rather than attempting it in a rush just before the cut-off date. If, for any reason, you fail to make the deadline, you should consider submitting evidence of special circumstances (See Section 6.4 of the *Course Guide*).

Note that you will not be able to revisit questions once you have completed them or to see your score immediately after you submit an iCMA. The score for each iCMA (apart from iCMA49) will be displayed on your StudentHome page about 10 days after the cut-off date for that iCMA.

iCMA 49 is longer than the other iCMAs and will include questions from across the whole course. We expect that, in preparing for this and the end-of-course assignment, you will use the notes you have taken during your study for revision purposes and revisit key points, bringing together the knowledge and understanding and skills you have developed. We are not able to release the results for iCMA 49 until the S104 Examination and Assessment Board has met to consider overall result statuses

Avoiding plagiarism

Remember that your answers to all assignment questions must be your own work. You should not post questions (in their current form or reworded) on to any websites or news groups on the internet in order to obtain the answer. If you submit an answer that consists of text taken word for word from any source including the course books, a website, news group or other internet site, this will be seen as cheating and is forbidden.

Appendix 2b FAQs from S104 Tutor Forum

Here are some answers to queries raised by you and your students about iCMAs, with some added insights from an analysis of student responses to the iCMAs in the 08B presentation.

Can I practise doing iCMA questions before iCMA41?
Although iCMA41 is only half-weighted, partly because of its 'practice' function, some students want extra practice. If they haven't already looked at 'Are you ready for level one science?' (http://www.open.ac.uk/science/courses-qualifications/are-you-ready-for-science/interactive-materials/level-1-.php) this would be a good starting point. Or encourage them to try the questions associated with the Maths Skills ebook (on the S104 course website under 'General resources' then 'Maths skills')

When should I do iCMA questions? (message to students)
Remember that each iCMA is available to you for several weeks and you can attempt each iCMA in as many sittings as you would like (the system remembers exactly where you are up to). In addition, you can look at the questions without attempting any of them). So we would encourage you to look at the relevant iCMA questions early in your study of each Book (in general, the iCMA for each book will be open when you start reading that book) and to complete questions as soon as you feel able to. That way you can check your understanding and, if you make a mistake, hopefully you can learn from the feedback provided while the subject in question is still fresh in your mind.
Note to tutors: please do encourage your students to attempt iCMA questions sooner rather than later. It is amazing how many start within an hour of the final cut-off date!

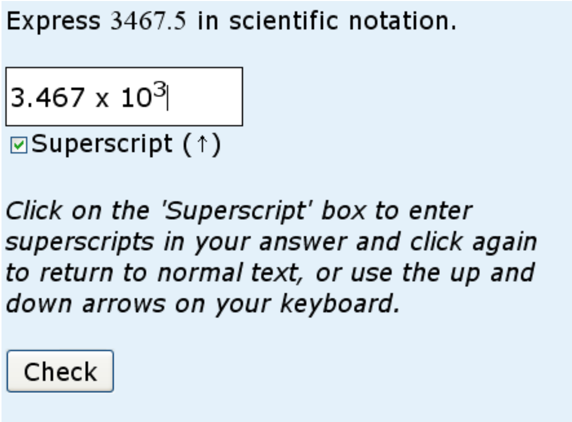
Do all students get the same version of the iCMA questions?
No. Most questions exist in several variants. We don't usually use random number generation (because that would result in different variants being of different difficulty) but there should be sufficient variability to restrict opportunities for plagiarism. It isn't just the numbers in calculations that change, so the question may appear quite different, but it should not be too difficult for ALs to recognise the common root - so if there is a calculation requiring an answer to be rounded up to two sig figs and with correct units of metres, that will be true for all students - so if they query a result it would be worth checking that they have rounded correctly and given the correct units.

Do students have to do the iCMA all in one go?
No, they can return to it as many times as they would like, and the system will remember where they are up to. But remember that pressing 'submit' acts as a guillotine (so they can't return to their work after doing this). Also remember that students must press 'submit' before the final cut-off in order for their score to count - and it is worth encouraging them to complete the iCMA well in advance of midnight on the final day - just in case they have computer or internet problems.

How many goes do they have at each question?
Usually three, sometimes two or one (and this is clearly indicated in the question). Note though that after a student has had their three goes at a question they cannot return to this question (this is another anti-plagiarism device).

Can they attempt each iCMA more than once and count their 'best' score?
No. Since the iCMAs are summative the students have just one go at each test (with up to three goes on each question but no more) - pressing 'submit' is final.

How do you enter superscipts?
The iCMA system has its own function for superscripts/subscripts. See screenshot below:



Students should not copy text already containing superscripts from Word or anywhere else. If they want extra practice at using the superscipt function, I suggest they try questions 39. 40, 41, 43, 45, 47, 48, 49, 51, 52, 53 of the Maths Skills questions (on the S104 course website under 'General resources' then 'Maths skills').

How long should an answer to a 'free-text' question be?
If the answer obviously needs to be more than one word long, it is best to give it as a single simple sentence. The answer matching is quite sophisticated (it is NOT just looking for keywords) but there are limits....

A question is 'greyed out' and I can't attempt it.
This is because the question is linked to the previous question (usually it uses the answer to the previous question) so you won't be able to see it until you have completed the previous question.

When do students see their score?
About 10 days after the cut-off date the students' scores will appear on StudentHome (and you will be able to see them on TutorHome). But in the meantime, please do encourage students to read and learn from the instantaneous feedback provided. I know it sounds very obvious, but students sometimes need reminding that if an answer has been marked as incorrect at the first attempt, the computer is not going to change its mind and mark the same response as correct at the second attempt...

Further information for students about iCMAs?
See the iCMA guide under 'Assessment' on the course website.

And what about AL access?
In the future all sorts of things will be possible, to enable you to monitor student progress through an iCMA and to see exactly which version of each question each student got, and how they answered it. But I'm afraid that these things are not technologically possible yet (and even if they were, the Course Team would have to address the workload implications for ALs). However you can repeat questions more than once, whereas your students will not be able to return to it after they have had their 'three goes'.

What if a student queries the computer's marking?
Experience from other courses, and early experience from S104, indicates that when a student says the 'computer has marked them as wrong' by far and away the most common reason is that their answer was incorrect (though perhaps not in a way that is obvious to the student, so they may have written 6 M instead of 6 m for a length). Generally we give targeted feedback for this sort of thing, so hopefully most students will work it out for themselves. Failing that, you may be able to help them to see that they have actually made a mistake. But we are not infallible, and there may be some instances (hopefully not many!) in which a student enters a correct response to an answer in a way that we have not thought of - and so the computer does indeed mark them inaccurately. If we know about these we can compensate. In addition, even if the computer's marking is accurate, we don't want students to feel aggrieved. So, if there are issues that you can't resolve, please contact us and we will check for you. **Please email s104-course-team@open.ac.uk if you want us to check the marking of a student's answer to an iCMA question, not forgetting to give the student's personal identifier.**

I also think it is important that students realise just how 'low stakes' the iCMAs are - so it really doesn't matter if they make a mess of a question, or indeed of a whole iCMA.

What are the most common difficulties with iCMAs:
1. Using an un-supported browser (students get a warning message if they try to do this. However the questions may appear to be behaving normally when they are not and students may run in to difficulties, especially with the superscript function and with drag and drop questions.
2. not reading the information screen at the front of each iCMA (and there is more information in the Course Guide and the iCMA guide)
3. not checking that the answer to each question makes sense before clicking on 'Enter answer'
4. Forgetting to click on 'Submit' at the end of each iCMA. Note that you can do this even if you haven't attempted all the questions (go to 'End test' in the top right hand corner of the screen).
5. Failing to enter superscipts correctly. But remember, the superscript function is there for lots of questions, so don't assume that you need to use the superscipt function just because it is there.
6. For free-text short answer questions, giving an answer that is far too long. The system usually copes well with answers in several sentences, but there are limits...Free test short answers are checked by a human marker (me!) but if I see that a student has given an incorrect answer than appended a correct one (trying to match keywords perhaps?) I'm likely to be less than sympathetic.

Plagiarism:
You may have noticed the following statement on the front screen on iCMAs. It might be worth reminding students that we are on the lookout for plagiarism of all sorts and we will take action if we detect it. All S104 assessment questions are designed to be answered from what students have learnt in S104, and the feedback provided is designed to help in the learning process.

Remember that your answers to these questions must be your own work. You should not post these questions (in their current form or reworded) on to any websites or news groups on the internet in order to obtain the answer. If you submit an answer that consists of text taken word for word from any source including the course books, a website, news group or other internet site, this will be seen as cheating and is forbidden.

Appendix 3 Good practice in the academic authoring of OpenMark questions

OpenMark question types
Which question type is most suitable for what you want to ask? Current options within OpenMark are

- Free text entry of numbers, letters and single words [N.B. this can accommodate checking for correct entry of scientific or decimal notation; correct units; correct case and common incorrect spellings of a word];
- Multiple choice (selection of a single option);
- Multiple response (selection of multiple options);
- Drag and drop (N.B. selected words/phrases can be removed or left in place for selection a second time);
- Hotspot (e.g. clicking on locations on a diagram or graph);
- Combinations of the above e.g. several boxes to enable entry of fractions or the cells of a table; multiple choice selection *and* entry of free text word.

Remember that students may be tempted to guess the answers to multiple choice and multiple response whereas those requiring the entry of free text require the student to work the answer out for themselves. However there are situations where multiple choice/multiple response/drag and drop questions are the most appropriate e.g.

- When students would otherwise need to enter symbols or complicated mathematical notation;
- When students are asked to 'match' appropriate options

If you would like to include questions requiring longer free-text responses (up to around a sentence in length) please contact Sally Jordan (s.e.jordan@open.ac.uk).

How many attempts do you want to allow?
Historically most OpenMark questions have allowed three attempts, with feedback increasing after each attempt. In summative use the student is then awarded three marks if the answer is correct at first attempt, two marks if the answer is correct at the second attempt and one mark if the answer is correct at the third attempt.

However for some questions it is only appropriate to allow one or two attempts (e.g. if the correct answer is 'true' or 'false' then you should only allow one attempt). Also, if you want to give some credit for answers that are partially correct, the standard way to do this is to allow just two attempts, then award three marks if the answer is completely correct at the first attempt, two marks if the answer is completely correct at the second attempt and one mark if the answer is partially correct at the second attempt.

The components of an OpenMark question
Each question needs:

- An unambiguous question (preferably with several variants)
- a worked answer
- intermediate feedback
- answer matching for correct and specifically incorrect student responses

Providing variability
Providing different variants of a question can prevent plagiarism (in summative use) and provide extra opportunities for students to practise (in formative-only use). In addition, different variants can be used to enable the same question to be used in different situations e.g. on different iCMAs for the same course or by different courses. Many of the questions in the S154 practice iCMA are reused in 'Are you ready for level 1 science' and the Maths Skills ebook iCMA (see S154 Question 4.6 – attached).

Variability can be provided by

- Providing several different data sets. Note that words as well as numbers and symbols can be different, so a runway can become a floorboard or a piece of carpet! (see S154 Question 4.6 – attached).
- Replacing letters in algebraic expressions. This can be done randomly, but if you want students to enter letters for themselves, take care to avoid letters such as ‘c’ and ‘k’ which look very similar on screen in upper and lower case. In the font used for OpenMark, italic ‘z’ looks like a 2 and italic ‘r’ look like ‘v’, so take care if students are required to enter these variables.
- Providing the variants in a different order (to ensure that the question is of similar difficulty you may like to specify, for example, that the correct option should never be given first).
- Selecting different options from longer lists. You may choose to always select, for example, two correct statements and four incorrect ones. (Some concern over whether the resulting questions will be of equivalent difficulty.)
- Requiring different students to label different parts of the same diagram or to complete different parts of a sentence. (Some concern over whether the resulting questions will be of equivalent difficulty.)
- Replacing an entire question with a similar one, assessing the same learning outcomes. (Some concern over whether the resulting questions will be of equivalent difficulty.)

I prefer to specify pre-determined options to the programmer rather than using random generation of numbers and letters etc. This is

- To make sure that the variants are of equivalent difficulty (e.g. all answers rounding up not down to an appropriate number of significant figures);
- To avoid ‘ugly’ questions. E.g. ‘Find the first derivative of $1y^3 + 0y^2 + 4y + 5$’

There is no reason why similar questions should not be used in both iCMAs and TMAs. However, care should be taken that one variant of an iCMA question does not provide more help than others with a subsequent TMA question.

Making the question as clear as possible
Nothing new here – everything that applies when writing good TMA questions applies to iCMA questions too. But without ALs to interpret students’ answers you have to be even more careful. For example do you want the answer to be expressed in its simplest possible form e.g. $\frac{1}{2}$ not $\frac{2}{4}$?; will you accept $(ab)^2$ as well as a^2b^2? You either need to provide answer matching to mark all correct options as correct, or you need to make it clear that, for example the answer should be entered in its simplest possible form, without the use of brackets.

For multiple response questions it is generally considered good practice to indicate how many options are to be selected (e.g. ‘Select the **two** options which….’), otherwise students report frustration that they are trying to ‘beat’ the question rather than learning from it. Multiple choice (single option) questions use a radio button so it is only possible to select one option.

For S104 we have decided to provide the superscript function for all numerical questions, to avoid guiding or misleading students by its presence or absence in particular questions. We explain this to students.

Helpful feedback
Assuming a question allows three attempts, then after the first incorrect attempt it is usual just to say ‘Your answer is incorrect’, with more detailed feedback after the second incorrect attempt and a full answer after the third incorrect attempt (or if the student gets the question right). However, if a student has made a ‘silly’ mistake (e.g. selected an incorrect number of options) this should be specified at both first and second attempt stage. Similarly if a student has got a ‘detail’ of the

question wrong (e.g. missing or incorrect units, incorrect case, inappropriate number of significant figures) targeted feedback on this should be given at both the first and second prompt.

At the second prompt, the feedback should provide students with a 'clue'. Targeted feedback should be given whenever possible (students find it frustrating to be given feedback which assumes that they have started the question in the wrong way, when they have actually made a mistake towards the end e.g. with the units or the significant figures). However, because it is not possible to anticipate all incorrect responses (other than for tightly constrained multiple choice questions) your programming instructions should include a general prompt ('General prompt 2') to be used for answers that are incorrect in some unidentified way.

The final answer should not just give the answer (e.g. 'The correct elements are carbon and oxygen') but explain *why* this answer is correct and, when appropriate, include working.

For S104, we have decided to give an appropriate reference to the course material both at second prompt stage and with the final answer.

For S104, we have also decided to remind students who have incorrectly selected options to multiple response questions that they need to deselect their previous options before proceeding. This is done at first and second prompt stage.

Answer matching
Remember that OpenMark uses string matching – it doesn't 'understand' the answers, so you need to specify exactly what you do and do not want to be accepted. I give quite detailed instructions. Our software developers will inevitably think of things that I haven't, but I see it as my responsibility to decide what I will accept as correct and what I won't. For example:

- For some questions you might accept a range of numerical values, or alternative spellings, for others you will require a very specific answer;
- Does the answer have to be in its simplest form?
- Does the order of the variables matter?
- Does the case of the variables matter?
- Are you assessing units? If not, the units can be given outside the data-entry box (and ignored if the student then gives units in their answer). If units are required, will you accept m/s and $s^{-1}m$ as equivalents to $m\ s^{-1}$ etc?
- Are you assessing significant figures? (you can specify that you want an answer to be within a range, but nevertheless given to a certain number of significant figures)
- Does the answer have to be entered in scientific notation. If so, will you accept if entered in 'E' notation (e.g. 1.23E5). For S104 we decided not to allow this. All other reasonable methods for entering scientific notation (e.g. $1.23 \text{ x } 10^5$, $1.23 \text{ X } 10^5$, $1.23*10^5$) are allowed.
- Unless you specify otherwise, spaces and commas will be removed before answer matching, along with repeated equals signs, all text after purely numerical answers (to allow for repeated units, statements of precision etc.), punctuation and text starting with 'to' or '(' after answers requiring units (to allow for 'to 2 sig figs' etc.) etc. and full stops within algebraic answers.
- Options selected at one attempt are usually left in place until the next attempt. However, for multiple response and drag and drop questions, you can choose to leave only correctly selected options in place (and to say so) but incorrect options should not be removed until the student clicks on 'try again' (so that the student is reminded of what they selected) and you need to take care that the student can't cheat and select all options then just have the correctly selected ones retained.

Accessibility issues

- OpenMark provides for different sizes of font, different colours of text and background etc.;
- Students can also select 'Plain mode' which can be read by screenreaders;

- Some questions need different variants for this purpose e.g. descriptions of graphs (see S154 Question 9.10 – attached)
- But describing some questions may make the assessment invalid, so do you want there to be a plain mode variant for every question? This is a course team decision. If plain mode variants are not available for all questions, students who are unable to attempt should be advised to bring this fact to the attention of the Award Board by completing a PT39.

Putting questions together into an iCMA.
You may want to keep track of the learning outcomes being assessed by each question, and balance this against learning outcomes assessed by other means (e.g. TMA questions). Feedback can be given at the end of the section or the whole iCMA on the demonstration of different learning outcomes.

Questions can be 'linked' so that a student cannot attempt one question until they have completed the previous one. This feature is used when one question assumes the answer to the previous one. However you should not expect students to remember the answer from a previous question; this should be re-stated at the beginning of the second question.

In summative use, students should be reminded to click on 'submit' when they have completed all the questions, but not to click on 'submit' until they have finished work on the iCMA.

You don't have to be perfect first time around!
The OpenMark reporting facility means that you can see exactly what students do wrong – and improve your questions and feedback accordingly.

However, in order for this to be useful, and in order to respond to queries from students, make sure that the report makes it clear which variant of the question each student received.

Checking OpenMark questions
There are two aspects to this

1. checking that the question as programmed has worked out as you intended. There may be programming errors, or a problem may become apparent for the first time when you see the programmed version of a question. Note: it is important to check all variants of each question.
2. checking that the question 'works' from the student perspective. Does it mark unusually entered but correct answers as correct; is the feedback helpful?

Ideally (1) should be done by the question author but (2) should be done by someone else, ideally someone who is not a subject expert but knows about the same amount about the subject as students do. It is better for this person to try the sorts of responses that a student might give, rather than trying the make the question 'fall over' by entering 'clever' responses.

To systematically check different variants:

- Do 'End test' and then press 'Submit' or 'Finish' Then press 'Restart entire test'
- In the address bar, add '?variant=0' to the end of the url. For example:
- http://kestrel.open.ac.uk/om-tn/s104-08b.icma43Draft3/?variant=0
- Press Enter on the keyboard.

You should now see the first info screen with [variant 0] near the top. As you work through the questions, each one will have this label. Do a similar thing to access variants 1, 2, 3 etc. The only time this won't work is when a question is generating completely random numbers and doesn't use datasets.

Examples of good practice

S154 Question 4.6
Calculation of area, with lengths in different units.
Question
A <thing> has length <length> <length unit> and width <width> <width unit>. What is its area?

Your answer should include appropriate units.

Click on the 'superscript' box to enter superscripts in your answer and click again to return to normal text, or use the up and down arrows on your keyboard.

The area of the <thing> = [box]

Accept <area 1> <unit 1> (or alternatives) or <area 2> <unit 2> (or alternatives) or <area3> <unit 3> (or alternatives). Case of unit must be correct.

Prompts
<Answer>
1 <length unit> = <conversion> <width unit>,
so <length> <length unit> = <length> × <conversion> <width unit> = <length 1> <width unit>.

Then area = length × width
= <length 1> <width unit> × <width> <width unit>
= <area 1> <unit 1>

This could also be given as <area 2> <unit 2>.

<General prompt 2>
The area can be found by multiplying the length by the width. However, you should start by converting the length and width to the same units, <width unit> or <length unit> on this occasion. <Course ref> Don't forget to include an appropriate unit of area in your answer.

<Units only prompt>
You have not included an appropriate unit of area in your answer.

<Unit case prompt>
Take care with the case of the unit.

Appearance of prompts
Prompt 1
If numerical answer is given as <area 1>, <area 2>, <area 3> or their alternatives and the unit is correct in all but case say
Your answer is incorrect
<Unit only prompt>
<Unit case prompt>

If numerical answer is given as <area 1>, <area 2>, <area 3> or their alternatives but the unit is incorrect (for the matching <area 1>, <area 2> or <area 3>) or missing say
Your answer is incorrect
<Unit only prompt>

For all other incorrect values say
Your answer is incorrect.

Prompt 2
If numerical answer is given as <area 1>, <area 2>, <area 3> or their alternatives and the unit is correct in all but case say
Your answer is incorrect
<Unit only prompt>
<Unit case prompt>

If numerical answer is given as <area 1>, <area 2>, <area 3> or their alternatives but the unit is incorrect (for the matching <area 1>, <area 2> or <area 3>) or missing say
Your answer is incorrect
<Unit only prompt>

For all other incorrect answers say
Your answer is still incorrect.
<General prompt 2>

Prompt 3
For all incorrect values say
Your answer is still incorrect.
<Answer>

Datasets for Question 4.6

	<course ref>	<thing>	<length>	<length unit>	<width>	<width unit>	<area 1>	<unit 1>	<alt. area 1>	<area 2>	<unit 2>	<alt. area 2>	<area 3>	<unit 3>	<alt. area 3>	<length 1>	<conversion>
L1 AYRF	*blank*	runway	4.0	km	80	m	320 000	m^2	3.2×10^5	0.32	km^2	3.2×10^{-1}	-	-	-	4000	1000
	blank	floorboard	3.0	m	12	cm	3600	cm^2	3.6×10^3	0.36	m^2	3.6×10^{-1}	360 000	mm^2	3.6×10^5	300	100
	blank	piece of carpet	2.0	m	70	cm	14 000	cm^2	1.4×10^4	1.4	m^2	-	1 400 000	mm^2	1.4×10^6	200	100
	blank	runway	1.5	km	60	m	90 000	m^2	9.0×10^4	0.090	km^2	9.0×10^{-2}	-	-	-	1500	1000
	blank	floorboard	2.0	m	15	cm	3000	cm^2	3.0×10^3	0.30	m^2	3.0×10^{-1}	300 000	mm^2	3.0×10^5	200	100
S154	See Box 4.3.	piece of carpet	1.5	m	80	cm	12 000	cm^2	1.2×10^4	1.2	m^2	-	1 200 000	mm^2	1.2×10^6	150	100
	See Box 4.3.	runway	4.0	km	70	m	280 000	m^2	2.8×10^5	0.28	km^2	2.8×10^{-1}	-	-	-	4000	1000
	See Box 4.3.	floorboard	2.0	m	12	cm	2400	cm^2	2.4×10^3	0.24	m^2	2.4×10^{-1}	240 000	mm^2	2.4×10^5	200	100
	See Box 4.3.	piece of carpet	5.0	m	70	cm	35 000	cm^2	3.5×10^4	3.5	m^2	-	3 500 000	mm^2	3.5×10^6	500	100
	See Box 4.3.	runway	2.5	km	60	m	150 000	m^2	1.5×10^5	0.15	km^2	1.5×10^{-1}	-	-	-	2500	1000

Datasets for Question 4.6 (Continued)

	<course ref>	<thing>	<length>	<length unit>	<width>	<width unit>	<area 1>	<unit 1>	<alt. area 1>	<area 2>	<unit 2>	<alt. area 2>	<area 3>	<unit 3>	<alt. area 3>	<length 1>	<conversion>
Maths Skills eBook	See Section 6.	floorboard	2.0	m	16	cm	3200	cm^2	3.2×10^3	0.32	m^2	3.2×10^{-1}	300 000	mm^2	3.2×10^5	200	100
	See Section 6.	piece of carpet	4.0	m	70	cm	28 000	cm^2	2.8×10^4	2.8	m^2	-	2 800 000	mm^2	2.8×10^6	400	100
	See Section 6.	runway	3.0	km	60	m	180 000	m^2	1.8×10^5	0.18	km^2	1.8×10^{-1}	-	-	-	3000	1000
	See Section 6.	floorboard	1.5	m	14	cm	2100	cm^2	2.1×10^3	0.21	m^2	2.1×10^{-1}	210 000	mm^2	2.1×10^5	150	100
	See Section 6.	piece of carpet	5.0	m	90	cm	45 000	cm^2	4.5×10^4	4.5	m^2	-	4 500 000	mm^2	4.5×10^6	500	100

Using Interactive Computer-marked Assignments in Level 3 Quantum Mechanics

John Bolton

Introduction

In 2009, we introduced interactive computer-marked assignments into the Open University Level 3 course on quantum mechanics (SM358: *The Quantum World*). This course covers the general principles, methods and interpretation of quantum mechanics, illustrated by applications to atoms, molecules and solids. The mathematical level assumes familiarity with complex numbers, differential equations, matrices and multiple integrals. In addition to basic wave mechanics, the topics covered include Dirac notation, ladder operators, angular momentum, spin matrices, many-particle systems, entanglement, perturbation theory and variational methods. The course material is in three main books with additional multimedia and film material provided on DVD.

The introduction of interactive computer-marked assignments into SM358 is a first step towards the use of purely formative continuous assessment in all Open University Level 3 Physics and Astronomy Courses (see *New assessment models for Physics and Astronomy* in this volume). In the 2009 presentation of SM358 we decided to retain four summative Tutor-Marked Assignments (TMAs) and to introduce seven new formative interactive Computer-Marked Assignments (iCMAs). The TMAs were slightly reduced in length compared to the only previous presentation of the course in order to make room for the iCMAs. Although the iCMAs were optional, we encouraged students to use them by emphasizing their value in acquiring the skills and knowledge needed to pass the final exam. The reason for moving only half-way towards purely formative continuous assessment was to give us a clear point of comparison. In 2010, essentially the same TMA and iCMA questions will be used formatively, so we should be able to see clearly the impact of presenting all the assignments formatively.

iCMAs in the context of SM358

Although it would have been easy to design relatively trivial quizzes, which could be answered with comprehension and recall, we did not think this would be appropriate at Level 3, especially as the TMAs were being shortened. Instead we took the opportunity to design a set of deeper questions that covered the most important skills and methods needed in the course, and which typically required work with pencil and paper off-screen; we could then honestly say to students that mastering the iCMAs would be an excellent way of gaining the skills needed to do well in the exam.

There were seven iCMAs -- one on mathematical background offered at at the outset of the course and six on quantum physics spread uniformly through the course. One iCMA contained 10 questions and all the others contained 8 questions. Each question in the first three assignments had 4 or 6 variants, but restrictions in funding, and a belief that more variants would not necessarily increase student learning, led us to restrict the number of variants to 3 in later assignments. We regarded 3 variants as the minimum number required to ensure that the weakest students would have enough attempts to master each question.

Students were presented variants at random and given three opportunities to get the right answer. If the first or second answers were wrong, a hint was given (specific for errors that could be anticipated, and otherwise generic). If the answer was wrong on a third attempt, a full solution was provided, and this was also provided after a correct answer. Each question included a reference to relevant course material and an indication was given about whether work with pencil and paper or calculator was required. The questions were scored according to the number of hints received and a total score given for the whole assignment together with recommendations for further study if necessary.

In the context of formative assessment, it is important to give students the opportunity to keep working on each type of question until they are confident that they have mastered the necessary skills. We therefore encouraged students to reselect a question immediately after getting it wrong. At this stage, they will have seen a full solution and can implement their understanding of it in the context of a fresh variant of the same question. Students were advised to keep going in this way until they were confident of their level of understanding. Alternatively, students could complete the whole iCMA before trying it again as many times as they wished, with different variants appearing at random. Whether students repeated questions within an assignment or tried the assignment a multiple number of times, they were advised to persist until they obtained an overall score of 70 % or more for each iCMA. Gradebook always recorded the student's best score on an assignment.

The questions were written in OpenMark, rather than Moodle. This allowed the questions to be more complex, with several inputs per question. Crucially, OpenMark supported the ability for students to keep exploring a question, via several different variants, before they completed the whole assignment. This is especially appropriate for our formative use as students may wish to try questions over an extended period, chapter by chapter, and have no need to complete the whole assignment in order to make sure that they have mastered a particular topic.

Student uptake and performance

There were 380 students registered on SM358 in 2009. Table 1 shows data on the formative iCMAs. The column marked "Started" refers to students who input the answer to at least one question, but did not click the Finish button. For comparison, Table 2 shows data on the TMAs. Of course, in this case, no data is available on students who started the assignment but did not submit their work.

It is not surprising that the TMAs were tackled by more students than the iCMAs because the TMAs were summative, and a minimum TMA score was needed to pass the course. Nevertheless, a reasonable number of students tried at least four of the iCMAs, and scores on all the iCMAs were high, showing that students treated these assignments seriously, in spite of their formative nature.

	Finished (%)	Started (%)	Mean score (%)
iCMA Maths	86	91	85
iCMA 51 (Book 1)	67	78	80
iCMA 52 (Book 1)	55	66	82
iCMA 53 (Book 2)	48	61	85
iCMA 54 (Book 2)	41	54	79
iCMA 55 (Book 3)	34	46	76
iCMA 56 (Book 3)	25	32	83

Table 1: Statistics on the iCMAs of SM358 in 2009.

	Finished (%)	Mean Score
TMA 01 (Book 1)	86	84
TMA 02 (Book 1+2)	78	76
TMA 03 (Book 2)	76	85
TMA 04 (Book 3)	70.5	79

Table 2: Statistics on the TMAs of SM358 in 2009. Detailed changes to the University's substitution rule in 2009 persuaded nearly all students who took the exam in 2009 to do all four of the TMAs.

A notable feature of the 2009 presentation was the large increase in retention (70.5 % in 2009, compared with 60.5 % in the only previous presentation of the course.) The pass rate, expressed as a percentage of all registered students, was 61.1 % in 2009, compared to 55.5 % in the previous presentation. Moreover, the percentage of students gaining Grade 1 on the course, expressed as a percentage of all registered students, rose to 21.8 % from 18.0 %.

Apart from the iCMAs, a number of other changes were made to the course presentation in 2009, including screencasts and Elluminate tutorials. The screencasts were received positively, but were only used by a small minority of students and the Elluminate tutorials had a mixed reception. We therefore believe that the iCMAs must have been the main factor behind the significant increases in retention, pass rate and Grade 1 percentage.

If the iCMAs do have a significant positive influence, we would expect there to be a strong correlation between individual student performance on the course and the use of iCMAs. The histograms in Figure 1 confirm that such a correlation does exist. By themselves, these histograms cannot establish causation: after all, we would expect stronger students to do a greater number of the optional assignments. However, coupled with the increase in retention, they strengthen the claim that iCMAs help students to survive the course and do better on it.

Anecdotal feedback also showed that iCMAs were highly appreciated. For example, one student commented: ``[iCMAs] really do give you confidence that you're learning and developing, as you continue to plough into the courses unrelentingly unfamiliar territory!'' and another student said ``Without question, a truly outstanding learning aid''.

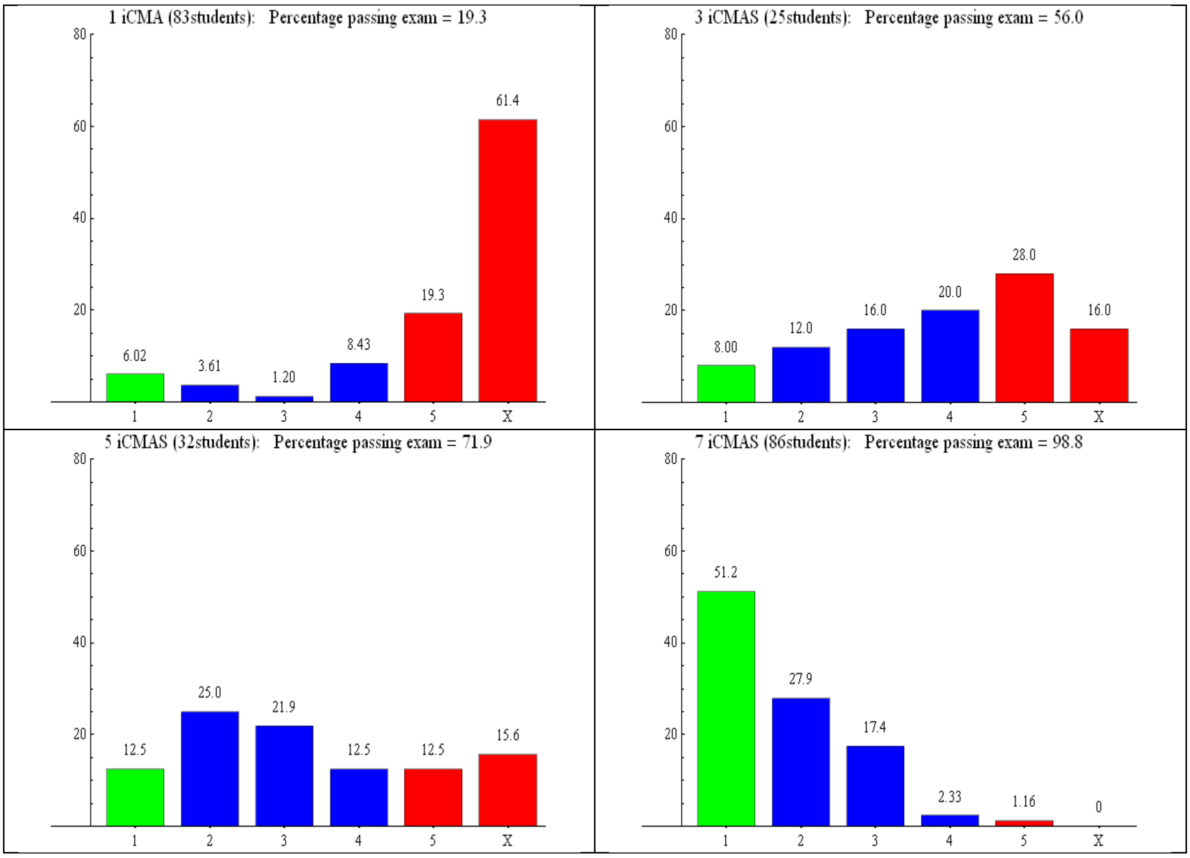


Figure 1: Histograms showing the distribution of course results on SM358 in 2009 for students doing 1,3,5 and 7 iCMAs. Grades 1-4 are passes, Grade 5 is a fail and X shows registered students who did not sit the final exam.

Student feedback and survey data

In September 2009, SM358 students were asked to take part in a questionnaire on various aspects of the course, including the iCMAs. The results were based on 53 responses. For respondents, the average percentage of iCMAs completed was 78 % overall, varying from 99.8 % for the first assignment to 37 % for the last. These were higher than the average figures for all students on the course (51 %, 86 % and 25 % repectively). At least part of the reason for this is that students who had done few assignments were more likely to have dropped out of the course by September.

The average time spent on each iCMA was 3.98 hours, with a standard deviation of 4.23 hours. This standard deviation was inflated by two students who claimed to spend 20 -- 30 hours on each iCMA, more than three standard deviations away from the mean. Removing these two outliers, a more typical average is 3.28 hours (with standard deviation 2.25 hours). This may however include multiple attempts on an iCMA or on the questions within it.

For comparison, the average time spend on each TMA was 15.1 hours, with a standard deviation of 8.54 hours. Thus, the time spent per iCMA was 22 % of that spent per TMA, and across the whole course the total time spent on all the iCMAs was 38 % of that spent on all the TMAs. These numbers inevitably reflect our assessment strategy in 2009, which had summative TMAs and formative iCMAs. The balance may change in 2010, when all assignments will be formative.

The survey included questions exploring student motivation for doing the iCMAs. Many students said that they used iCMA questions because they are good for exam preparation (79 % agreed, 6 % disagreed), while significant but smaller numbers said they they uses iCMA questions to help practice the skills needed for the summative TMAs (58 % agreed, 19 % disagreed). Most students thought that answering iCMA questions helped them directly in acquiring skills and knowledge (83 % agreed, 10 % disagreed) and that answering iCMA questions helped them to understand what they needed to study further (75 % agreed, 10 % disagreed).

It is interesting to compare students' perceptions of iCMAs and TMAs. Around 42 % of students said that they learnt more from doing TMA questions than by doing iCMA questions (but 10 % disagreed and 48 % were neutral). Also, 31 % of students agreed that the feedback provided by their tutor on TMAs was more useful than the feedback provided by the computer on iCMA answers (but 23 % disagreed and 46 % were neutral). Bearing in mind that students spent 2.6 times more time on the TMAs than on the iCMAs, and that the TMAs were summative and the iCMAs formative, these results are encouraging.

We asked students to rank eight features of the iCMAs in order of their helpfulness. These features are listed below, together with the percentages of students who chose the feature as being first or second in order of helpfulness.

- Being given a full solution.
  (Most helpful 50 %, second most helpful 13 %)

- Being told instantly whether I got each answer right.
  (Most helpful 42 %, second most helpful 8 %)

- Being given appropriate references to course material.
  (Most helpful 38 %, second most helpful 18 %)

- Having 3 tries at each question with increasing feedback after wrong answers. (Most helpful 35 %, second most helpful 21 %)

- Being able to repeat questions with different variants.
  (Most helpful 32 %, second most helpful 24 %)

- Being given a score for the whole iCMA.
  (Most helpful 24 %, second most helpful 10 %)

- Being given hints when my answer was incorrect.
  (Most helpful 23 %, second most helpful 13 %)

- Talking to my tutor about my progress on the iCMA.
  (Most helpful 22 %, second most helpful 2 %)

These results reveal a wide range of opinions, with even the least popular feature being rated as the most helpful by 22 % of students. However, we can say that being given a full solution and references to course material are both regarded as helpful.
44 % of students frequently printed out the solution for future reference (and a similar number frequently printed out the question). Around 81 % of students frequently referred to course materials while tackling questions.

Some distinctive features of iCMAs (the ability to make three attempts at each question, to repeat questions with different variants and being given instant feedback) are also highly-appreciated by many students. Being given hints for incorrect answers had a lower rating. This may be because receiving a full solution and having the ability to try a series of different variants of a question is more powerful than being given a hint, especially if students are focused on getting the right answer rather than analyzing previous errors. Most students said that being given a full solution was sufficient for them to get the correct answer to a subsequent variant (77 % agreed, 2 % disagreed), rather fewer said that the hints were enough for them to correct a wrong answer (62 % agreed, 23 % disagreed).

Unfortunately, some students appear to make little use of feedback. Most students read the full solution if they get a question right (about 81 % did this frequently, and about 2 % never did it). One might expect more students to read the solution if they get a question wrong, but this was not the case: only 72 % frequently read the solution to a question they got wrong and 15 % never did this. We are not sure what the reasons for this behaviour are, but are concerned that failing to analyze their mistakes may prevent some students from getting the most out of iCMAs.

Not surprisingly, being given an overall score was regarded as being less important in a formative context. However, most students felt that the score given accurately reflected their performance on the iCMA (73 % agreed, 4 % disagreed), and only a minority of students felt they were unfairly penalized for careless mistakes (25 % agreed, 48 % disagreed and 27 % were neutral).

A minority of students regarded the ability to be discuss the iCMAs with tutors as being very important (22 % rated this as the most helpful feature). However, this may partially reflect general enthusiasm for direct tutor contact rather than any specific experience in the context of iCMAs. In fact, 94 % of students said they had never discussed an iCMA question with their tutor and 92 % said they had never discussed their overall performance on iCMAs with their tutor. It may be that some students would like more tutor contact about iCMAs than they actually received.

Students were asked several questions about their mode of use of the iCMAs.
Around 73 % of students frequently tackled an iCMA as a single quiz, with all the questions attempted in a short period. Only 21 % said they frequently tackled each question soon after studying the relevant course material, building up the answers to the iCMA over a period of weeks. We would like to encourage more students to tackle the iCMAs in the latter mode, as this reinforces understanding at the time of study and could therefore be more efficient way of learning;

there is nothing to restrict students from trying the quiz a second or third time for practice and revision purposes. However, many students are used to being driven by cut-off dates, so this would mark a change in their usual working methods.

We also asked about different ways of attempting questions a multiple number of times. About 62 % of students said they had frequently completed a quiz as a whole and then had another go at it. About 56% of students said that they had frequently attempted different variants of a question before moving on to other questions. Again, we would like to encourage the latter use further, but probably need to overcome ingrained working patterns.

Conclusions

When we introduced iCMAs into SM358, we were uncertain what their impact would be. The questions were designed to practice the most important skills covered in the course, so they could not be trivial or short. We did not know how students would react to this, or whether they would regard formative assignments as being inessential.

In general, the students have responded very positively and there are many indications that students regard the iCMAs as important learning aids. Moreover, we believe that the large increase in retention (from 60.5 % to 70.5 %) is largely due to the iCMAs.

It should be noted, however, that our results apply to a particular course at Level 3, and to a particular pattern of continuous assessment in which the iCMAs were formative and the TMAs were summative. In 2010, we will complete the progression to formative assignments in SM358 by making both the TMAs and the iCMA formative (with thresholds for satisfactory engagement). Essentially the same questions will be used as in 2009, so we should be able to see clearly how iCMAs function in a different assessment environment. We suspect that quite delicate issues of psychology come into play when marks for credit cease to be a primary goal.

Paper presented at the GIREP/EPEC/PHEC Conference, Leicester, August 2009

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Using e-assessment to support distance learners of science

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Introduction

This paper describes the use of online interactive computer marked assignments (iCMAs) in a range of physics and general science modules at the UK Open University (OU), and an evaluation, jointly funded by the Physics Innovations Centre for Excellence in Teaching and Learning (piCETL) and the Centre for Open Learning of Mathematics, Science, Computing and Technology (COLMSCT) into student engagement with these iCMAs. Although the work has been done in the context of one particular large distance-learning university, the software used is open source and the evaluation has wider implications for those seeking to find the most appropriate way to use e-assessment to support their students' learning.

The Joint Information Systems Committee (JISC) define e-assessment as 'the end-to-end electronic assessment processes where ICT is used for the presentation of assessment and the recording of responses'(JISC, 2009). There are many exciting ways in which e-assessment can be used to support learning, including the use of e-portfolios and the assessment of students' contributions to online discussions (Buzzetto-More and Alade, 2006). Here we describe the use of online quizzes, where a student enters his or her responses and receives instantaneous feedback. Note however that the range of question types in use goes far beyond the selected response multiple-choice questions that are commonly associated with assessment of this type.

Background

Throughout the Open University's 40-year history there has been some blurring of the summative ('for measuring') and formative ('for learning') roles of assessment. OU undergraduate students are typically (though no longer exclusively) adults, studying part-time alongside other commitments and they have a wide range of entry qualifications from previous higher education qualifications to, literally, none. Many have not studied for many years and so they may be particularly lacking in confidence. The students study at a distance, but the OU's model of supported distance education means that they are usually supported by a tutor. This tutor will provide occasional tutorials (face-to-face or using a range of synchronous and asynchronous electronic communication technologies) and be available to support student learning by telephone or email; however a substantial part of the tutor's contracted time will be spent in grading and providing feedback on 'tutor-marked assignments' (TMAs). The fact that this task is described as 'correspondence tuition' reflects the importance that is placed on the feedback provided by tutors to their students in this way; this is particularly important in a distance-learning organisation, where many students never meet their tutor and opportunities for informal feedback are extremely limited. However TMA scores have usually contributed substantially to students' overall course grades.

The use of e-assessment also has a long history at the Open University. TMAs have long been supplemented by computer-marked assignments (CMAs), initially comprising solely multiple choice questions, with students' responses entered on machine-readable forms and submitted by post. Now, in many Science Faculty courses, students complete online interactive computer-marked assignments (iCMAs) from their own computers at home.

Why e-assessment, or why not?

It is widely recognised that rapidly received feedback on assessment tasks has an important part to play in underpinning student learning, encouraging engagement and promoting retention (see, for example, Rust, Donovan and Price, 2005). Online assessment, with its instantaneous feedback, can been seen as providing 'a tutor at the student's elbow' (Ross, Jordan and Butcher, 2006, p125), of particular importance in a distance-learning environment. For high-population modules and programmes, e-assessment can also deliver savings of cost and effort. Finally, e-assessment is the natural partner to the growth industry of e-learning.

However, opinions of e-assessment are mixed and evidence for its effectiveness is inconclusive; indeed e-assessment is sometimes perceived as having a negative effect on learning (Gibbs, 2006). There are more widely voiced concerns that e-assessment tasks (predominantly but not exclusively multiple-choice) can encourage memorisation and factual recall and lead to surface-learning, far removed from the tasks that will be required of the learners in the real world (Scouller and Prosser, 1994).

Thus when e-assessment is used, careful evaluation is required to ensure that it is being used to optimum effect and having a positive not a detrimental effect on student learning. There are a number of related questions, for example:

- What sorts of e-assessment tasks have the best potential to support student learning?
- What mode of use is most effective: summative, formative, thresholded etc.
- What sort of feedback on e-assessment tasks is most useful?
- Does it matter that the feedback is generated by a computer rather than by tutors, peers or the students themselves?

E-assessment at the Open University
The iCMAs included in the current evaluation all use the ‘OpenMark’ web-based assessment system (Butcher, 2006) within the Moodle virtual learning environment (Butcher, 2008). Question types include those requiring free text entry of numbers, letters, and words in addition to more conventional drag and drop, multiple choice, multiple response and hotspot questions. In most cases, students are allowed multiple attempts (usually three) at each question, with increasingly detailed and tailored prompts allowing them to act on the feedback whilst it is still fresh in their minds and so to learn from it (Sadler,1989; Gibbs and Simpson, 2004), as illustrated in the simple question shown in Figure 1. The hints frequently refer students back to relevant course material (which might be a book, a video sequence or an interactive activity). Feedback can also be provided on the student’s demonstration of learning outcomes developed in the preceding period of study. OpenMark has good accessibility features and wherever possible, questions exist in several variants. In summative use this enables different students to receive different assignments, whilst in formative-only use, the different questions provide extra opportunities to practise.

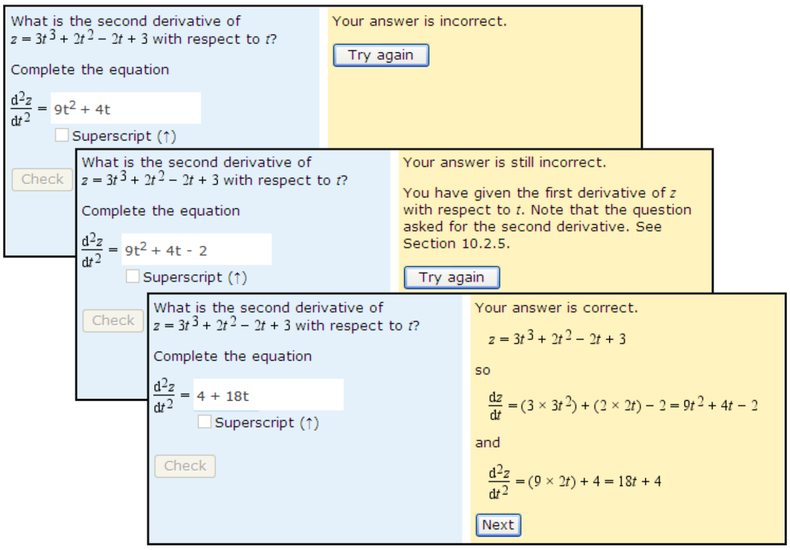

Figure 1 A simple numerical OpenMark question, with increasing feedback given at each attempt.

The range of question types has been extended still further to include those in which students have to construct a response in the form of a phrase or sentence of up to 20 words. The answer matching for these questions was initially written using a commercial linguistically-based authoring tool (Jordan and Mitchell, 2009); answer matching of equivalent accuracy can now be obtained using OpenMark's own 'PMatch' algorithmically-based system. Whichever software is used, the answer matching is developed using previous responses from students, and the questions sit within the OpenMark framework, so multiple attempts are allowed, with increasing feedback (Figure 2).

Within the Open University Science Faculty, iCMAs are embedded in courses' assessment strategies in a wide variety of ways, for example:
Case 1: The level 1 10 CATs point course S151: *Maths for Science* has a single summative OpenMark end of course assignment (available to students for 5 weeks) with instantaneous feedback given to students on individual questions. The students are not told their mark. A similar practice assessment (Case 1 PA) is available for the duration of the course.
Case 2: The introductory 10 CATs point course S154 : *Science Starts Here* has two very short tutor marked assignments and two very short summative but low stakes iCMAs (Case 2 SA) plus a purely formative iCMA (Case 2 PA) available for the duration of the course.
Case 3: The Science Faculty's major 60 point foundation course S104 : *Exploring Science* (the introduction to physics, chemistry, biology and Earth science) has nine summative but low stakes iCMAs, eight tutor marked assignments and an end of course assignment.
Case 4: The level 3 physics course SM358 : *The quantum world* has regular formative iCMAs, clearly embedded within the course alongside tutor-marked assignments. Students are told that there will be similar questions to those in the iCMAs in the final examination. From 2010, all TMAs and iCMAs on this course and other level 3 physics and astronomy courses will be formative only, but thresholded i.e. students will have to complete a certain number of the assignments, where satisfactory completion of an iCMA will be deemed to be a score of 30% or more.
Case 5: iCMAs are used for diagnostic purposes in a series of 'Are you ready for?' quizzes, designed to help students to decide whether or not they are sufficiently prepared to study a particular course.

The Moodle Gradebook enables students to monitor their own progress, encouraging sustainable self-assessment practices (Boud, 2000), and the tutor's view of the Moodle Gradebook encourages discussion between students and tutors.

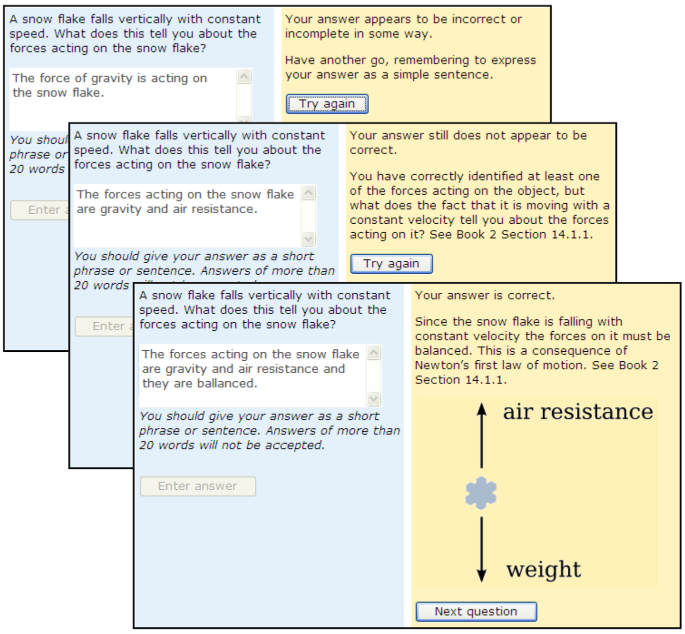

Figure 2 A short answer free-text question, with increasing feedback given at each attempt.

Previous evaluation

Evaluation methodologies have included surveys of student opinion, observation of students in a usability laboratory, a ‘success case method’ approach (Hunter, 2008) and a comparison of accuracy of computer and human marking (Jordan and Mitchell, 2009). The systems have been found to be robust and accurate in marking and most students report enjoying the iCMAs and finding them useful. However there are some anomalies. For example, whilst more than 90% of students report finding the feedback provided useful and, when observed in a usability laboratory, some students were seen to read the feedback and then to adjust their answer in a sensible way, others do not make use of the feedback in the way that iCMA authors would hope.

The current work

The current project is seeking to ‘observe’ student behaviour remotely, by means of a quantitative and anonymised analysis of the data captured when students attempt iCMAs. Tools have been produced to extract summary information from the databases. It should be noted that the quantitative data extracted in this way are reliable since the student populations of the courses in question are large, for example, the course identified as ‘Case 3’ above has two presentations each year with 1500-2000 students per presentation.

How many students attempt each question?

Not surprisingly, when iCMAs are summative (even if low stakes), students are highly motivated to attempt all the questions, as shown in Figure 3 below.

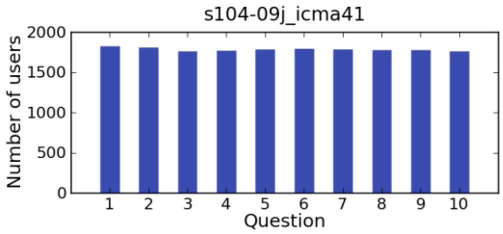

Figure 3 The number of students attempting each question in a summative but low-stakes iCMA (Case 3).

However, when an iCMA is formative-only, usage drops off in a characteristic way, as shown in Figure 4.

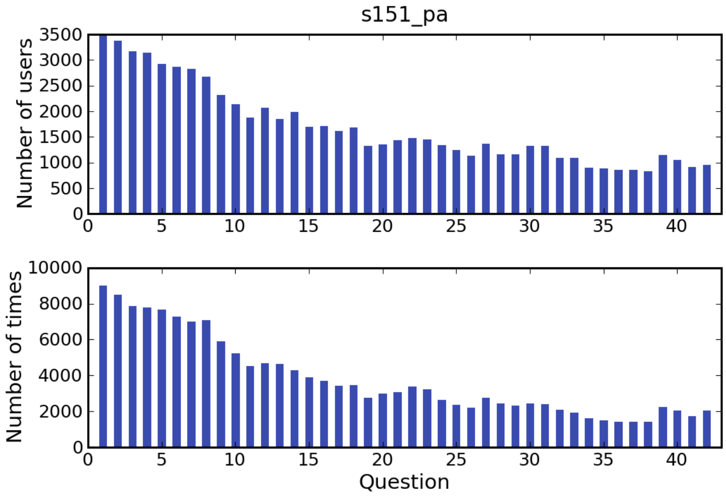

Figure 4 The number of students attempting each question in a formative-only iCMA (Case 1 PA)

The top bar-chart in Figure 4 shows the number of students who attempted each question; the lower bar-chart shows the number of separate uses of each question (so each user attempted each question an average of three times). Note that this particular iCMA includes forty-two questions; usage drops off less for iCMAs with fewer questions, however if there are then several separate iCMAs spread over the duration of the course, there is then a drop in use from iCMA to iCMA, resulting in a similar drop in use from the first question in the first iCMA to the final question in the final iCMA. Typically, the number of users has dropped to around half by half-way through the iCMA or course and to around a quarter by the end. In addition, some students view the questions in the iCMA but never attempt any; for the iCMA illustrated in Figure 4 and over the same time-scale, the iCMA was viewed by around 4500 students.

There appear to be particular aspects of iCMA design that can contribute to a marked decline in use (which is not recovered in subsequent questions); this is often linked to questions that are deemed to be complicated (perhaps with multiple boxes to complete) or time-consuming (though not necessarily difficult) or which require the student to access a piece of multi-media or even perhaps just to use their calculator (as illustrated in the example shown in Figure 5 below, which is question 19 in the iCMA under consideration in Figure 4). However use can be encouraged by making it clear which questions relate to which section of the course (as shown in the navigation panel to the left hand side of Figure 5); Figure 4 shows that students who had not attempted previous questions were nevertheless sufficiently motivated to attempt the questions linked to Chapter 7 (starting with question 27) and Chapter 10 (starting with question 39). Identifying which questions relate to which sections of the course (and reminding students to attempt them at appropriate times, by notes in the course texts or website) is now considered to be good iCMA design, although it is not practical in all situations, for instance when iCMA questions have a deliberately synoptic role.

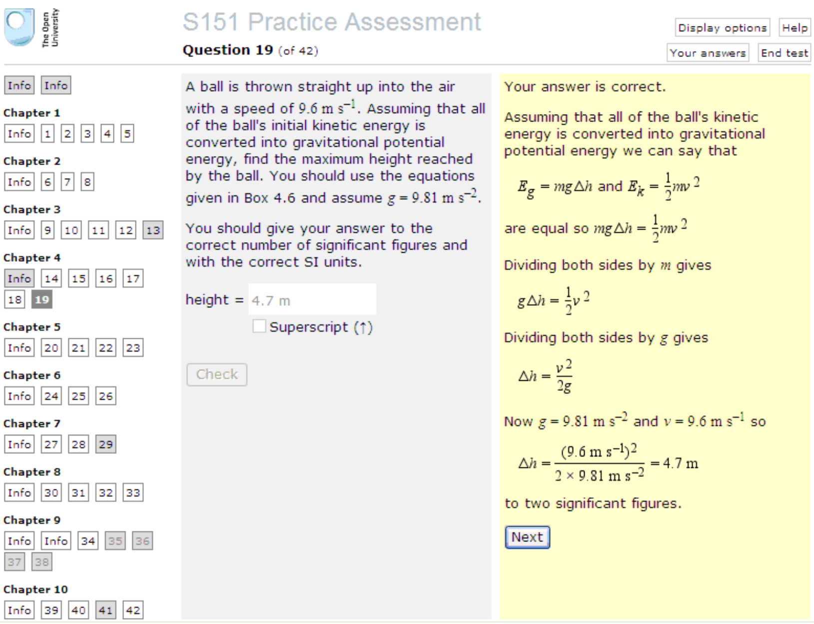

Figure 5 The iCMA under consideration in Figure 4, showing Question 19 and the navigation panel.

When do students attempt the questions?

Summative iCMAs are usually made available to students for a period of several weeks and within that time scale students are allowed to spend as long as they would like to on the questions; if a student closes their browser and returns to an iCMA at a later stage, the system will remember where they were up to. However most summative iCMAs have a ‘hard’ cut-off date; this is a deliberate policy, designed to encourage OU students (who frequently have many competing demands on their time) to keep up to date in their studies. In Case 3, the cut-off date for each iCMA is a few days after students are scheduled to have completed their study of the relevant course material. Figure 6 shows that the cut-off date is clearly effective in encouraging students to attempt the iCMA but most complete the questions in the few days immediately before the cut-off date. The three graphs in Figure 6 are for an early question (Question 1), a late question (Question 9) and the combined usage of all 10 questions in the iCMA; thus the behaviour is similar for all questions.

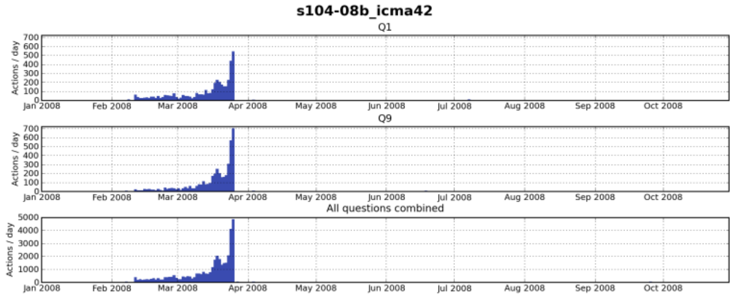

Figure 6 Number of actions on iCMA questions per day, for a summative iCMA with a hard cut-off date (Case 3)

The situation for Case 2 is rather different. The purely formative practice iCMA has 88 questions and is available to students throughout the course's 10-week duration. Figure 7 shows the number of actions per day for an early question (Question 2), a question around half-way through the iCMA (Question 40), a late question (Question 88) and all the questions combined. The relatively uniform overall usage appears to be attributable to the fact that students are attempting different questions at different times. This iCMA, like the one shown in Figure 5, has questions linked to different chapters of the course, and students are reminded after each chapter to try the relevant questions.

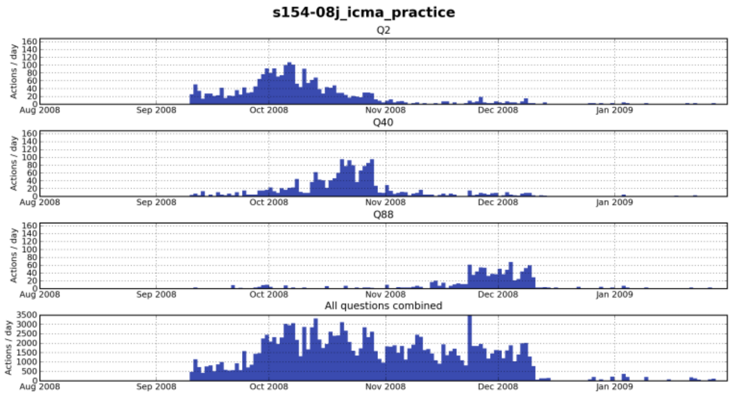

Figure 7 Number of actions on iCMA questions per day, for a formative-only iCMA (Case 2 PA)

Figure 8 shows the number of actions per day for the summative iCMA for the same course (Case 2 SA), for an early question (Question 1) a late question (Question 9) and all the questions combined. The course teams who produced the courses in Case 2 and Case 3 had designed the summative iCMAs of the two courses (which are linked; Case 2 is a precursor to Case 3) to be similar; the iCMAs have similar weightings, both have 10 questions, they both have hard cut-off dates and they are available to students for a similar length of time. So it is surprising that Figure 6 is rather different from Figure 8; in the latter case students again appear to be attempting different questions at different times. One possible explanation of this is purely that this is what students are advised to do; the questions in the first summative iCMA assess three chapters of the course; on completing Chapter 2, students are advised to attempt the relevant formative and summative questions, and similarly for Chapters 3 and 4.

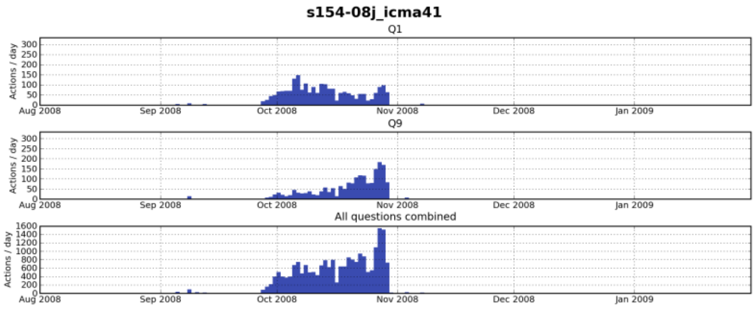

Figure 8 Number of actions on iCMA questions per day, for a summative iCMA with a hard cut-off date (Case 2 SA)

Most of the courses included in the study have a final assessed component that is completed in the student's own home and with access to course material. Case 4 (the level 3 physics course) ends with an examination, taken at an exam centre. It is clear from Figure 9 that many students are making use of the iCMA questions on this course for revision, so it appears that use of formative iCMAs can be encouraged simply by saying that the practice and feedback will be useful for the examination. Figure 9 shows the use of an iCMA primarily intended for use earlier in the year; selections of earlier questions had been combined together into three 'revision' iCMAs and these were also heavily used in the run up to the examination, though the fact that some students chose to use the earlier iCMAs perhaps indicates that they were using iCMAs in their revision of specific topics. The reasons for this behaviour will be explored further by interview.

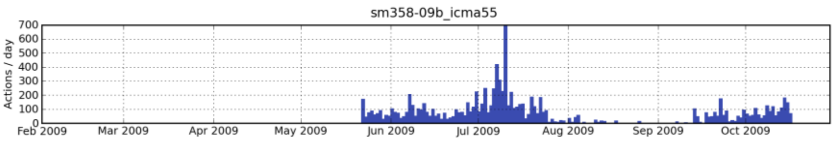

Figure 9 Number of actions on iCMA questions per day, for a formative-only iCMA on a course with a final exam (Case 4)

When do individual students attempt the iCMA?

In addition to looking at all actions on a particular iCMA question, it is possible to inspect the way in which individual students progress through the iCMA, and three typical student behaviours are shown in Figure 10 (all for Case 2 SA). 'Student 1' and 'Student 2' are typical for all summative uses: many students attempt all 10 questions on the very last day an iCMA is open (like Student 1) whilst some attempt a question, then attempt another, then return to the first question etc. in an apparently chaotic fashion, sometimes with a period of several days between consecutive uses of the same question (like Student 2). However graphs such that shown for Student 3 were observed frequently for Case 2 SA but never for Case 3, and this is another illustration of the behaviour shown in Figure 8. This student has attempted the 4 questions that assess Chapter 2, then presumably worked through Chapter 3 and attempted that chapter's questions, then similarly for Chapter 4.

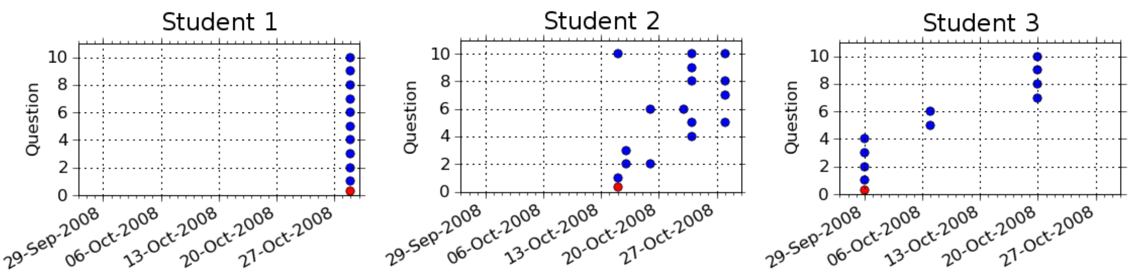

Figure 10 Days on which three students made attempts at the questions on a summative iCMA (Case 2 SA)

Closer inspection of student responses to questions
Inspection of the actual responses entered by students, in particular to free-text responses in summative use, has been used to learn about common student misconceptions (Jordan, 2007). Student responses can also provide valuable insights into more general factors concerning the use of iCMAs by students.

Closer inspection of student responses to questions: (a) the length of free-text answers
Student responses to short-answer free text questions in summative use have generally been found to be

- more likely to be correct
- more likely to be expressed as sentences (as requested in the course guide and the introductory screen in Case 3)
- longer

than the responses to the questions in formative-only use. Figures 11 and 12 compare the length of responses obtained to the question shown in Figure 2 (without the wording shown in italics).

In formative-only use (Figure 11) the peak at one word corresponds to the answer 'balanced' and the peak at 3 words corresponds to the answers such as 'they are balanced' and 'equal and opposite'. In summative use (Figure 12) the peak at 4 words corresponds to answers such as 'the forces are balanced' and the peak at 8 words corresponds to answers such as 'the forces acting on the snowflake are balanced' and 'there are no unbalanced forces acting on it'. It is quite common for the distribution of lengths to be bimodal; in other questions there is sometimes a peak for answers that simply answer the question (e.g. 'the force is reduced by a factor of four') and another for answers that add an explanation (e.g. 'the force is reduced by a factor of four since it depends on dividing by the square of the separation').

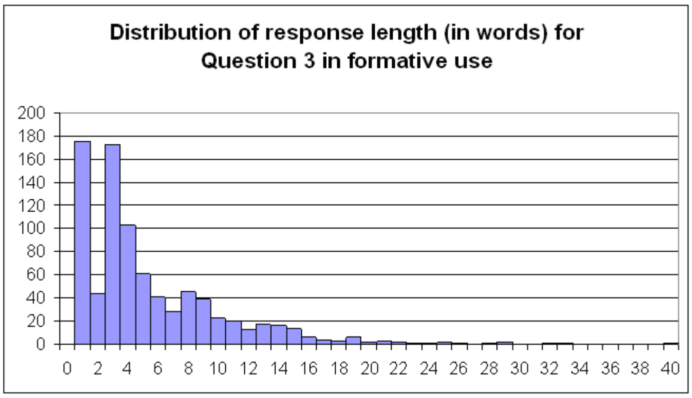

Figure 11 Distribution of length of 888 responses to the question shown in Figure 2 (without the wording shown in italics) in formative-only use.

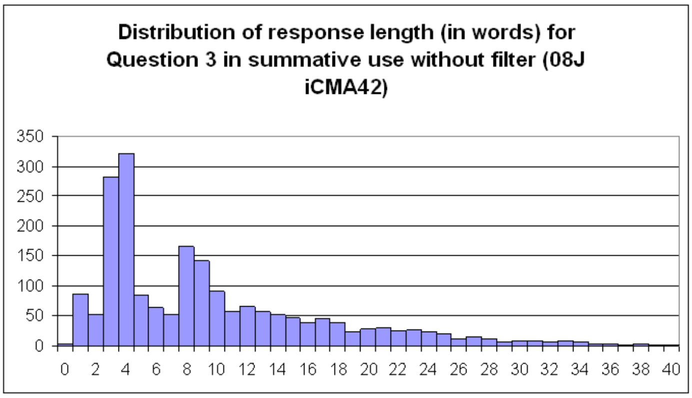

Figure 12 Distribution of length of 2057 responses to the question shown in Figure 2 (without the wording shown in italics) in summative use (Case 3).

Unfortunately some excessively long responses were received (up to several hundred words) to early summative versions of short-answer free text questions, and these frequently contained a correct answer within an incorrect one. Responses of this type are recognised as being the most difficult for computerised marking systems of any type to deal with and for this reason, from February 2009, a filter has been introduced to limit the length of responses to 20 words. Students who give a longer answer are told that their answer is too long and are given an extra attempt. The filter was initially accompanied by the text shown in Figure 2 (*You should give your answer as a short phrase or sentence. Answers of more than 20 words will not be accepted*).

The introduction of the filter and explanatory text reduced the number of students who added text to previous answers without thought to the sense of the response so produced. It also dealt with the excessively long responses that were difficult to mark, and increased the number of students giving their responses as sentences. However, for all questions, the addition of the filter and explanatory text resulted in an overall *increase* in median response length (see the distribution shown in Figure 13).

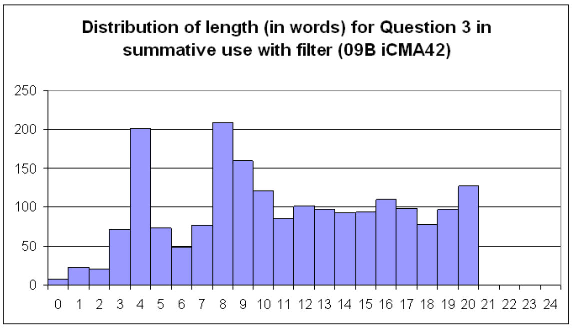

Figure 13 Distribution of length of 1991 responses to a question in summative use (Case 3) with filter and additional wording on the question.

A possible explanation of this effect is that more students were heeding the advice to give their answer as a sentence, now that this advice was given in the question. A less desirable explanation is that students were interpreting the advice to use no more than 20 words as indicating that they should be writing exactly or almost twenty words. From July 2009, the advice accompanying the filter has been changed to '*You should give your answer as a* ***short*** *phrase or sentence.*' The question shown in Figure 2 has not been used since then, but length distributions for other questions illustrate that the latest change of wording appears to have had the desired effect, reducing the median length and the number of responses that are exactly or just under 20 words in length.

Closer inspection of student responses to questions: (b) use of feedback
One of the anomalies of previous evaluations of e-assessment at the Open University and elsewhere is that the vast majority of students report finding the feedback provided on iCMA questions useful, but yet some are observed to make no use of it. In a first attempt to interpret evidence of actual behaviour, graphs have been plotted to show the number of incorrect responses that were unchanged at second and third attempt. Figure 14 illustrates the number of repeated responses *for the same question* in summative and formative-only use (for Case 2) and in diagnostic use (Case 5). In the figure, grey shading indicates blank responses, green shading indicates correct responses; red, orange or yellow shading indicates incorrect responses; an identical colour from first to second attempt or from second to third attempt indicates an unchanged response.

Thus it can be seen that a proportion of responses are left blank and in some circumstances almost half are left unchanged for a second and third attempt even when users have been told that their previous answer was incorrect. Not surprisingly, the proportion of blank and repeated responses varies markedly with mode of use, with very little of this behaviour in summative use, more in purely formative use and more still in diagnostic use. The proportion of responses that are blank and/or repeated also varies considerably with question type; students are more likely to repeat responses when they cannot guess the answer (in a multiple choice or drag and drop question). It is possible that students are deliberately leaving responses blank or repeating them in order to receive the feedback provided at a later stage. Reasons for this behaviour will be explored further by interview.

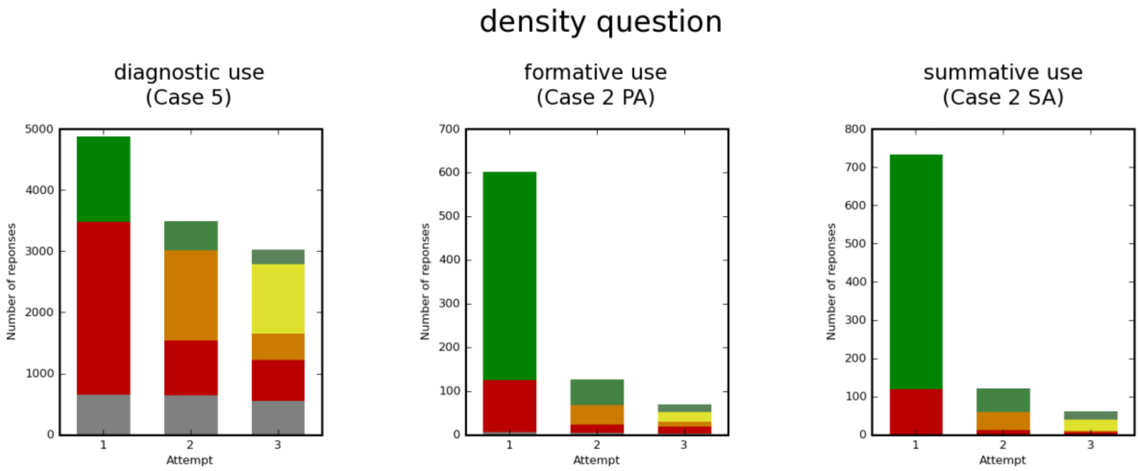

Figure 14 Blank and repeated responses for the same question in diagnostic, formative-only and summative use.

Conclusions

In general terms, students appear to engage with iCMAs in a deeper way when the questions carry some summative weight. However, in summative use, students become obsessed with the minutiae of the grading, as witnessed by many emails from students who believe – usually wrongly – that 'the computer has marked them incorrectly'. The use of thresholding or a 'carrot' (e.g. having similar questions in an unseen exam) may provide an alterative mechanism for encouraging students to engage with iCMA questions and so to learn from the feedback provided.

Things are not always as simple as you think they will be. At face value, use of the iCMAs in Case 3 and Case 2 SA should be similar, but this has been shown not to be the case. The differences appear to be entirely attributable to students' interpretation of what they have been told to do (in Case 2 SA they have been told to do the questions after studying the relevant part of the course; in Case 3 emphasis has been put on the importance of checking access to the iCMA in plenty of time, even if the student doesn't attempt any of the questions). Similarly, the increase in average length of responses to free text questions in response to the instruction that responses should be no more than 20 words in length, points towards a student interpretation that 'no more than 20 words' means 'nearly 20 words'. The fact that responses were more likely to be in complete sentences suggests that students may be more likely to read instructions when they are provided within the question, rather than hidden away in an introductory screen or in the course guide.

Ongoing work

The results reported here are just some of the outcomes from the quantitative analysis of the data captured when students attempt iCMAs. Other factors that are being investigated include the length of time students spend in answering iCMA questions of various types and in different modes of use, and the order in which they answer the questions. The effect of variables such as start date, finish date, elapsed time and active time on performance will also be analysed, in order to investigate whether students who engage with iCMAs in different ways perform differently, for example, are early and late completers of iCMAs equally successful? Linked to this will be further investigation into whether students behave differently in different situations, for example, do students exhibit similar behaviour when they are revising to that when attempting an iCMA for the first time?

A comparison of iCMA scores, TMA scores and overall course performance will investigate whether iCMAs are a good predictor of success in other areas.

In autumn 2009, online questionnaires were sent to students on SM358 *The quantum world* (Case 4) and a range of level 1 courses, with the aim of discovering the reasons for some of the behaviour that has been observed, for example students leaving responses blank and repeating unchanged responses at second and third attempt. A subset of the students who completed the questionnaires will be interviewed.

From February 2010, four level 3 physics and astronomy courses (including SM358 *The quantum world*) will have a radically different assessment strategy, with all assignments being formative-only but thresholded i.e. students will have to complete a certain number of TMAs and iCMAs, where satisfactory completion of an iCMA will be deemed to be a score of 30% or more. A similar quantitative analysis of the responses to these courses' iCMA questions, and a comparison with findings from the current work (especially for SM358 in 2009 and for courses in which the iCMAs are in summative use) will be one of the mechanisms used to evaluate the impact of the change in assessment strategy.

For further information on this project, and updates, see
http://www.open.ac.uk/colmsct/projects/sejordan

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References
Boud, D. (2000) Sustainable assessment: rethinking assessment for the learning society, *Studies in Continuing Education*, 22(2), 151-167.

Butcher, P.G. (2006) OpenMark examples. Available online at http://www.open.ac.uk/openmarkexamples/index.shtml [accessed 14th Nov 2009].

Butcher, P.G. (2008) Online assessment at the Open University using open source software: Moodle, OpenMark and more. 12th International CAA Conference, Loughborough, UK, July 2008.

Buzzetto-More, N.A. and Alade, A. J. (2006) Best practices in e-assessment. *Journal of information technology education*, 5, 251-269.

Gibbs, G. (2006) Why assessment is changing, in C. Bryan and K.V.Clegg (eds) *Innovative Assessment in Higher Education*. London: Routledge, 11-22.

Gibbs, G and Simpson, C. (2004) Conditions under which assessment supports students' learning. *Learning and Teaching in Higher Education*, 1, 3-31.

Hunter, A.G. (2008) Using an online formative assessment framework to enhance student engagement: a learning outcomes approach. Paper presented at the Improving Student Learning Symposium, Dublin, 3-5 Sept 2007.

JISC (2009) Accessed from http://www.jisc.ac.uk/whatwedo/programmes/elearning/assessment.aspx, 14th Nov 2009.

Jordan, S.E. and Mitchell, T. (2009) E-assessment for learning? The potential of short free-text questions with tailored feedback. *British Journal of Educational Technology, 40,* 2, 371-385.

Jordan, S.E. (2007) The mathematical misconceptions of adult distance-learning science students. CETL-MSOR Conference, Loughborough, 11-12 September 2006. Maths, Stats and OR Network, 87-92.

Ross, S.M., Jordan, S.E and Butcher, P.G. (2006) Online instantaneous and targeted feedback for remote learners. In C. Bryan and K.V.Clegg (eds) *Innovative Assessment in Higher Education*. London: Routledge, 123-131.

Rust, C. O'Donovan, B and Price, M (2005) A social constructivist assessment process model: how the research literature shows us this could be best practice. *Assessment & Evaluation in Higher Education*, 30(3), 231-240.

Sadler, D.R. (1989) Formative assessment and the design of instructional systems. *Instructional Science*, 18, 119-144.

Scouller, K.M. and Prosser, M (1994) Students' experiences of studying for multiple choice question examinations. *Studies in Higher Education*, 19(3), 267-279.

Paper presented at the CETL-MSOR Conference, Loughborough, 11th-12th September 2006 and published in the conference proceedings in 2007, pp87-92.

The mathematical misconceptions of adult distance-learning science students

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An analysis of student answers to interactive online assessment questions for the Open University course 'Maths for Science' is providing insight into adult distance-learning science students' mathematical misconceptions. Some of the findings have been unexpected and frequently errors are caused by more basic misunderstandings than lecturers might imagine. The analysis has revealed specific misconceptions relating to units, powers notation, arithmetic fractions and the rules of precedence.

Undergraduate courses in the UK Open University (OU) are completely open entry. One implication of this is that students studying Science Faculty courses have a very wide range of mathematical backgrounds, varying from those who already have a degree in a numerate discipline to those with no previous mathematical qualifications at all. Many OU students have not studied mathematics since they were at school (which, for adult students, might have been many years ago) and they frequently lack confidence in their mathematical abilities. Elementary mathematical skills are embedded in the Science Faculty's interdisciplinary level 1 course *Discovering Science*, but lack of mathematical ability and confidence remains a problem for many students as they progress to level 2 courses in physics, astronomy, chemistry, Earth science and biology. The 10 point level 1 course *Maths for Science* [1] was written to meet this need. The course, described in more detail in a paper presented to the Helping Everybody Learn Mathematics Conference in 2005 [2], has now been studied by approximately 7000 students since it was first presented in 2002. It has been both well received by students and instrumental in increasing retention rates on higher level Science Faculty courses.

One of the issues confronting all providers of distance education is the need to provide students with meaningful feedback without necessarily ever meeting them, and the Course Team which produced *Maths for Science* took the decision to pilot an interactive web-based system for both summative and formative assessment. The system, whose operation and pedagogy is described in more detail in Ross et al. [3], makes minimal use of multiple choice questions and allows students three attempts at each question, with the amount of feedback provided increasing after each attempt. Since the assessment is completed online, the feedback is provided in a timely fashion, one of the factors identified by Gibbs and Simpson [4] as important if assessment is to support student learning. The assessment system, currently known as 'OpenMark', is now used by several Open University courses and is being further expanded and integrated into the University's Moodle-based virtual learning environment [5].

In addition to its many benefits for student learning, the OpenMark system has provided a rich source of information about the mistakes made by students. Data from more than 70 *Maths for Science* assessment questions have been analysed, typically for around 200 students at a time, and this is leading to increased insight into students' mathematical misconceptions. The remainder of this paper will discuss some of these misconceptions, but several points are worth noting at the outset. Although, for reasons of security, the actual questions cited in the paper are taken from

Maths for Science's purely formative 'Practice Assessment', most of the reported analysis has been done on questions from the 'End of Course Assessment', which has a summative as well as a formative function. An implication of this is that students are trying very hard to get the questions 'right', so the errors revealed cannot, in the main, be attributed to students guessing the answer. In addition, since so few of the questions are multiple choice, the analysis has been able to go beyond a consideration of commonly selected distractors to look at the actual responses entered by students. Finally, most of the assessment questions exist in several variants, with different questions being presented to different students. This feature, which exists to limit opportunities for plagiarism, has also added to the author's confidence in the general applicability of some of the findings. For example, for one variant of a question, around 50% of incorrect responses gave the answer 243; for a different variant of the same question a similar percentage of incorrect responses gave the answer 11809.8, and so on. These errors can be explained by an identical misunderstanding, in this case a misunderstanding of the rules of precedence. This is discussed in more detail below.

Common misunderstandings – the physical reality of scientific calculations

Figure 1 shows a question of a type that has been surprisingly badly answered on every *Maths for Science* assessment to date, with only around 20% of students getting such questions right at the first attempt and 40% still being incorrect after three attempts. Students are provided with an equation and are asked to substitute given values, giving their answer in scientific notation, with correct SI units and to an appropriate precision. Note that no rearrangement of the equation is required.

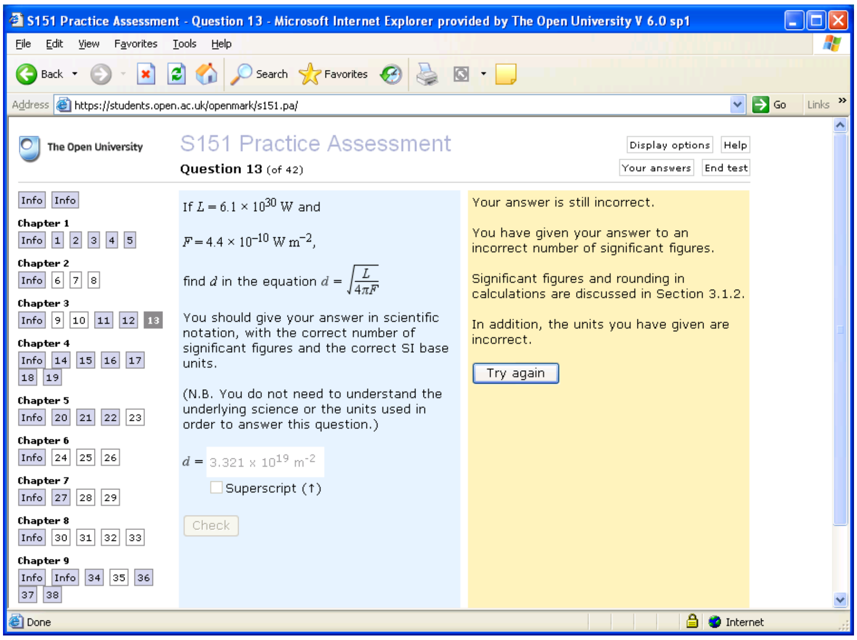

Figure 1 A 'Maths for Science' assessment question, showing a student response with incorrect units and an incorrect number of significant figures, and the feedback provided to the student in this situation.

Most students get these questions numerically correct, and the requirement that the answer should be given in scientific notation does not present too many problems. Most students attempt to give appropriate units (so, as discussed above, their errors cannot be attributed to laziness or carelessness) but it is the units of the answer and the number of digits quoted (the 'number of significant figures') that most frequently cause the response to be incorrect. Sometimes the error can be attributed to a trivial arithmetic mistake, for example, errors in quoting an answer to a particular precision are frequently caused by the fact that students truncate the value rather than rounding it. However it appears that a lack of understanding of the physical reality of the question is at least partly to blame for the large number of errors in questions of this sort – around 50% of all responses have incorrect units. This is in line with the difficulty students have whenever asked to convert the units of an answer from, say, m^3 to mm^3; despite the fact that this is very carefully taught in the course, many students neglect to cube the conversion factor.

More detailed analysis reveals an interesting pattern in the incorrect units given in answer to questions such as the one shown in Figure 1. In response to this question (where the units of the correct answer are m), the most common incorrect units are m^2, m^{-1} and m^{-2}, so students are forgetting to find the square root, having difficulty in interpreting negative powers, or both! In a similar question where students were asked to find a value for a time period using the formula $T = 2\pi\sqrt{\frac{L}{g}}$, the commonly incorrect units of s^2, s^{-1} and s^{-2} reveal the same misunderstandings. Although, in both of these questions, a handful of students' numerical answers reveal that they had, for example, neglected to take the square root of their answer, this was done by considerably fewer students than made the equivalent error with the units. One possible explanation of this is that it is possible to get the correct numerical answer by just substituting numbers into a calculator, but it is not so easy to get the units right without writing down any working, and students' reluctance to write down working has been reported elsewhere [6].

Common misunderstandings – simplifying, fractions and negative powers

The Course Team's view has always been that the pivotal section of *Maths for Science* is the one which introduces the rearrangement and combination of algebraic equations. It is therefore pleasing that the questions designed to assess this section are generally well answered. However, students' ability to rearrange and combine equations is not matched by their ability to simplify them. In a question which requires students to combine two equations and to give the answer in its simplest possible correct form, the correct answer takes the form $A = BC^2$. 19% of incorrect responses (6% of all responses) were equivalent to the correct answer, but not in the simplest form, with virtually all responses in this category being of the form $A = B/C^{-2}$, $A = B/1/C^2$, $A = BD/DC^{-2}$ or $A = B/D/DC^2$.

Student reluctance or inability to simplify algebraic expressions is demonstrated in several other *Maths for Science* questions (for example, many answers to another question are left in the form $\frac{ab}{9a}$) and evidence of similar behaviour has been found elsewhere within the OU Science Faculty. For example, students frequently fail to see that the factor *'m'* is common to the left and right hand side of equations such as $mg\Delta h = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$. However there is also evidence of a tendency to 'over-simplify' on occasions i.e. to attempt to simply an algebraic expression inappropriately, perhaps in an attempt to get to a more meaningful answer, such as would be obtained if dealing with numbers not symbols. In a *Maths for Science* multiple choice question asking students to identify equivalent expressions, the most common incorrect response is to say that $(A + 3)^2$ is equivalent to $A^2 + 9$, and in a second level physics examination, many students simplified $\sqrt{x^2 - y^2}$ to $x - y$. Sawyer [7] reported a similar effect in children's mathematical development.

The prevalence of answers of the form $A = B/C^{-2}$ or $A = B/1/C^2$ instead of $A = BC^2$, along with a massive 35% of incorrect responses to the same question (12% of all responses) which were of the form $A = B/C^2$, illustrates two other areas of student difficulty, both also demonstrated in other *Maths for Science* questions, and elsewhere. The first of these difficulties is in understanding the meaning of negative powers i.e. in failing to recognise that

$$\frac{1}{x^{-n}} = x^n$$

The second difficulty is in dividing by a fraction, so students do not recognise that

$$\frac{B}{1/C^2} = BC^2$$

Both of these difficulties persist despite the fact that arithmetic with fractions and the use of powers notation are both taught in the first chapter of *Maths for Science* in a purely numerical context and then applied to symbols and units later in the course.

Common misunderstandings – precedence

Although most students obtain the correct numerical answer to the question illustrated in Figure 1, those who do not are frequently wrong because of an incorrect understanding of precedence (or perhaps an over-reliance on their calculator!). So instead of calculating $\sqrt{\frac{L}{4\pi F}}$ they find $\sqrt{L \div 4 \times \pi \times F}$, which in the case of the variant of the question illustrated in Figure 1, leads to an incorrect answer of 4. 6 × 10^{10} m. Figure 2 shows the result of a similar error.

Here the student has found $\frac{27^4}{3}$ instead of $27^{4/3}$, in a similar misunderstanding to the one which leads many students to evaluate $\frac{3^6}{3}$ (and so to obtain an answer of 243) when asked to find $(3^6)^{1/3}$.

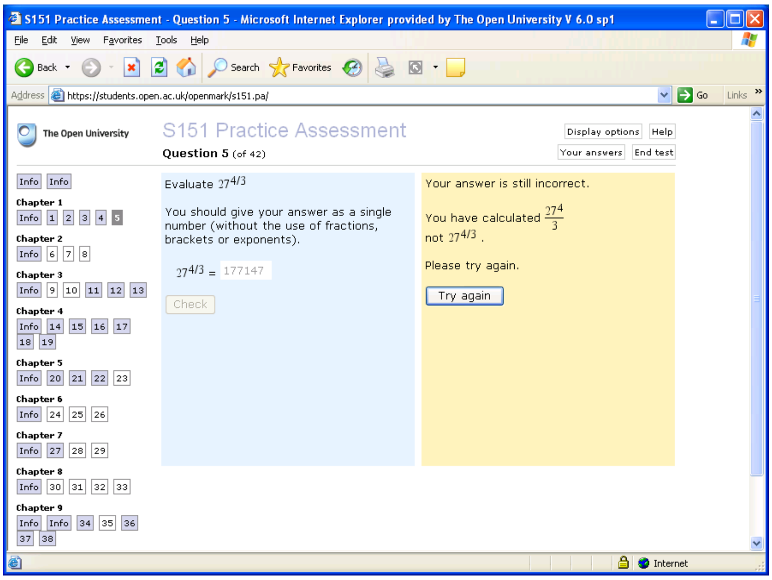

Figure 2 A 'Maths for Science' assessment question, showing a student response that is incorrect because of misunderstanding of the rules of precedence.

Common misunderstandings – graphs, gradient and the basis of calculus

The concept of gradient (and the method for calculating the gradient of a straight line) is taught about half-way through the course and then this is developed into a discussion of elementary differential calculus right at the end of the course. The assessment questions on calculus, along with those on angular measure, trigonometry, logarithms, probability and statistics, have yet to be analysed. However, early analysis of questions designed to assess students' understanding of the gradient of a straight line indicates that, in much the same way as many problems in algebra can be attributed to 'lower-level' misunderstandings in arithmetic (for example with fractions), some students' difficulty with differentiation may stem from their poor understanding of gradient.

Discussion

The increased insight gained into *Maths for Science* students' mathematical misconceptions is being used in several ways. The assessment questions themselves have been improved, so that targeted feedback is provided in response to commonly incorrect responses, as shown in Figure 1 and Figure 2. In some cases, the analysis has revealed that different variants of the 'same' question are in fact of different difficulty. For formative only assessment this is not a major consideration, but for summative assessment it is considered important that each student should receive questions of comparable difficulty, so some variants have been altered or removed. In addition to improving *Maths for Science*'s assessment, some changes have been made to the course itself, in particular, additional practice questions have been provided for areas of common student difficulty. Future OU Science Faculty courses are also benefiting from our increased understanding of what students do wrong, and why. For example, the teaching of arithmetic with fractions is being incorporated into the new introductory course 'Science Starts Here'.

The evidence presented in this paper relates to students who may be considered to be atypical in three respects: they are adult students, sometimes returning to study after a considerable length of time; they are, in the main, studying towards a qualification in science not mathematics; and they are studying at a distance. However, the author has no reason to suppose that younger students studying science in conventional universities, especially those who have not come from particularly numerate backgrounds, do not have similar mathematical misconceptions. In addition, there is no evidence to support the notion that students' mathematical misunderstandings result from bad teaching at school. Taken as a whole, Open University students have a widely varied experience of the primary and secondary education system both in the UK and elsewhere and, as soon as they are reminded, most remember what they learnt at school about, for example, fractions. However it is perhaps not reasonable to assume that this knowledge will remain at the forefront of students' memories over a period of several years or decades, especially since the skills of arithmetic with fractions are not much practised in everyday life.

The 'Maths problem' is sometimes thought of as relatively recent, and specific to particular cultures. However, as early as 1939 and 1959, the Russian authors Bradis, Minkovskii and Kharcheva [8] recognised difficulties in algebra caused by misunderstandings of fractions and square roots. Nevertheless, the implications of a lack of basic understanding of arithmetic etc. on study at a higher level remain serious. For example, when students are asked to rearrange $E_k = \frac{1}{2}mv^2$ to make v the subject, it is frequently not the squared term, v^2, that causes the difficulty, but rather the '$\frac{1}{2}$'. Once we appreciate that students may not realise that multiplying by half is equivalent to dividing by two, this fact ceases to be surprising. Back in 1964, Sawyer [7] commented 'If we imagine that a pupil understands something, when in fact he does not, we are like a man trying to build on a foundation of air', and the phenomenon of 'the dropped stitch' was identified by Sheila Tobias in 1978 [9]. If a student fails to understand, for whatever reason, one aspect of simple mathematics (Tobias's statement of this is 'the day they introduced fractions I had the measles') then more advanced concepts may appear unassailable. The first challenge to those of us who seek to rectify students' mathematical misconceptions is to correctly identify the true cause of these misconceptions.

Acknowlegements

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References

1. Jordan, Sally, Ross, Shelagh and Murphy, Pat.(2002) Maths for Science. The Open University. ISBN 074925677X.

2. Jordan, Sally (2005) "Maths for distance-learning science students". Helping Everyone Learn Mathematics, Loughborough, 14-15 September 2005. Accessed via http://www.engsc.ac.uk/nef/events/helmconf_programme.asp#eng2 (28 August 2006)

3. Ross, S.M., Jordan, S.E. and Butcher, P.G. (2006) "Online instantaneous and targeted feedback for remote learners". In C. Bryan and K.V. Clegg, eds. *Innovative assessment in Higher Education*. Routledge, pp 123 – 131.

4. Gibbs, G. and Simpson, C. (2004) Conditions under which assessment supports students' learning. *Learning and Teaching in Higher Education*, Vol. 1: 3-31.

5. Sclater, Niall, Butcher, Phil, Thomas, Pete and Jordan, Sally. (2006) "Moodle : enhancing the assessment capabilities of the leading open source virtual learning environment". The 10th Computer Assisted Assessment Conference, Loughborough, 4th-5th July 2006. Accessed via http://www.caaconference.com/pastConferences/2006/proceedings/Sclater_N_Butcher_P_Thomas_P_Jordan_S_L1.pdf (28 August 2006)

6. Van den Heuvel-Panhuizen, M. and Bodin-Baarends, C. (2004) All or nothing: Problem solving by high achievers in mathematics. *Journal of the Korea Society of Mathematical Education*, Vol. 8 (3): 115-121.

7. Sawyer, W.W. (1964) Vision in elementary mathematics. Penguin.

8. Bradis, V.M; Minkovskii, V.L. and Kharcheva, A.K. Kharcheva. (1959) Lapses in mathematical reasoning. Translation of 2nd edition, published by Pergamon Press, 1963.

9. Tobias, Sheila (1978) Overcoming math anxiety. Norton & Co.

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New assessment models for Physics and Astronomy

"… the times they are a-changin."[1]

The OU is in a time of rapid change, both in the technologies available for presenting our courses and in the nature of our students. We need to embrace the possibilities provided by the VLE and e-learning and we need to accommodate the requirements of students (including 18-year-olds) who wish to complete our degrees in three or four years, without alienating our traditional students, many of whom wish to study at a much slower rate. To enable changes in these areas, the Physics Innovations CETL is supporting initiatives within the Physical Science award that aim to radically change the pattern of continuous assessment; the summative TMAs will be replaced by formative TMAs and iCMAs. This should allow ALs to spend more time providing direct support to students, it should allow courses to be presented more frequently without prohibitive additional costs, and eventually it should allow a flexible period of study for our courses.

Assessment of Physics and Astronomy courses follows a fairly standard pattern of four summative TMAs per 30 points plus a three hour written exam. Many courses used to have summative CMAs also, but these were largely dispensed with to save money in the mid 1990s, though a few formative CMAs were retained. It is widely accepted by students, ALs and course teams that doing the assignments, and receiving feedback on them, are an essential part of the student learning experience.

But do the TMAs need to be summative, with all of the accompanying security issues that arise because TMA marks can affect the students' course grades? We believe that the answer is "no". In practice, the summative nature of the continuous assessment is somewhat illusory for the vast majority of Physics and Astronomy students since their course grade is determined by their exam mark, which is generally significantly lower than their continuous assessment mark.

The advent of the VLE, along with Moodle quizzes and OpenMark questions, provides another stimulus to re-examine our assessment models. Using a mix of iCMAs delivered via the VLE and TMAs will allow us to provide shorter, more-frequent assignments, to engage students at the time they are studying the relevant material. ALs will be able to keep track of students progress via the Moodle gradebook, and be more proactive in intervening when students appear to be struggling.

[1] Bob Dylan (1964)

So we are proposing an assessment model for a 30-point Level 3 courses that comprises four half-length TMAs and 6-8 iCMAs, plus a three-hour exam. The continuous assessment marks will not be used to determine the course grade, but students will be required to complete a proportion (3/4) of the assignments to a specified standard to be awarded credit. It may be that we should tell students that the 'A' in TMA and iCMA stands for (learning) Activity, not Assessment.

We see a number of significant advantages associated with this new assessment model.
- More effort would be put into optimising the questions, the tutor notes and feedback, and the hints and answers provided by iCMAs, because they would be reused each year. Improvements could be made if necessary in light of experience.
- Shorter, more-frequent assignments could be more-closely tied to what students are learning in a particular week or month, and the more-frequent cut-off dates would be good for pacing.
- TMA feedback could be more rapid, and therefore more effective, because the non-summative nature of the assignments means that ALs could mark and return them even before the cut-off date. iCMA feedback would be instantaneous.
- More dialogue about assignments could take place between students and ALs before submission.
- Since new assignments would not have to be produced for each presentation, one of the barriers to more frequent presentation of the courses and to flexible study rates would be removed.

There is a lot of evidence that students put much less effort into formative assessment than into summative assessment. Given that we are designing the new formative assessment to provide better learning experiences than the previous summative TMAs, it is vital that students engage with it seriously. How can we encourage this? Among the carrots that we will use are persuading students that these activities are designed to reinforce learning and are based on the most important concepts and skills needed to succeed with the course, and informing students that some exam questions will be very similar to assignment questions. This will be backed up with a big stick; students will be required to complete certain proportion of the assignments to a certain standard to obtain credit for the course.

One potential benefit of reducing the length of the tutor-marked activities is that AL time could be freed up to provide additional student support. A reduction of 20 minutes per TMA x 20 students x 4 TMAs equates to almost 30 hours, and this could be used for one-to-one support delivered via telephone, email or face-to-face, or for additional tutorials, day schools or e-tutorials. Indeed there are currently several projects sponsored by piCETL that are investigating ways to support students with AL-produced screen capture videos and using the Elluminate synchronous conferencing system, and these promising new methods could only be used effectively if ALs have more time to devote to them.

One benefit of using the same assignment activities each year is that the feedback provided to students can be improved in light of experience in previous years. We are trialling the use of screen capture video for providing feedback on misconceptions and difficulties revealed by assignments. These are time consuming to produce, but if they can be made available every year then that is time well spent. When discussing these proposals, two main concerns emerged, and these are encapsulated in the following two questions:

• Will students put the effort into assignments/activities if they are not awarded marks that contribute to their final grade?
• Will students be deterred from registering, or be more likely to drop out, if their result depends explicitly only on the exam?

Student survey

Before going ahead with such a major change, we thought we should sound out our students about the proposals. So we sent a survey to almost 500 students who studied Level 3 Physics and Astronomy courses in 2007 and 40% of them responded. It included a series of statements about the proposed assessment model, and students were asked to respond using a five-point scale, ranging from *strongly disagree* to *strongly agree*. Here's what they thought.

Using a mix of TMAs and iCMAs for assessment Replacing the current TMA-only assessment model by a mix of TMAs and iCMAs appears to be acceptable to most students. Almost 70% think that the mix would be a suitable way to assess understanding and skills in the Level 3 physics and astronomy courses, they would prefer a mix rather than TMAs alone (45% agree versus 35% disagree), only 30% think that they would learn less from the mix of TMAs and iCMAs than from TMAs alone, and 75% think that the marks would provide a good measure of their understanding of the course even though the assignments were formative. However, students would be very strongly opposed (75%) to the use of iCMAs alone for continuous assessment.

iCMAs Students recognise a number of the benefits of iCMAs: their ability to assess understanding of the breadth of the course at the time the student is studying each topic; the instant feedback; the hints that help students work towards the correct answer if their initial answer is incorrect. About half of the students think that they would use the iCMAs more than once. The requirement to answer the iCMAs via the internet would not deter most students (60%) from studying courses with this sort of assessment; however, 20% of students did indicate that they would be deterred.

Number and length of assignments, cut-off dates and scheduling The shorter, more-frequent assignments are welcomed by most students (50% supporting and 30% disagreeing). Students agree that frequent fixed cut-off dates for the short assignments would help to keep them to the study schedule, and 55% agree that they would fall behind if the assignments did not have fixed cut-off dates. Even so, 45% would welcome more flexibility in the cut-off dates to help them fit their studies in with other commitments.

Effort students put into assessment A majority (60%) of the students responding to the survey indicated that they would put as much effort into the proposed formative assignments as they currently put into the summative assignments, but a substantial minority, about 30%, indicated that they would put in less effort. However, if the students knew that a proportion of exam questions would be based on the formative questions in TMAs and iCMAs then the division of opinion changes to 75% agreeing that they would put is as much effort and only 10% disagreeing. Clearly it will be important to convince students of the benefits of engaging fully with the formative assessment.

Tutor contact The decrease in the TMA marking workload would allow an increase in time ALs spend on targeted one-to-one support for struggling students, and this could have major benefits in terms of enhanced retention and improved student performance. Most students would welcome more support from their tutor. About 70% would welcome their tutor contacting them if they had difficulties with an iCMA, only 10% would not want to have more contact with their tutor, and 50% think that they would learn more effectively if they had the opportunity to discuss assignment questions with their tutor before submission.

Dependence of course grade on the examination alone Survey responses indicate that students are fairly evenly split between those who think their final grade would not be as good with the proposed assessment model and those who disagree (39% versus 31%). About half of students don't think that their result would reflect their achievement as well as with the existing assessment system, compared with 25% disagreeing. About 2/3 of responders are concerned that their exam performance would let them down, do not think that a three-hour exam would be a fair measure of their understanding of the course, and would not want to go into the exam knowing that their course result depended only on exam performance. Over 90% of students think that the continuous assessment marks should be taken into account where the exam mark is close to a borderline between grades. A major effort will be required to overcome these concerns.

The student survey also asked about presentation patterns, and the responses indicated widespread concern about studying 30-point Level 3 Physics and Astronomy courses over a six month (or less) semester – but that's another story…

Work on implementing the new assessment model is now underway, with iCMAs being developed for the 2009 presentation of SM358 *The Quantum Wor*ld and for the 2010 presentaion of SMT359 *Electromagnetism*. We will be trying to extend the scope of OpenMark and Moodle quizzes to allow entry of answers that are relatively complicated mathematical expressions.

At the same time, two new astronomy courses are being produced for 2010, and these will also use similar models for the assessment

We will be carefully evaluating the effects of these changes on student retention, performance and satisfaction and on the AL role, and will disseminate our findings at the end of next year.

Formative assessment and presentation patterns for Level 3 physics and astronomy courses: a survey of student views

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July 2008 (v1)

Proposals have been made for radical changes to the mode of assessment and to the presentation pattern for the four Level 3 physics and astronomy courses. One proposal is to replace the summative tutor marked assignments (TMAs) by a mix of formative TMAs and formative interactive computer marked assignments (iCMAs). A second proposal is to present all four of the courses every year, each over a period of a semester rather than over the current nine-month period. The aims are to enhance student learning through increased use of formative assessment and to provide more flexible and more rapid pathways to a degree. However, these changes could have major effects on student retention and performance, and a survey was therefore conducted with students who registered for a Level 3 physics and astronomy course in 2007 to ascertain their views about the proposals.

The results from the survey indicate that students would be happy with a mix of TMAs and iCMAs, and they recognised some benefits of this assessment model. Though a majority said they would put as much effort into the new formative continuous assessment as at present, about 30% indicated that their effort would decrease. A large majority (c 60%) expressed concern about the course result depending solely on the examination. Various ways to motivate students to put appropriate effort into the formative assessment and to reduce concerns about the exam are discussed.

Students who responded to the survey had registered for 48 CATs points on average in 2007, but only managed to complete an average of 34 points. Three quarters of students expressed a preference for the study period for the courses to be nine months or longer, and only 30% indicated that the semester presentation model would make it more likely that they would study the courses. This indicates that a semester model for presentation of Level 3 physics and astronomy courses is not appropriate for a large majority of current students.

1 Introduction and background

One of the major challenges that the OU currently faces is to attract larger numbers of students, particularly those who do not have a degree-level qualification, and school leavers are one of the potential target groups. Such students may wish to study for a degree at something like a full-time rate; they may therefore want to complete courses quickly and want courses to be available when they are ready to study them. However, part-time learners, many of whom are studying for general interest rather than vocational reasons, are still likely to form the majority of students studying physics and astronomy courses, and we must be careful that any changes to our courses do not disadvantage them. Each of the four 30-point Level 3 physics and astronomy courses[2] is currently presented in alternate years over the standard 9-month February – October period, and this is a disadvantage to students who want to complete their degrees rapidly. Thus we need to find ways of increasing the frequency of presentation of our courses and introducing more flexibility into the presentation periods.

One of the major constraints on presenting courses more frequently, or over variable lengths of time, with the current assessment models is the need to provide a new and secure set of summative assignments for each presentation. The need for security of the continuous assessment also constrains the teaching value that can be derived from the assignments. Furthermore, although students derive satisfaction from completing assignments and being awarded marks that they believe will help to determine their course grade, it is generally the case that a student’s final grade is determined overwhelmingly by their examination mark, so the summative role of the continuous assessment is rather illusory.

However, if the summative continuous assessment were replaced by a series of well-structured and integrated formative assignments, many of the difficulties associated with more-frequent and more-flexible

[2] S357 *Space, Time and Cosmology*, SM358 *The Quantum World*, SMT359 *Electromagnetism*, S381 *The Energetic Universe*. In addition, a fifth physics and astronomy course SXP390 *Science Project Course: Radiation and Matter* is presented annually.

presentation could be eliminated and significant teaching benefits would accrue. In addition, the Course Team would have time for greater involvement in student support, for example, by producing timely extras such as podcasts or online mini lectures, and thus fostering a learning-community culture.

In order to gain some insight into how our students might view various proposals for changes to continuous assessment and to presentation periods, a survey was sent out to students who had registered for the two Level 3 physics and astronomy courses that were presented in 2007.

2 The survey

The authors of this report developed a paper questionnaire to elicit students' views about the proposed changes to assessment and presentation patterns. The questionnaire had two sections, the first concerned with proposed changes to continuous assessment and the second concerned with changes to presentation patterns.

2.1 Continuous assessment

In a preamble to this section, students were told that there were plans to reduce the emphasis on the use of assessment to validate achievement and increase the emphasis on its use to support learning. They were asked to consider the following scenario for assessment of the 30-point Level 3 physics and astronomy courses.

- The four TMAs are reduced to about half of their current length, but are marked just as they are now, with tutors providing marks, comments and feedback to students.
- Interactive computer-marked assignments (iCMAs) are also provided via the course website. The computer-based questions are interactive: students submitting incorrect responses are given hints and allowed to try again, and the computer provides model answers and feedback as soon as each question is completed. The assignments are designed to improve understanding close to the time of study of each part of the course. The assignments can be repeated with different questions for practice and also for revision before the exam.
- Students are ***required*** to attempt the majority of the assignments, and are told their marks for the TMAs and interactive computer marked assignments so they know how well they are achieving the course's learning outcomes, but these marks are ***not*** used to determine the course grade, which is determined solely by the examination mark. However, the assignment marks are taken into consideration by the Exam Board for students whose examination mark is close to a borderline. Note that with the current assessment system, most students find it more difficult to achieve the threshold exam mark required for a particular grade than to achieve the threshold continuous assessment mark, so grades are generally governed by exam performance.
- One possible package for the assignments for a 30-point physics and astronomy course would be four half-length TMAs, spread through the course as at present, plus eight short iCMAs.
- The end of course examination would be the same as at present. A proportion of exam questions would be based closely on questions in the TMAs, iCMAs or additional revision questions.

The preamble also indicated that the assessment scenario outlined above would have the following consequences.

- The emphasis in the assignments would be placed on helping students to achieve key learning objectives, rather than judging their performance.
- More-rapid feedback would be provided on assignments – with immediate feedback on iCMAs.
- Shorter, more frequent, assignments would provide better pacing for study throughout the course.
- A mix of TMAs and iCMAs would allow more-thorough coverage of the breadth of the course materials.
- More tutor support would be available for students – the time saved on TMA marking would be used for additional one-to-one and group support.
- Tutors would be able to discuss students' difficulties with TMA questions more openly if TMA marks were not used to determine course grades, and would be able to teach more effectively.
- Tutors would monitor progress on iCMAs, and would offer study advice or extra tuition where necessary.

Students were then provided with 30 statements about assessment and asked to indicate their agreement or disagreement with each using a five point scale (Strongly disagree, Disagree, Neither agree not disagree, Agree, or Strongly agree). In addition, a box was provided for any additional written comments about continuous assessment.

2.2 Presentation patterns

The second part of the questionnaire asked students about the extent to which current alternate year presentation of the Level 3 physics and astronomy courses had impacted on their study plans, about the time period over which they would like to study the courses, and about various options for presenting the courses over a semester or over variable periods.

The survey form told students that

> The University is considering proposals for changing the period of time over which courses are presented. One proposal is that the 30-point Level 3 physics and astronomy courses could be presented over six-month periods (e.g. November – April, or May – October). Students who study only one 30-point course in a year would have a shorter period of more-intense study, while students who study two 30 point courses in a year may be able to study the courses sequentially. Another proposal is that students would be allowed to register for a course that has an examination in October, but would be able to start studying the course any time between February and May that year (or even the previous November).

Students were then asked to indicate their agreement or disagreement with a series of statements about the proposed presentation patterns.

2.3 Student sample

The questionnaire was mailed at the end of November 2007 to 200 students who were initially registered for S357 *Space, Time and Cosmology*, 200 students initially registered for SM358 *The Quantum World*, and an additional 80 students initially registered for both of these courses. The number of questionnaires returned by the cut-off date was 176 (37%). The students who responded were not a completely representative sample of the total populations of the courses. Compared with all initially registered students for the two courses, the responders included higher percentages of students with pass grades 1 and 4 and lower percentages of students who had failed or had withdrawn from the courses, and higher percentages who already had an HE qualification but lower percentages with two A-levels or lower prior qualifications.

3 Survey results: views on proposed model for assessment

The statements about assessment have been re-ordered and divided into six main topics, and these are discussed in the six subsections that follow. In each of these subsections, we summarise students' views and include a figure showing bar charts that indicate the percentage of students responding strongly disagree (sd), disagree (d), neither agree nor disagree (n), agree (a) and strongly agree (sa) to the relevant statements.

3.1 Using a mix of TMAs and iCMAs for assessment

Moving from the current TMA-only assessment model to a model that uses a mix of TMAs and iCMAs appears to be acceptable to most students (Figure 1). Almost 70% think that the mix would be a suitable way to assess understanding and skills in the Level 3 physics and astronomy courses, they would prefer a mix rather than TMAs alone (45% agree versus 35% disagree), only 30% think that they would learn less from the mix of TMAs and iCMAs than from TMAs alone, and 75% think that the marks would provide a good measure of their understanding of the course even though the assignments were formative. However, students would be very strongly opposed (75%) to the use of iCMAs alone for continuous assessment.

On balance, then, students appear to support the proposed move to providing both TMAs and iCMAs, though a substantial minority of a third of the students would not prefer this change. There were many very positive comments about the value of the current TMAs:

"*I find the current system of TMAs to be the best method of learning as well as for assessment.*"

"I enjoy TMAs as a learning challenge, and try my very best to achieve high marks."

"*The best part of old system is that tackling big TMA question is fun. Knowing it will be thoughtfully marked and that it matters is highly motivating*."

"*Current TMAs are most satisfying part of the course - forcing you to think and really test your understanding.*"

"*I've sometimes felt that I've only really got to grips with a subject after wrestling with a really meaty TMA question*."

Also, a third of students think that they would learn less from a mix of TMAs and iCMAs, and there was a strong correlation between students expressing this view and them *not* preferring a mix of TMAs and iCMAs. This minority viewpoint may be held by students with little experience of the OU's OpenMark iCMA questions, which have a strong teaching function and which can be quite demanding. Some of their comments indicated that they visualized the iCMAs as being multiple choice quizzes that were not very challenging, and this is certainly not the intention. However, it will be important to try to assess whether students learn as effectively after the introduction of the mix of iCMAs and TMAs as they did before.

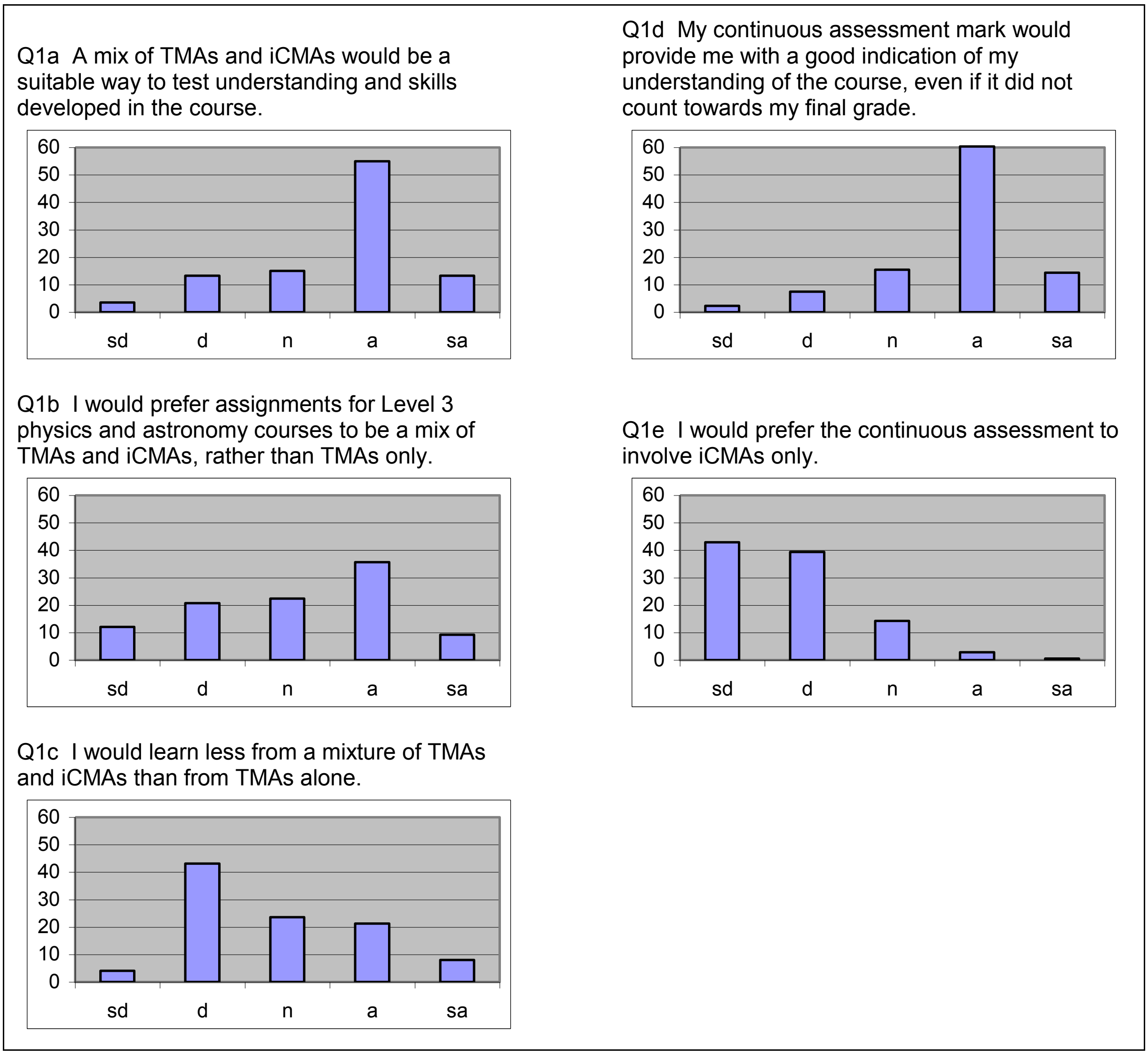


Figure 1 Students' views about use of a mix of TMAs and iCMAs for assessment.

3.2 iCMAs

Students recognise a number of the benefits of iCMAs (Figure 2): their ability to assess understanding of the breadth of the course at the time the student is studying each topic; the instant feedback; the hints that help students work towards the correct answer if their initial answer is incorrect. About half of the students think that they would use the iCMAs more than once. The requirement to answer the iCMAs via the internet would not deter most students (60%) from studying courses with this sort of assessment; however, 20% of students did indicate that they would be deterred.

A major concern about the move towards more e-learning and e-assessment in our courses is that it will exclude or deter a large proportion of students, so it is reassuring to see that a large majority say they would not be deterred by the online iCMAs. However, 20% indicate that they would be deterred, and the question then is whether they would be sufficiently deterred that they would not register for such a course. One student commented: "*Forcing people to use internet isn't going to work as some students, such as those posted overseas in armed services, have no internet access.*"

One of the strengths of the proposed iCMAs is that students will be able to repeat them, often with variations in each question, and will therefore be able to reinforce their learning and ensure they master relevant skills. This facility is particularly important for less able and less confident students, and it is good to see that half of the students indicated that they would repeat iCMAs to ensure they understood the course materials.

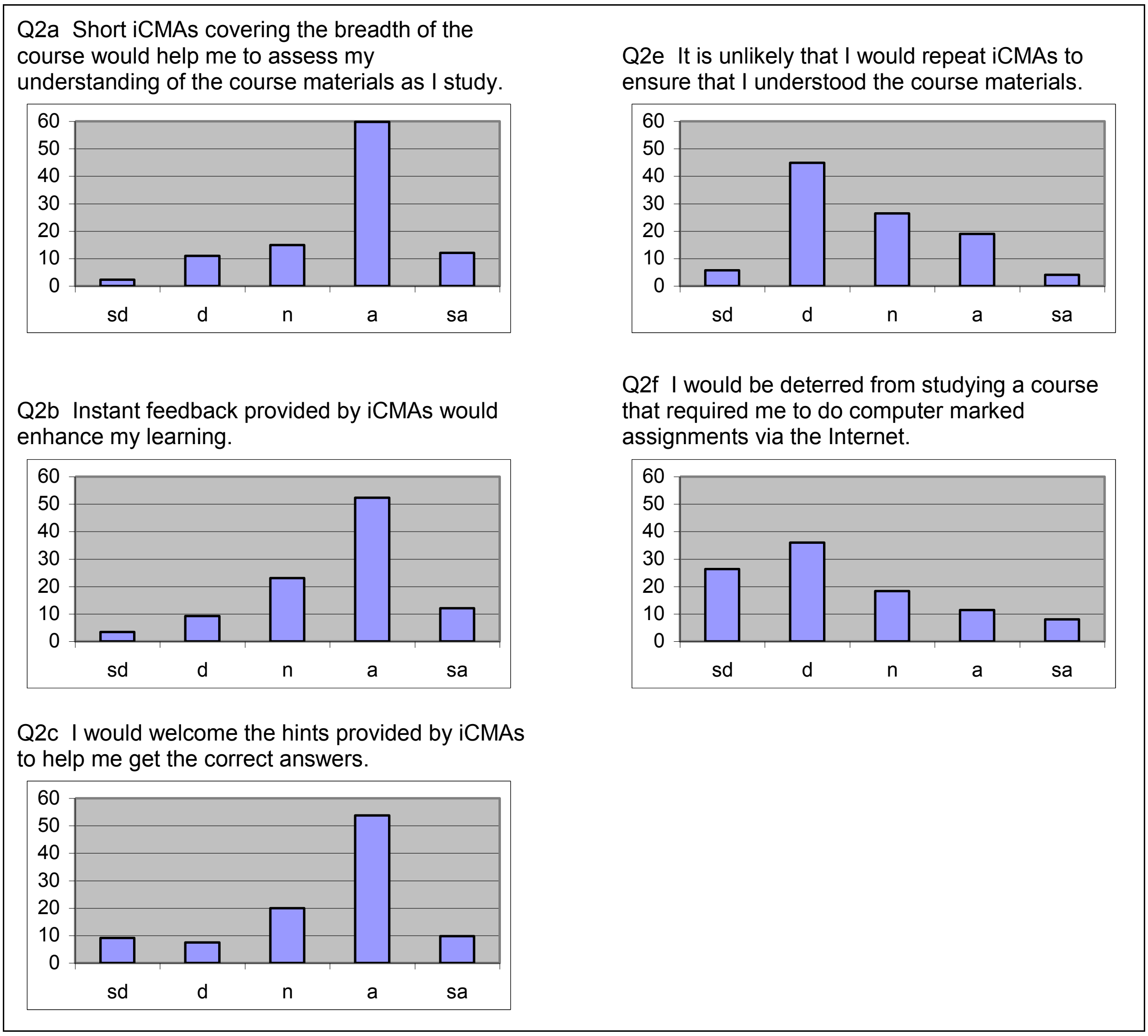


Figure 2 Students' views about iCMAs.

3.3 Number and length of assignments, cut-off dates and scheduling

The assessment model that we outlined to students would have four TMAs and eight iCMAs. Each assignment would be much shorter than each of the four TMAs used in the past, but there would be only two or three weeks between cut-off dates, rather than two months. Figure 3 shows that the shorter, more-frequent assignments are welcomed by most students (50% supporting and 30% disagreeing). The majority of students also agree that the fixed cut-off dates for the short TMAs and iCMAs would help to keep them to the study schedule, and 55% agree that they would fall behind if the assignments did not have fixed cut-off dates. Even so, 45% would welcome more flexibility in the cut-off dates to help them fit their studies in with other commitments.

OU students often need to schedule study time and to meet assignment cut-off dates for several courses, while working in a full-time job, coping with family responsibilities and maintaining some sort of social life. For some students, replacing the four TMA cut-off dates that we currently have for our 30-point courses by up to a dozen cut-off dates could cause problems. As one pointed out: "*Frequent deadlines would remove* *flexibility in juggling studies with work and family commitments*." Another wrote: "*When doing several 30 point courses, TMA deadlines often clash, and I can have very heavy workloads at certain times. I worry that, while I like the idea, more shorter TMAs will clash even more.*" However, the majority of students were not concerned about this. Each of the formative assignments would be much shorter than the previous TMAs, and so would represent a much smaller hurdle.

Also, the formative nature of the assignments mean that students can submit assignments as early as they like; with the iCMAs they will get instant feedback and with the TMAs the feedback could be much more rapid than at present, though depending on the ALs availability. One of the strong arguments for many, short assignments is that the fixed cut-off dates help to pace the students' study, and the survey results indicate that students recognise the importance of this. One commented: "*More frequent TMAs and iCMAs sound daunting but they would definitely help me stick to my study plan. However, as a disabled student who has frequent periods in hospital or unable to work, more deadlines might be harder to meet.*"

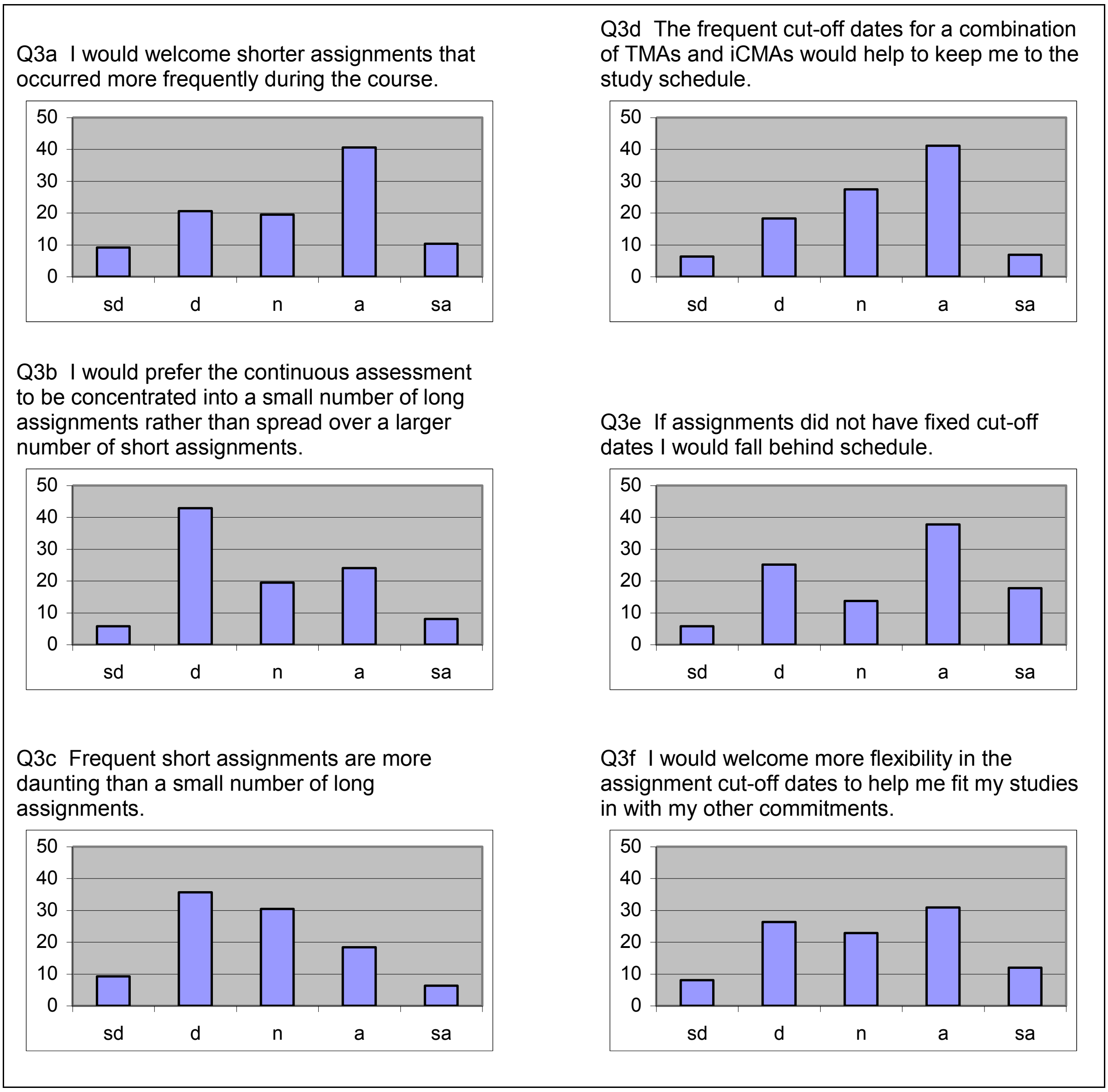


Figure 3 Students' views about number and length of assignments, cut-off dates and scheduling.

3.4 Effort students put into assessment

A major concern with any transition from summative assessment to formative assessment is whether students will put as much effort into the assessment – and therefore whether they will learn as much by tackling the formative assignments as they would from summative assignments. The majority (60%) of the students responding to the survey think that they would put as much effort into the proposed formative assignments as they currently put into the summative assignments (Figure 4), but a substantial minority, about 30%, indicate that they would put in less effort. As one student commented: "*I often cheat with iterative questions on DVD – I find answers with as little effort as possible and use the answers to enhance my understanding. I'd be strongly tempted to do this with iCMAs, so it would be a waste of time for my tutor to offer help. I might need a bigger carrot to put effort into iCMAs*." However, if the students were told that a proportion of exam questions would be based on the formative questions in TMAs and iCMAs then the division of opinion changes to 75% agreeing that they would put is as much effort and only 10% disagreeing.

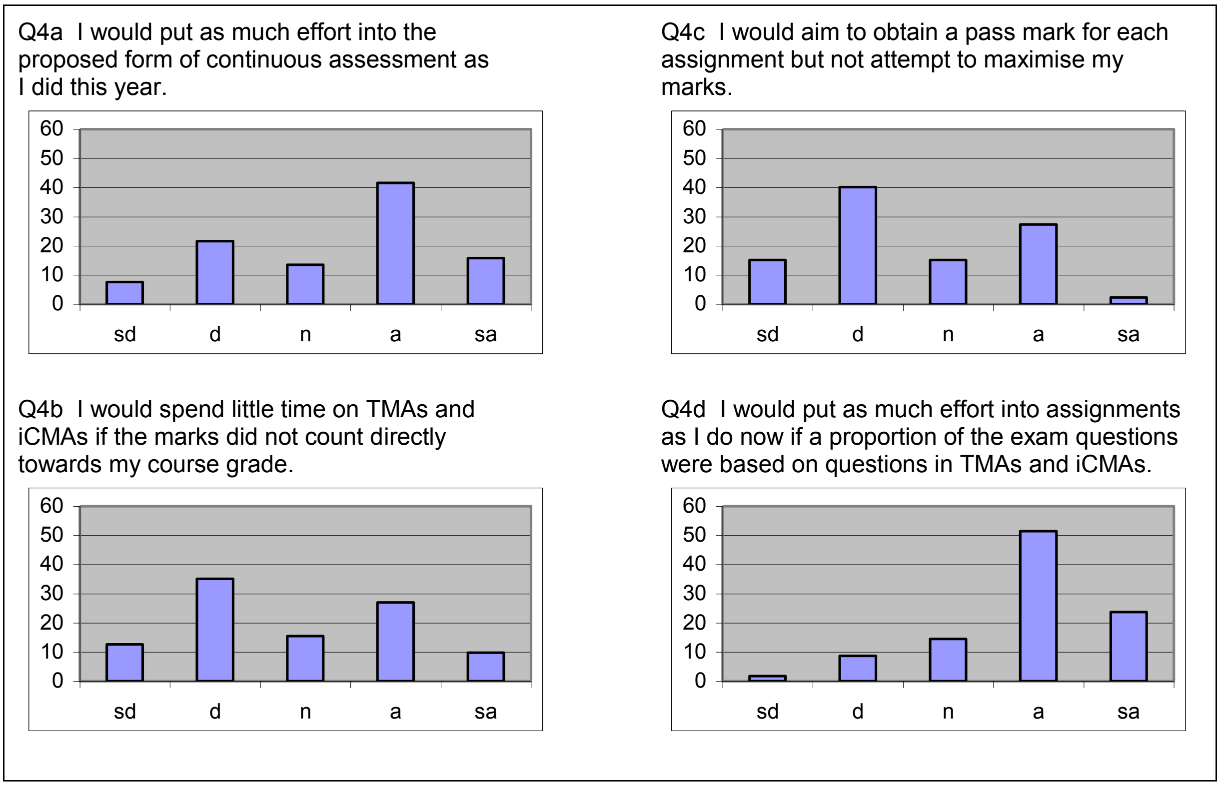


Figure 4 Students' views about the effort they would put into formative assessment.

Clearly it will be important to convince students of the benefits of engaging fully with the formative assessment. They must realise that the assignments are reinforcing the understanding and developing the important skills that are likely to be assessed in the exam, and the responses to Question 4d indicate that knowledge of this could be a powerful motivator. However, the best of intentions may be forgotten when there are pressures on a student's time as the cut-off date approaches, so some of the 60% who indicated that they would put the same amount of effort into the proposed formative assessment may be rather optimistic. On the other hand, it may not be a bad thing if some of the 30% who said they would put in less effort with the formative assessment did just that. There are undoubtedly students who spend too much time polishing a TMA question to ensure they maximise their mark, when they would be better off spending more time getting to grips with other parts of the course. One student commented: "*I spend a disproportionate amount of time 'perfecting' TMA answers to ensure a good grade. Ideally I would spend less time on TMAs but still achieve the same learning outcomes. Hence less emphasis on marks and more on feedback would be a huge improvement.*"

3.4 Tutor contact

The introduction of iCMAs would mean that the formative TMAs would only be about half of the length of the current summative TMAs, and the marking workload of ALs would be substantially decreased. Though this could be seen as an opportunity to reduce the expenditure on ALs, we believe that the reduction in the time ALs spend marking assignments should be balanced by an increase in time spent in targeted one-to-one support for struggling students. The students requiring additional support could be identified from their performance on TMAs and iCMAs. This additional support could have major benefits in terms of enhanced retention and improved student performance.

The survey indicates that most students would welcome more support from their tutor (Figure 5). About 70% would welcome their tutor contacting them if they had difficulties with an iCMA, only 10% would not want to have more contact with their tutor, and 50% think that they would learn more effectively if they had the opportunity to discuss assignment questions with their tutor before submission. About 40% of students would like the opportunity to resubmit a TMA solution to make sure that they understood how to answer a question. A few students made written comments about their interaction with their tutor:

"*I'd welcome the chance to revise solutions with tutor, but not to resubmit. More important would be to ask questions while doing the TMA.*"

"*When I have trouble with a TMA, the tutor's help is limited, often almost mysterious. By the time I get TMA feedback, it's weeks later, I've moved on and so it tends to not be so valuable. It would be much better to make assignments mandatory but not counting, so students get the maximum learning potential from tutors.*"

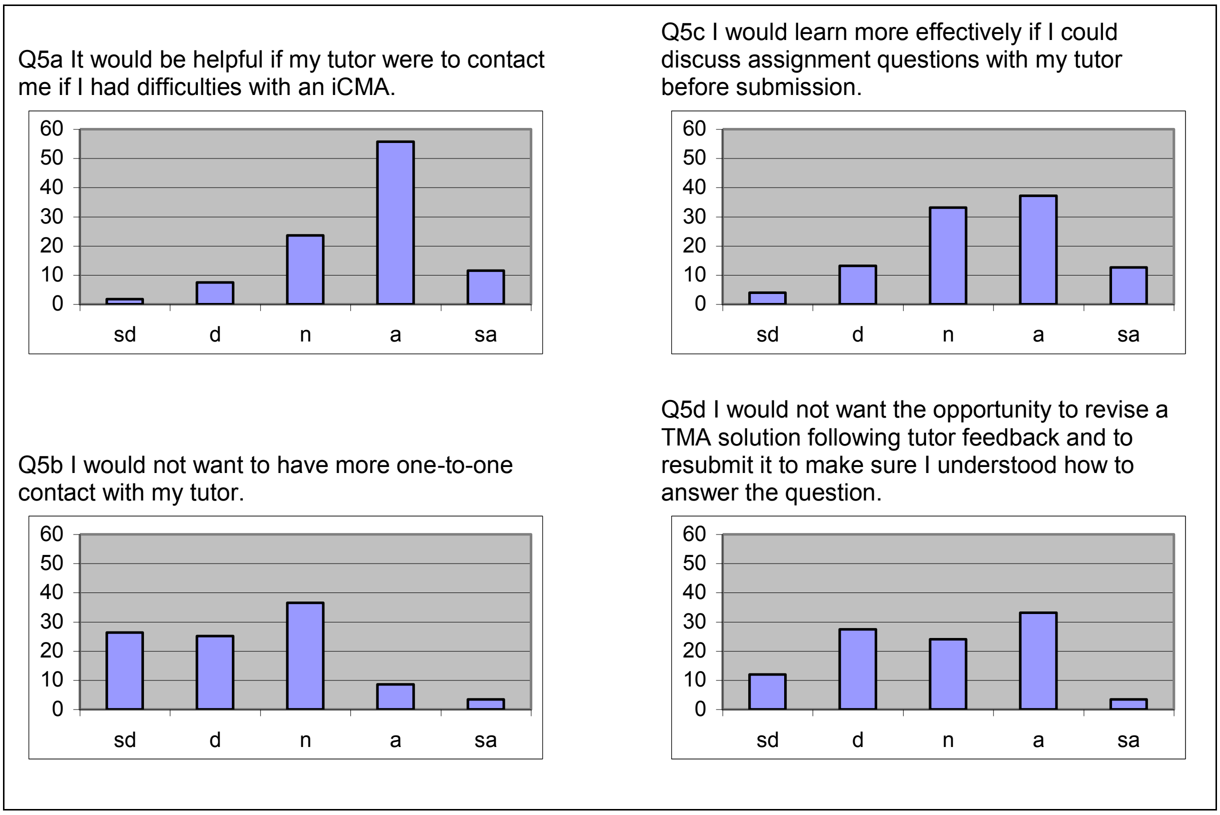


Figure 5 Students' views about increased one-to-one contact with their tutor.

3.5 Dependence of course grade on the examination alone

Survey responses in Figure 6 indicate that students are fairly evenly split between those who think their final grade would not be as good with the proposed assessment model and those who disagree (39% versus 31%). About half of students don't think that their result would reflect their achievement as well as with the existing assessment system, compared with 25% disagreeing. One written comment said "*Continuous assessment and exam 'counting' gives a better overall measure of performance/comprehension of the course.*" About 2/3 of responders are concerned that their exam performance would let them down, do not think that a three-hour exam would be a fair measure of their understanding of the course, and would not want to go into the exam knowing that their course result depended only on exam performance. Over 90% of students think that the continuous assessment marks should be taken into account where the exam mark is close to a borderline between grades.

A major effort will be required to overcome these concerns, since they could cause students to drop out, or to study the complete course but fail by not attending the exam. Reducing the fear of the unknown or unexpected will be one way to tackle the concerns: knowing that some exam questions are closely based on the continuous assessment should help, as should providing screencasts showing how to tackle typical exam questions. Student concerns might also be alleviated if they were made aware that, with the current assessment model, the summative continuous assessment score generally has little or no direct effect on the course grade that a student achieves, and so introducing a system in which it becomes explicit that the assessment score does not contribute to the course grade would have little effect on their performance.

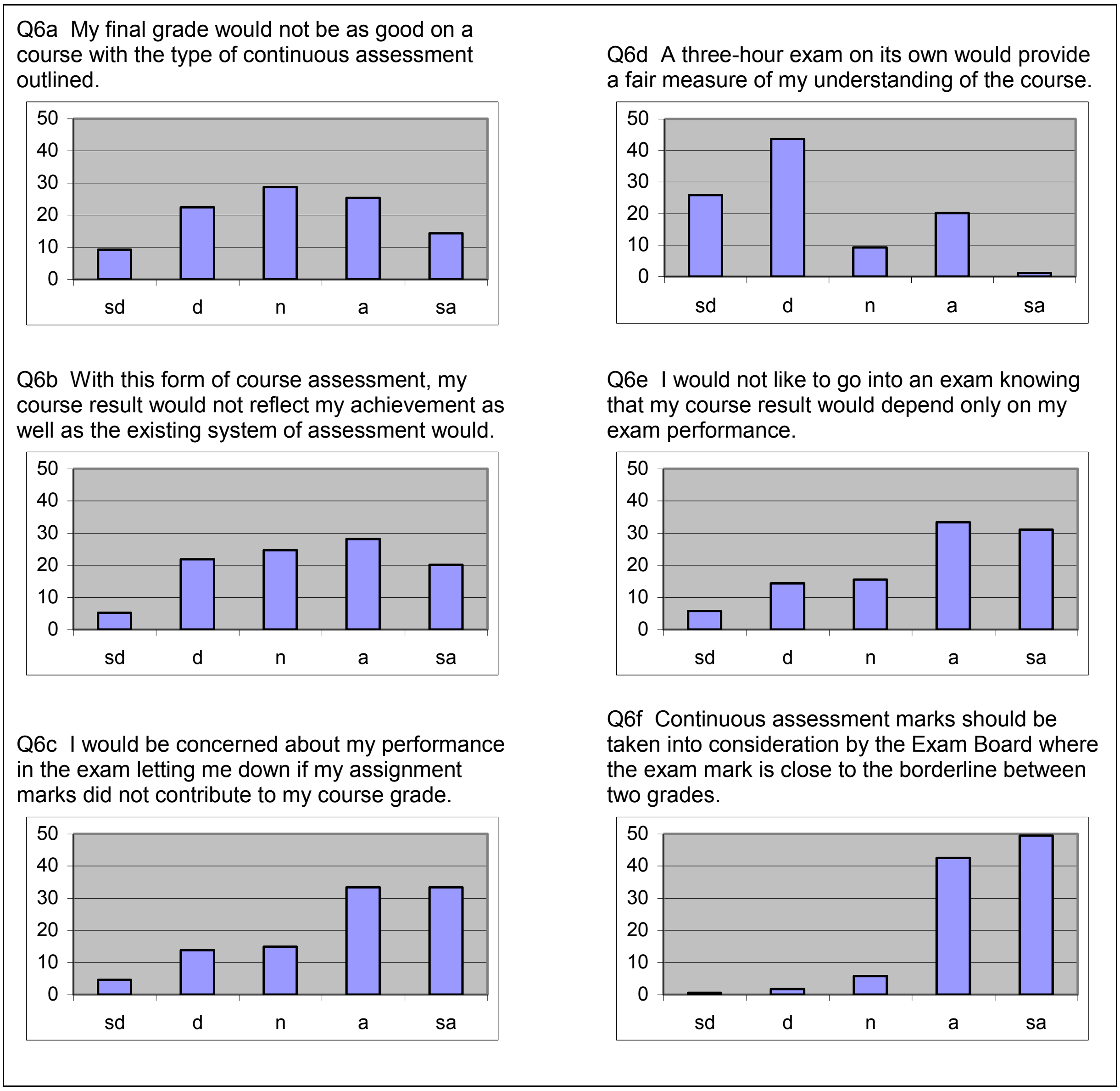


Figure 6 Students' views about the examination mark alone determining the course grade.

4 Survey results: views on presentation patterns

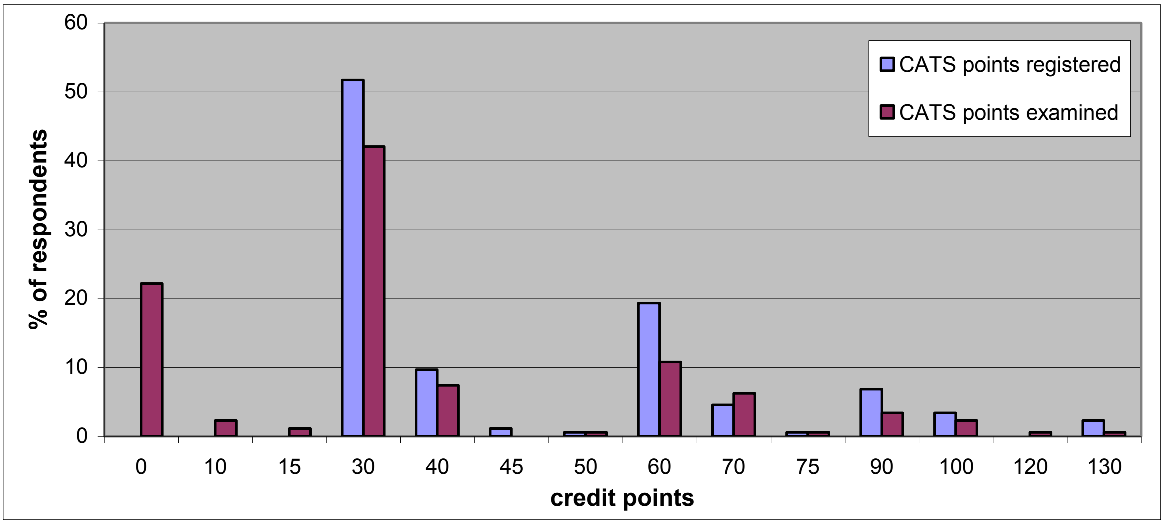
The students' responses to the items about presentation patterns have been divided into five main topics, and these will be discussed in the five subsections that follow. In each of these subsections, we again summarise students' views and include a figure showing bar charts that indicate the percentage of students giving each response.

4.1 Study in 2007

Since students' views about the period over which a course should be studied are likely to be correlated with the number of courses they currently study per year, we asked about the number of CATs points for which they had registered in 2007 and the number of points for which they had sat the exam (or completed the ECA). We also asked which courses they had registered for and which they had completed. As shown in Figure 7, half of the students who returned the survey had only registered for 30 points, i.e. they were only studying S357 or SM358, and another 10% registered for 40 points, most of whom (14/17) were studying SM358 and SMXR358. Almost 20% registered for 60 points, and 18% registered for more than 60 points. The mean number of points for which students registered was 48. Comparison of these figures with the points for which students had taken exams indicates that many students signed up for more than they were able to complete – the average number of points examined was only 34. There were 22% of the students who did not complete *any* of the courses for which they registered, and another 42% only completed 30 points, so 2/3 of students completed 30 points or fewer. A quarter of students completed 60 points or more. It is interesting that 77% of students said that when they registered they thought they would definitely complete all of the courses, and an additional 20% thought that they probably would, whereas only 62% actually did so. Only 3% admitted that they thought they would probably or definitely not complete some of the courses for which they initially registered, whereas 37% did not complete 30 points or more of courses.

The overall picture here is of many students overestimating how much they can study successfully in a year. The small proportion of students who admitted at the start of the year that they didn't expect to complete all of their courses seems to indicate that these are not serial withdrawers. However, the data do indicate that 5 of the 12 students who did not complete 60 points or more were receiving financial assistance with their course fees and so didn't have a financial incentive to complete.

Q7a How many credit points did you initially register to study in 2007, and for how many points did you sit the exam (or ECA)?



Q7b Courses for which students initially registered In 2007 and courses for which students sat exam or submitted ECA.

	frequency		percent of responders	
	registered	exam	registered	exam
S357	101	67	57	38
SM358	105	74	60	42
SMXR358	35	32	20	18
SXP390	7	5	4.0	2.8
S207	3	3	1.7	1.7
MST209	4	4	2.3	2.3
MST322	6	2	3.4	1.7
M377	4	3	2.3	1.7
Other	33	30	19	17

Q7c At the start of the year did you think that you would complete all of the courses for which you were registered?

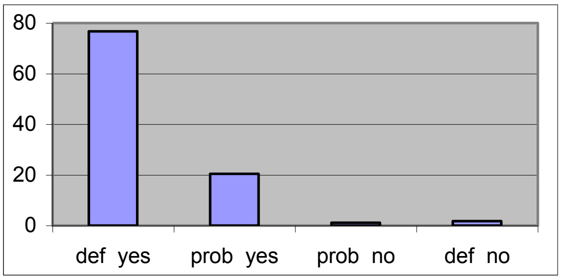


Figure 7 Number of CATs points and the courses for which students initially registered and completed by sitting the exam (or ECA) in 2007.

4.2 Effect of alternate year presentation on students' plans

The Level 3 physics and astronomy courses are currently presented in alternate years, with S357 and SM358 (or its predecessor SM355) presented in odd-numbered years and S381 and SMT359 (or its predecessor SMT356) in even-numbered years. Alternate year presentation was implemented to increase the number of students registering for each presentation and to reduce the annual maintenance workload. There is pressure now to present all four Level 3 physics and astronomy courses every year, but it is not clear how many current students think that alternate year presentation has disadvantaged them. To elicit their views they were asked whether they agreed or disagreed with four statements about alternate year presentation.

Almost 30% of students agreed that alternate year presentation has had no effect on their studies, but 53% disagreed (Figure 8). About 36% think that they would have studied a different combination of courses had all four courses been presented every year, and almost 60% would have studied courses in a different sequence. However, only 20% thought that they would have completed their degree more rapidly if all four courses had been presented every year.

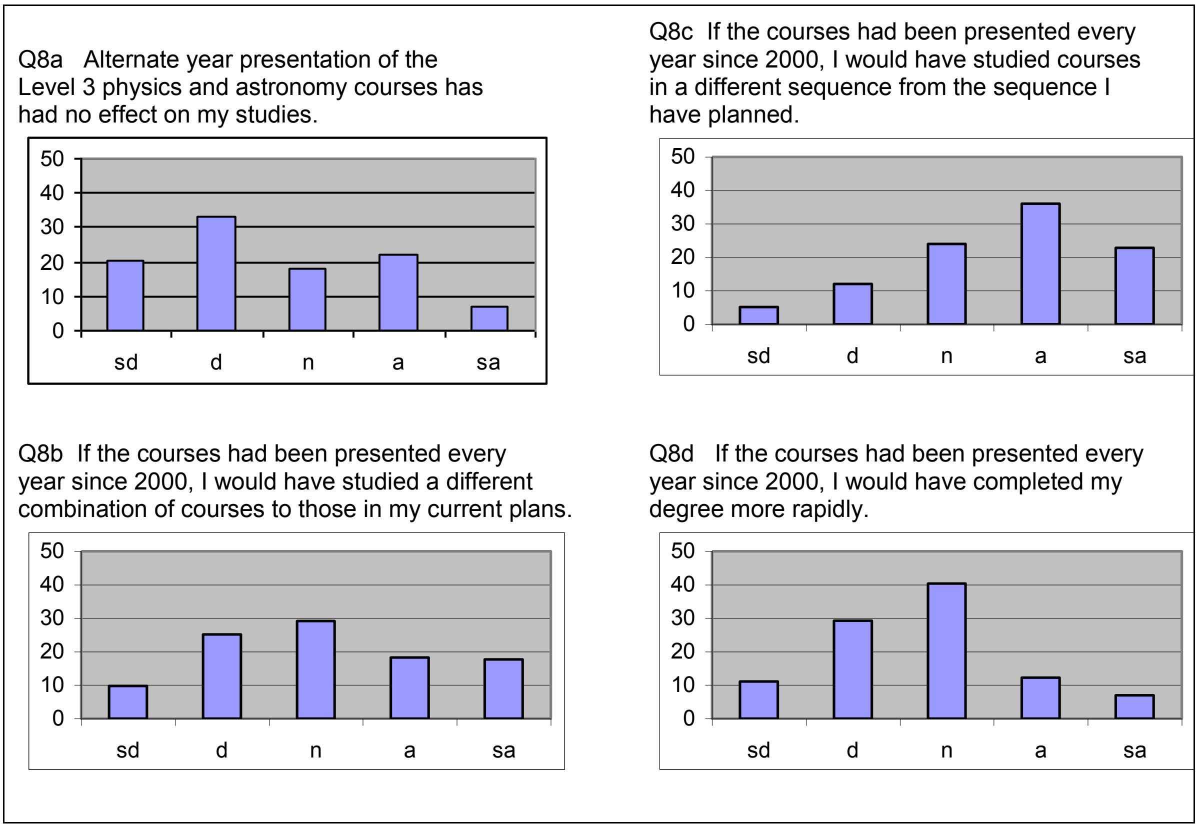


Figure 8 The effect of alternate year presentation of Level 3 physics and astronomy courses on students' study plans.

So half of the students would have studied differently if all of the courses had been presented every year, and the major difference would have been in the order that they studied the courses. Since there are sound academic reasons for studying courses in particular sequences, or studying pairs of courses concurrently, moving to annual presentation for all of the Level 3 courses would be advantageous for significant numbers of students. One problem with alternate year presentation highlighted by students is that if a student needs to repeat a course, then they cannot do this in the following year. However, there are some negative consequences of alternate year presentation; as one student wrote: "*Keeping student numbers high enough to keep a course viable is a bigger consideration. If presenting every year means there's a greater likelihood of being assigned to an inaccessible tutor group, then I'm all for AYP*."

4.2 Changes to improve retention for non-completers

Given the significant non-completion rate for the Level 3 physics and astronomy courses, the 36% of students who indicated that they did not complete S357 or SM358 were asked whether they would have completed the courses if three possible changes had been made. About half of these students did not think that they would have completed the courses even if the study period had been longer, if the TMAs didn't have fixed cut-off dates, or if there had been more, shorter assignments, and only about 20% of them thought these changes would have helped them complete the courses (Figure 9).

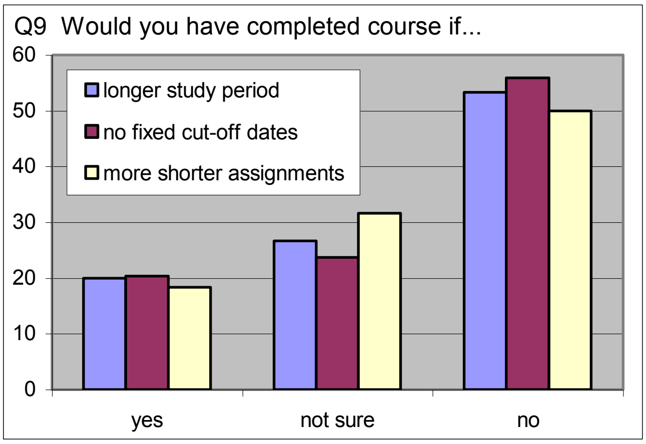


Figure 9 Only about 20% of the 64 students who did not complete S357 or SM358 in 2007 thought that they might have completed the courses if the indicated modifications had been made to the courses.

4.3 Preferred study period

There is some concern about whether students could cope with presentation of the Level 3 physics and astronomy courses over a one-semester period, which might equate to five months or less of study time. Students were therefore asked to indicate the length of the study period they would have preferred for the course studied in 2007, and 50% of them opted for the current nine-month period, with an additional 28% opting for even longer periods of 10 or 11 months (see Figure 10). Only 13% of students preferred periods of six months or shorter. Almost 60% agreed with the statements that they would find it more difficult to complete the courses if they were presented over six months, and that the courses needed a study period of at least nine months to study successfully, compared with just over 20% who disagreed. Over 60% of students would welcome the ability to register for a course that has the exam in a specified month but where they could choose their start date and therefore the period over which they studied the course. Only a quarter of students thought that they would be disadvantaged if other students were studying different parts of the course at a particular time, which would be one consequence of introducing flexibility to the length of the study period.

There appears to be a very strong warning here that slotting the 30-point Level 3 physics and astronomy courses into a 6-month semester system (in which the study period is only about 5 months, compared with 8 months for the current February – October presentation) would make it more difficult for students to complete the courses successfully. This certainly confirms the views of those responsible for producing and teaching these courses. The courses are conceptually difficult, and students require time to assimilate the new concepts and to develop the skills to apply them. Here are a few of the comments that students made:

"*My biggest problem is finding time - less time for a course would be a disaster for people like me.*"

"*For those of us studying principally for pleasure, reducing study period could make studying a chore*."

"*Difficult to see how SM358 content can be compressed into shorter period without placing impossible demands on students with full time jobs.*"

"*I would be put off studying if courses were presented over 6 months - probably true for many disabled students*."

"*I found it hard enough to complete in 9 months. Pretty near impossible in 6 months.*"

"*Studying 30 points over 6 months would allow less time for assimilation of new knowledge.*"

However, there were some opposing views:

"*It would be great to study 30 pts in 6 months, so as to finish my degree quicker. Instead I've tried to study two courses and been unable to complete both at same time*."

"*Strongly welcome opportunity to study 2 30 point courses consecutively over 12 months. Feel exam performance would improve greatly if had 12 months for 60 points rather than 9.*"

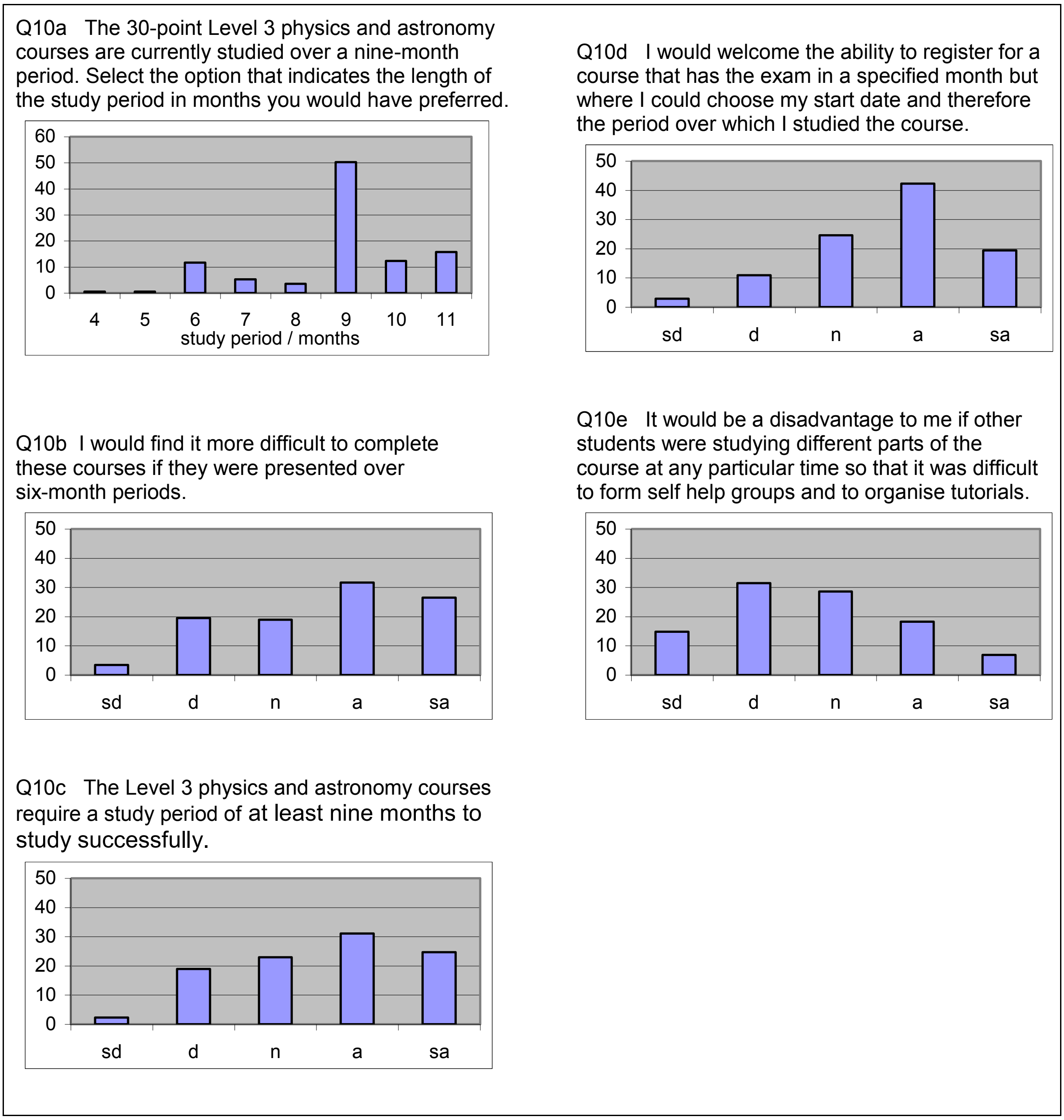


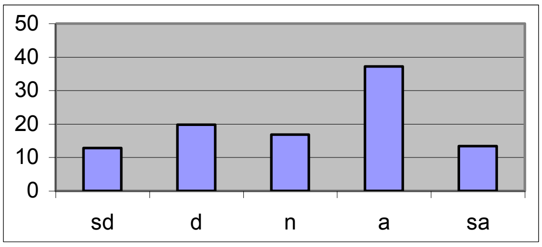
Figure 10 Students' views about the length of the study period for the courses.

4.4 The six-month semester model

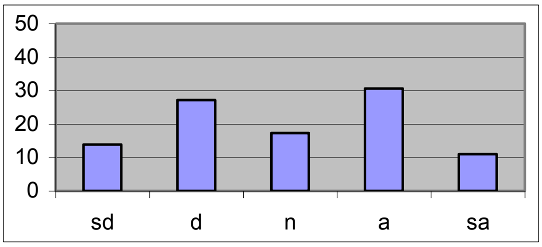
Students were asked to "Suppose that the Level 3 physics and astronomy courses were presented over six-month periods, either from November to April or from May to October. For example, one possibility would be to present SMT359 and S381 from November to April and to present SM358 and S357 from May to October." They were then asked to indicate agreement or disagreement with a number of statements relating to this model.

Half of the students preferred this model to the current alternate year presentation pattern, and one third disagreed (Figure 11). Approximately equal proportions of students (40%) prefer this model to one in which all four courses are presented between February and October every year, and the ability to study two of the 30-point Level 3 courses consecutively during a 12-month period was welcomed by 42% of responders, compared with 31% who disagreed. If the courses had exams in October and April, 2/3 of students would prefer to start studying these 30-point courses nine months before the exam rather than six months before. Half of the students have no preference for studying in either of the two semesters suggested, and the other half were split 39% to 12% in favour of the November to April semester. More students expressed a preference for studying SM358 and the associated residential school course sequentially than for studying the two courses concurrently (37% to 19%), with 45% not expressing a preference. Finally, only 30% of students agreed that they would be more likely to study Level 3 physics and astronomy courses if they followed the presentation pattern outlined, whereas 42% disagreed (though disagreement cannot be equated to ‘less likely’).

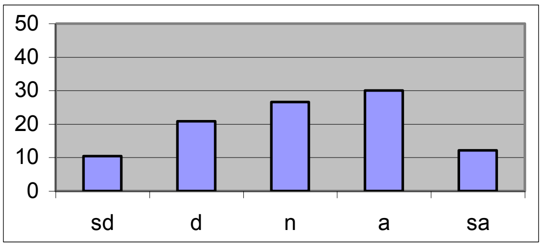
Q11a This presentation pattern would be better than the current alternate year presentation pattern.



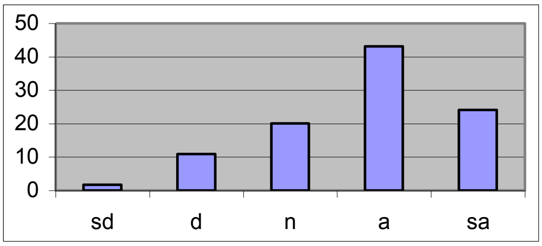
Q11b This presentation pattern would be better than presenting all four courses between February and October every year.



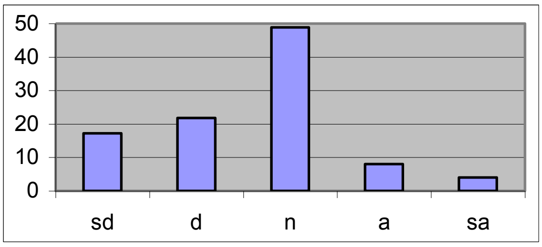
Q11c I would welcome the ability to study two of the 30-point Level 3 courses consecutively during a 12-month period.



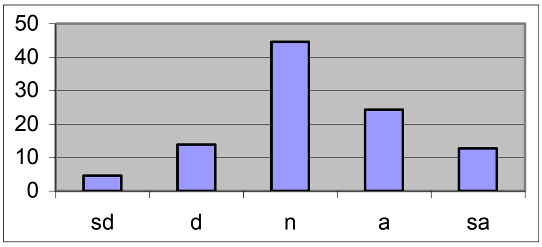
Q11d If the courses had exams in October and April, I would prefer to start to study these 30-point courses nine months before the exam rather than six months before.



Q11e I would prefer studying a 30-point course from May to October rather than from November to April.



Q11f I would prefer to study SM358 in November-April and then SMXR358 during July/August rather than studying SM358 in May-October while studying SMXR358 concurrently.



Q11g I would be more likely to study Level 3 physics and astronomy courses if they followed the presentation pattern outlined.

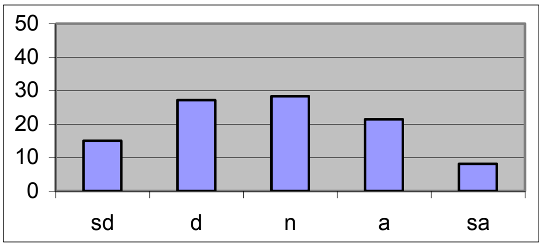


Figure 11 Students’ views about the semester presentation pattern.

In view of responses to Question 10, which indicated support for study periods of 9 months or longer, it is surprising that 43% of students appear to prefer the semester model to a model in which all four courses are presented between February and October every year and also surprising that a similar percentage would like to be able to study two courses consecutively during a year.

For some students one advantage of the nine-month presentation model is that it provides some time off from studies: "*These courses need 9 months, and need a break after exam to recuperate, or students will be forced to take year off and perhaps not return to study after.*" However, for others this is a disadvantage: "*I like the idea of 6 month consecutive 30 point courses as I struggle to maintain study skills in Nov-Jan gap*."

5 Conclusions

The survey indicates that many of the responders are content with the existing models for course assessment and presentation, and it confirms many of the *a priori* concerns held by academic staff about the impact of the proposed changes.

When introducing the proposed changes to continuous assessment, it will be important to:

- Ensure that the iCMAs are at least as challenging as the TMA questions they replace and that they provide a real learning experience. Students and ALs must not conclude that the changes to the continuous assessment amount to a 'dumbing down' of the Level 3 physics and astronomy courses.
- Convince students of the importance of engaging fully with the continuous assessment. The iCMAs will be designed to assess achievement of many of the most important learning outcomes, and students will be able to repeat questions as often as they like to ensure that they achieve these learning outcomes. The exam will asses the same learning outcomes, so the continuous assessment should be excellent preparation for the exam.
- Convince students of the benefits of keeping to the course schedule and meeting the specified cut-off dates for the assignments.
- Reassure students that the formative continuous assessment will not lead to poorer final grades for the course as long as they tackle the continuous assessment seriously. Including in the exam paper a proportion of questions that are closely related to questions in the TMAs, in the iCMAs and in course materials, and making students aware of this policy, will be one way to build students confidence. Students concerns about the exam will also be reduced if we can tell them that the exam board will take the continuous assessment marks into consideration when the exam mark is close to a borderline.
- Ensure that the AL marking time saved by reducing the length of the TMAs is used effectively to support students, particularly those at risk of withdrawing or failing. ALs will have access to both iCMA and TMA results, and these should allow them to identify students who are in difficulty.

The survey results provide a strong warning against introduction of a semester-only model for presenting the Level 3 physics and astronomy courses. A majority of current students appear averse to reducing the study period below the current length. However, the introduction of formative assessment does make flexible presentation periods feasible. It would be worth conducting a trial in which students were able to register for courses for which the examination was in a specified month, but with individual students able to choose a study period of between five months and a year.

Acknowledgements

We are grateful to Emma Street from the Survey Research Department for support with the production and processing of the survey and to Anne Slee of the Institute for Educational Technology for providing a compilation of the raw data from the survey and demographic data for the responders

Level 3 Physics and Astronomy student survey 2007

Please use a ball point pen to complete the questionnaire. Do not use fountain or felt pens as the ink may be visible on the other side of the page. The questionnaire will be read with the help of a scanner so please fill it in as described. Please put an 'X' in the appropriate box keeping within the boundary of the box. For example: [X]. Do not spend too long on each item. If you make a mistake and cross the wrong box, please block out your answer and then cross the correct box. For example: ■ ☐ ☐ [X] ☐

SECTION A: Continuous assessment

Educational research has indicated that there is often too much emphasis on using assessment to validate a student's achievements at the expense of using assessment to support learning. The Physics and Astronomy Department has been considering proposals for ways to redress the balance, and we would appreciate your views on possible changes.

Please consider the following scenario for assessment of Level 3 Physics and Astronomy courses.

- The TMAs are reduced to about half of their current length, but are marked just as they are now, with tutors providing marks, comments and feedback to students.
- Interactive computer-based assignments (iCMAs) are also provided via the course website. The computer-based questions are interactive: students submitting incorrect responses are given hints and allowed to try again, and the computer provides model answers and feedback as soon as each question is completed. The assignments are designed to improve understanding close to the time of study of each part of the course. The assignments can be repeated with different questions for practice and also for revision before the exam.
- Students are *required* to attempt the majority of the assignments, and are told their marks for the TMAs and interactive computer marked assignments so they know how well they are achieving the course's learning outcomes, but these marks are ***not*** used to determine the course grade, which is determined solely by the examination mark. However, the assignment marks are taken into consideration by the Exam Board for students whose examination mark is close to a borderline. Note that with the current assessment system, most students find it more difficult to achieve the threshold exam mark required for a particular grade than to achieve the threshold continuous assessment mark, so grades are generally governed by exam performance.
- One possible package for the assignments for a 30 point Physics and Astronomy course would be four half-length TMAs, spread through the course as at present, plus eight short iCMAs.
- The end of course examination would be the same as at present. A proportion of exam questions would be based closely on questions in the TMAs, iCMAs or additional revision questions.

The assessment scenario outlined above would have the following consequences.

- The emphasis in the assignments would be placed on helping students to achieve key learning objectives, rather than judging their performance.
- More-rapid feedback would be provided on assignments – with immediate feedback on iCMAs.
- Shorter, more frequent, assignments would provide better pacing for study throughout the course.
- A mix of TMAs and iCMAs would allow more-thorough coverage of the breadth of the course materials.
- More tutor support would be available for students – the time saved on TMA marking would be used for additional one-to-one and group support.
- Tutors would be able to discuss students' difficulties with TMA questions more openly if TMA marks were not used to determine course grades, and would be able to teach more effectively.
- Tutors would monitor progress on iCMAs, and would offer study advice or extra tuition where necessary

After reading the description on page 1 of an alternative system of assessment, please indicate your agreement or disagreement with each of the following statements.

	*(Please cross **one** box only in **each** row)*	Disagree strongly	Disagree	Neither agree nor disagree	Agree	Agree strongly
1a	A mix of TMAs and iCMAs would be a suitable way to test understanding and skills developed in the course.	☐	☐	☐	☐	☐
1b	My final grade would not be as good on a course with the type of continuous assessment outlined on page 1.	☐	☐	☐	☐	☐
1c	I would prefer assignments for Level 3 Physics and Astronomy courses to be a mix of TMAs and iCMAs, rather than TMAs only.	☐	☐	☐	☐	☐
1d	I would learn less from a mix of TMAs and iCMAs than from TMAs alone.	☐	☐	☐	☐	☐
2a	I would put as much effort into the proposed form of continuous assessment as I did this year.	☐	☐	☐	☐	☐
2b	I would spend little time on TMAs and iCMAs if the marks did not count directly towards my course grade.	☐	☐	☐	☐	☐
2c	I would put as much effort into assignments as I do now if a proportion of the exam questions were based on questions in TMAs and iCMAs.	☐	☐	☐	☐	☐
2d	I would aim to obtain a pass mark for each assignment but not attempt to maximise my marks.	☐	☐	☐	☐	☐
3a	My continuous assessment mark would provide me with a good indication of my understanding of the course, even if it did not count towards my final grade.	☐	☐	☐	☐	☐
3b	I would be concerned about my performance in the exam letting me down if my assignment marks did not contribute to my course grade.	☐	☐	☐	☐	☐
3c	Continuous assessment marks should be taken into consideration by the Exam Board where the exam mark is close to the borderline between two grades.	☐	☐	☐	☐	☐
3d	With this form of course assessment, my course result would not reflect my achievement as well as the existing system of assessment would.	☐	☐	☐	☐	☐
3e	I would not like to go into an exam knowing that my course result would depend only on my exam performance.	☐	☐	☐	☐	☐
3f	A three-hour exam on its own would provide a fair measure of my understanding of the course.	☐	☐	☐	☐	☐

After reading the description on page 1 of an alternative system of assessment, please indicate your agreement or disagreement with each of the following statements.

	*(Please cross **one** box only in **each** row)*	Disagree strongly	Disagree	Neither agree nor disagree	Agree	Agree strongly
4a	I would welcome shorter assignments that occurred more frequently during the course.	☐	☐	☐	☐	☐
4b	I would prefer the continuous assessment to be concentrated into a small number of long assignments rather than spread over a larger number of short assignments.	☐	☐	☐	☐	☐
4c	The frequent cut-off dates for a combination of TMAs and interactive computer marked assignments would help to keep me to the study schedule.	☐	☐	☐	☐	☐
4d	Frequent short assignments are more daunting than a small number of long assignments.	☐	☐	☐	☐	☐
5a	Short interactive computer marked questions covering the breadth of the course would help me to assess my understanding of the course materials as I study.	☐	☐	☐	☐	☐
5b	I would be deterred from studying a course that required me to do computer marked assignments via the Internet.	☐	☐	☐	☐	☐
5c	Instant feedback provided by iCMAs would enhance my learning.	☐	☐	☐	☐	☐
5d	I would prefer the continuous assessment to involve iCMAs only.	☐	☐	☐	☐	☐
5e	I would welcome the hints provided by iCMAs to help me get the correct answers.	☐	☐	☐	☐	☐
5f	It is unlikely that I would repeat iCMAs to ensure that I understood the course materials.	☐	☐	☐	☐	☐
6a	It would be helpful if my tutor were to contact me if I had difficulties with an iCMA.	☐	☐	☐	☐	☐
6b	I would not want to have more one-to-one contact with my tutor.	☐	☐	☐	☐	☐
6c	I would learn more effectively if I could discuss assignment questions with my tutor before submission.	☐	☐	☐	☐	☐
6d	I would not want the opportunity to revise a TMA solution following tutor feedback and to resubmit it to make sure I understood how to answer the question.	☐	☐	☐	☐	☐

7 Please note any additional points that you would like to make about continuous assessment for the Level 3 Physics and Astronomy courses.

SECTION B: Different presentation patterns

Effects of alternate year presentation of Level 3 Physics and Astronomy courses on your study plans

The Level 3 Physics and Astronomy courses are currently presented in alternate years, with S357 and SM355 (or its predecessor SM355) presented in odd-numbered years and S381 and SMT359 (or its predecessor SMT356) in even-numbered years. Please answer the following questions to indicate the extent to which this alternate presentation has impinged on your study plans.

8 Please indicate your agreement or disagreement with each of the following statements.

*(Please cross **one** box only in **each** row)*

	If the Level 3 Physics and Astronomy courses had been presented every year since 2000......	Disagree strongly	Disagree	Neither agree nor disagree	Agree	Agree strongly
8a	… I would have studied a different combination of courses to those in my current plans.	☐	☐	☐	☐	☐
8b	… I would have studied courses in a different sequence from the sequence I have planned.	☐	☐	☐	☐	☐
8c	… I would have completed my degree more rapidly.	☐	☐	☐	☐	☐
8d	Alternate year presentation of the Level 3 Physics and Astronomy courses has had no effect on my studies.	☐	☐	☐	☐	☐

8e **Please note any comments that you would like to make about alternate year presentation of the Level 3 Physics and Astronomy courses.**

Changes to the period of study of OU courses

The University is considering proposals for changing the period of time over which courses are presented. One proposal is that the 30 point Level 3 Physics and Astronomy courses could be presented over six-month periods (e.g. November – April, or May – October). Students who study only one 30 point course in a year would have a shorter period of more-intense study, while students who study two 30 point courses in a year may be able to study the courses sequentially.

Another proposal is that students would be allowed to register for a course that has an examination in October, but would be able to start studying the course any time between February and May that year (or even the previous November).

Please answer the following questions to help us to understand your current study pattern and your views about possible changes.

9a **How many credit points did you initially register to study in 2007?**
(Enter 30 points as [0][3][0] and 120 points as [1][2][0].)

9b **How many credit points did you sit examinations (or submit ECAs) for in 2007?** (Enter 30 points as [0][3][0] and 120 points as [1][2][0].)

10 Please indicate with crosses those courses for which you registered in 2007 and those courses for which you sat the exam or submitted the ECA.

		Initially registered	Sat exam or ECA
10a	S357 …………………………………………………	☐	☐
10b	SM358 ………………………………………………..	☐	☐
10c	SMXR358 …………………………………………….	☐	☐
10d	SXP390 ………………………………………………	☐	☐
10e	S207 …………………………………………………	☐	☐
10f	MST209 ………………………………………………	☐	☐
10g	MS324 ………………………………………………..	☐	☐
10h	MST322 ………………………………………………	☐	☐
10i	M337 …………………………………………………	☐	☐
10j	Other courses ………………………………………..	☐	☐

10k **If you indicated that you registered in 2007 for 'Other courses', please write the course code(s) below, and say whether you sat the examination or submitted the ECA.**

11	**At the start of the year, did you think that you would complete all of the courses for which you were registered?**	Definitely yes	Probably yes	Probably no	Definitely no
	*(Please cross **one** box only)*…………………….…..	☐	☐	☐	☐

12 The 30 point Level 3 Physics and Astronomy courses are currently studied over a nine-month period. Given what you know about these courses, and assuming that the course material remained the same, select the option that indicates the length of the study period in months you would have preferred.

	4	5	6	7	8	9	10	11
*(Please cross **one** box only)…………*	☐	☐	☐	☐	☐	☐	☐	☐

13 <u>If you did not complete S357 or SM358 this year</u>, please answer questions 13a – 13c.

(Please cross <u>one</u> box only in <u>each</u> row)

	Would you have completed the course …	Yes	No	Not sure
13a	… if the study period had been longer?	☐	☐	☐
13b	… if the first three TMAs did not have fixed cut-off dates and could have been submitted at any time before the final cut-off date for TMA04?	☐	☐	☐
13c	… if there had been more, shorter assignments with fixed cut-off dates?	☐	☐	☐

14 Please indicate your agreement or disagreement with each of the following statements.

	*(Please cross **one** box only in **each** row)*	Disagre e strongly	Disagree	Neither agree nor disagree	Agree	Agree strongly
14a	If assignments did not have fixed cut-off dates I would fall behind schedule.	☐	☐	☐	☐	☐
14b	I would welcome more flexibility in the assignment cut-off dates to help me fit my studies in with my other commitments.	☐	☐	☐	☐	☐
14c	I would welcome the ability to register for a course that has the exam in a specified month but where I could choose my start date and therefore the period over which I studied the course.	☐	☐	☐	☐	☐
14d	It would be a disadvantage to me if other students were studying different parts of the course at any particular time so that it was difficult to form self help groups and to organise tutorials.	☐	☐	☐	☐	☐

15 Suppose that the Level 3 Physics and Astronomy courses were presented over six-month periods, either from November to April or from May to October. For example, one possibility would be to present SMT359 and S381 from November to April and to present SM358 and S357 from May to October.

Please indicate your agreement or disagreement with each of the following statements relating to this presentation pattern.

*(Please cross **one** box only in **each** row)*	Disagree strongly	Disagree	Neither agree nor disagree	Agree	Agree strongly
15a This presentation pattern would be better than the current alternate year presentation pattern.	☐	☐	☐	☐	☐
15b This presentation pattern would be better than presenting all four courses between February and October every year.	☐	☐	☐	☐	☐
15c I would be more likely to study Level 3 Physics and Astronomy courses if they followed the presentation pattern outlined above.	☐	☐	☐	☐	☐
15d I would find it more difficult to complete these courses if they were presented over six-month periods.	☐	☐	☐	☐	☐
15e I would welcome the ability to study two of the 30 point Level 3 courses consecutively during a 12-month period.	☐	☐	☐	☐	☐
15f I would prefer studying a 30 point course from May to October rather than from November to April.	☐	☐	☐	☐	☐
15g If the courses had exams in October and April, I would prefer to start to study these 30 point courses nine months before the exam rather than six months before.	☐	☐	☐	☐	☐
15h The Level 3 Physics and Astronomy courses require a study period of at least nine months to study successfully.	☐	☐	☐	☐	☐
15i I would prefer to study SM358 in the period November – April and then study the residential school course SMXR358 during July/August rather than studying SM358 in the period May – October while studying SMXR358 concurrently.	☐	☐	☐	☐	☐

16 **Please note below any additional comments that you would like to make about the presentation periods for the Level 3 Physics and Astronomy courses.**

*(Please cross **one** box only)*	Yes	No
17a **Would you be happy to participate in a follow up telephone interview?.....**	☐	☐

17b **If yes, please note telephone numbers on which you are willing to be contacted below.**

Daytime weekdays ………..
Evening weekdays ………..
Daytime weekends ………..

It is very useful for us to be able to illustrate the findings from student surveys in internal reports and external publications with quotes from students' comments. We must stress that these would never be attributed to an individual student and your comments will remain completely anonymous, like your responses to all questions in this survey.

If you would rather we did not use your comments in this way, please cross this box. ☐

Thank you for your co-operation in completing this questionnaire.

Data Protection Information
The data you provide will be used for research and quality improvement purposes and the raw data will be seen and processed only by The Open University staff and its agents. This project is administered under the OU's general data protection policy guidelines which can be found at:
http://www3.open.ac.uk/our-student-policies/pdf/dataprotection.pdf

Please return the questionnaire as soon as possible using the reply-paid envelope
(To: FREEPOST ANG 5175, The Survey Office, Institute of Educational Technology, The Open University, MILTON KEYNES, MK7 6YR, UK)

S382/S383 Assessment & Tuition Strategy

Introduction

S382 *Astrophysics* and S383 *The Relativistic Universe* are two Level 3 courses, currently in their first presentation from February 2010. The courses each have a novel assessment and tuition strategy, aimed at improving student recruitment, retention and progression, whilst at the same time reducing costs in presentation, as well as increasing engagement of academic staff with students. The courses are part of the Level 3 Physics and Astronomy Student Support Team pilot project within the Student Support Review.

Each 30 credit point course consists of three equal-sized, stand-alone parts; each of the six parts is designed to be studied over 10 weeks. Five of these are based around purpose-written self-study texts that are co-published by Cambridge University Press; the second part of S382 is a VLE-enabled group project based on the acquisition, analysis, and interpretation of astrophysical data. Students are offered a choice of two projects – one using spectroscopic data from an international robotic telescope archive (the Sloan Digitial Sky Survey) and one using photometric data from the OU's own Robotic Telescope in Mallorca (PIRATE). During the project, the students will complete a set of 'tasks' and record their progress in personal weekly Progress Reports. The group will also produce a final report on their project in the form of a Wiki, which all members of the group contribute to.

Summative and formative assignments

The overall grade on an OU course is traditionally determined from a two parameter grid that includes the students' overall examination score (OES) and overall continuous assessment score (OCAS). Although many students believe that their overall course score is in some sense an 'average' of these two (equally-weighted) components, in practice, a student's grade is exclusively determined by the *lower* of their two components. Since the OES is less than the OCAS for virtually all students, the OCAS has virtually no effect on overall course grade, which is almost always determined solely by the student's performance in the exam. Not only is this misleading for students, it may give them a false sense of security on entering the exam room.

The effect of removing a summative score from the continuous assignments is that students who scored OCAS ~ OES still get the same grade; students who scored OCAS > OES still get the same grade; and students who scored OCAS < OES get a higher grade. If continuous assignments are formative then we keep the advantages of: maintaining students' pace through materials; effective teaching of students through targeted feedback; and tutor-assessment (and self-assessment) of students' progress towards learning outcomes. We lose the ability to grade students' ongoing achievement, but the overall grade at the end of the course is unaffected. We also make gains of less resource needed in annual presentation and have assignments that are better suited to teaching.

Furthermore, by providing *two* summative assessment components, which assess different parts of the course, and which simply combine to produce the overall course grade, the student is better served overall. The model adopted for S382 and S383 means that students have 1/3 of their overall course grade 'in the bag' before they even enter the exam room, and they only have to revise 2/3 of the course material for the unseen exam.

Formative assignments in S382/S383

The assessment model of both courses may be summarised by the description 'little and often'. Each part of the course (apart from the embedded project) has four short formative assignments (2x eTMA and 2x iCMA) which together amount to around 1.2 TMA-equivalents on each part. The pattern for each part of the course is: iCMA (5 questions, after weeks 1&2), eTMA (1 question, after weeks 3&4), eTMA (1 question, after weeks 6&7), iCMA (5 questions, after weeks 8&9); weeks 5 and 10 of each part are 'consolidation' weeks. This pattern allows students to get rapid feedback (on the iCMA) at the start of each part of the course, and again at the end of each part when they are ready to move on to the next part of the course. It also provides detailed tutor-generated feedback on the core central sections of each part of the course.

For the S382 project, there is one iCMA (at the start) based on knowledge and understanding that students are expected to bring to the project they will undertake and one eTMA (after the first couple of weeks of the project) comprising the first two of the student's weekly Progress Reports, in which students largely plan how they will conduct their project.

Each iCMA consists of five questions and each question has typically three (randomly selected) variants. Every time a student accesses a question they are allowed up to three attempts to get it correct. Feedback is provided on incorrect, or partially correct, answers and hints are given if necessary, until the student gets the answer correct or is provided with a worked solution. iCMAs remain 'open' for the duration of the course and students may attempt them as often as they wish, learning from the feedback they are provided with on their answers. As long as they submit their answers after each attempt at the iCMA, their highest 'score' will be the one that is retained at the end of the course. Given this pattern of use, it should be difficult to 'fail' any of the iCMAs, but since their purpose is to aid student learning rather than assess their knowledge and understanding, this is not an issue.

All eTMAs are assessed by the students' tutors using criterion referencing against achievement of a subset of the course learning outcomes. Tutors provide detailed feedback to students on their eTMA answers, and a nominal 'mark' is calculated by a weighted sum of the scores on each assessed learning outcome. As a further feedback mechanism to students, the Course Team has produced Camtasia screencasts of complete worked solutions to each eTMA, and these are made available to students through the course website after the cut-off date for the submission of each eTMA.

Although 'marks' from these iCMAs and eTMAs do not contribute to the overall course score, students must exceed a minimal threshold on 8/10 assignments for S382 and 9/12 assignments for S383, in order to be considered for a grade based on the summative assessment components. Exam board discretion will be used in those cases where students have been unable to submit the required number of formative assignments.

Sumative assessment in S382/S383

There are two summative assessment components for each course: EC2 is a conventional end-of-course examination in October based on the first and third parts of the course only, whilst EC1 is submitted in July and is based on the second part of the course only. Both the EC1 and EC2 need to be passed separately (i.e. mark >40%) in order to successfully pass the course as a whole, but the overall course grade is based on a simple weighted (2:1) sum of the individual marks. The EC1 for the second part of S382 is a portfolio comprising the student's individual weekly Progress Reports plus the group's collaborative Wiki-based Report, with a 60:40 weight between them. The EC1 for the second part of S383 comprises an extended piece of written work. Both EC1s will be fully double marked, usually by the students' tutor and one other.

There are several advantages of having two summative components, the scores of which simply combine to produce the overall course grade. Firstly, students will get 1/3 of the course out of the way before the unseen exam. Part of their course grade is therefore achieved even before they have finished studying. Secondly, students do not have to revise the entire contents of the course in preparation for the unseen exam. This should take pressure off students and allow them to perform better in the exam itself.

The re-sit policy of the two courses is also novel. As usual, students who narrowly fail the exam (EC2) in October will be eligible to retake the exam in the following April. If they have passed the other component (EC1) that score will simply carry forwards and combine with the new exam grade. If instead, they narrowly fail the portfolio (S382 EC1) or extended assignment (S383 EC1), they will be offered a viva-voce examination with a member of the course team, just on the appropriate second part of the course. If they have passed the other component (EC2) that score will simply carry forwards.

Tuition on S382/S383

As part of the Physical Science Student Support Team (SST) Pilot, all tutors for S382 & S383 are appointed through the OU's Manchester Regional Office, rather than on a geographic basis from each individual region and nation, as is the norm on most other courses. Each tutor's group of students is therefore not geographically co-located, but this does not matter, as tuition on S382 and S383 is wholly electronic in nature. There are no face-to-face elements in the tuition at all.

Both courses make extensive use of Moodle Forums, provided through the OU VLE, as well as Elluminate Live! web-based collaborative meeting software. Students are offered a number of small-group tutorials led by their own tutor using the interactivity offered by Elluminate to participate in discussions (both audio and written) and use a shared white-board. Without the limitations of geography imposed by traditional face-to-face tutorials, students can also join in with another tutor's tutorial if their own tutor's tutorial is at an inconvenient time (subject to agreement from the tutor concerned).

Students are also offered a number of course-wide seminars, which are more traditional lecture-like presentations, again delivered through the Elluminate interface. There is the capability to record Elluminate seminars so that students may watch the recording at a later time if they are unable to participate in the live event, or if they wish to revisit some of its content.

At the start of each course, 'Introduction Lectures' were also presented via Elluminate, by the Course Team Chair. The in-built polling options enabled rapid feedback from the remote live audience of 40-50 students in answer to questions posed by the presenter. This feature is likely to prove very useful as Tutors and Course Teams develop their experience with the software and how best to use it.

A final use of Elluminate is in the Project element of S382, where students may meet informally with the rest of their project group (and their tutor if necessary) in an Elluminate room in order to discuss their weekly activities on the project itself. Likewise, on either course, a tutor may make informal or ad hoc arrangements to meet one or more students in their own Elluminate room whenever necessary in order to provide extra tuition as and when required.

Finally, through the Student Support Team, each S382 & S383 student is assigned to a Pathway Tutor. These comprise eight individuals, four each drawn from the experienced Physical Science Associate Lecturer cohort and the central academic staff of the Physics and Astronomy Department. Pathway tutors take both proactive and reactive roles, ensuring that students are prepared for the course(s) they have embarked on, and that they are maintaining an appropriate pace through the learning materials of these courses. Much of the notification to Pathway Tutors about students' progression is provided automatically by newly developed systems. In addition, the SST will organise virtual, on-line events using forums and Elluminate in order to inform and guide students with regard to appropriate choice of subsequent courses, study paths and careers guidance.

Overall it is expected that these novel assessment and tuition strategies will improve student retention on, and progression between, courses, and that the SST in particular will lead to the development of a greater sense of community amongst OU Physical Science students.

Andrew Norton
Production CT Chair, S382 & S383 3rd March 2010

PAR – Physics Assessment Resource

Part I – Background and Current Status

Project aim

The Physics Assessment Resource [PAR] project was set up with the following aims in mind:

- To build a resource based on analysis of existing assessment materials in terms of learning outcomes covered, student scores achieved, and question re-use.
- Initially covering S207 (The Physical World) and S103 (Discovering Science), to build an extensible system that can easily be applied to other courses.
- To facilitate preparation of new assessment materials, ensuring balanced and effective coverage of Learning Outcomes.
- To encourage Outcome-led development of future assessment materials by providing an effective and simple tracking and monitoring resource.

Building on past work

Traditionally, the process of producing assignments has been based partly on question re-use, but the archive of existing materials is difficult to search and statistics on previous questions difficult to collate.

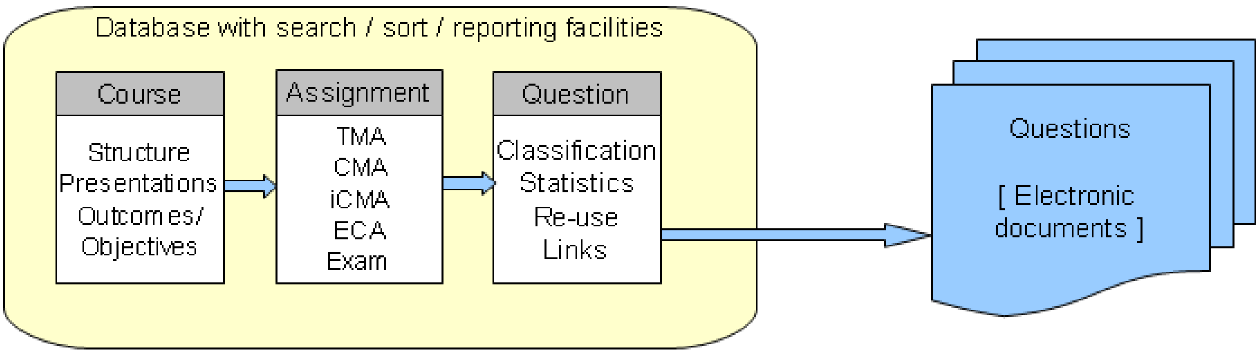
Using PAR, it will be easy for an assignment author to see how existing questions have worked in the past, and hence to design a well-balanced assignment using a combination of re-used and newly written questions.

Previous projects have looked at learning outcome coverage of assignments, but PAR has been designed to go much further, combining these with statistics on question performance and question re-use as well.

The end result is a searchable resource with direct links to electronic copies of individual assignments and questions.

Structure

PAR consists of a searchable database containing information about individual courses, assignments and questions, together with a bank of electronic documents containing the text of the assignment questions themselves:



The information contained in the database is presented through a user-friendly interface which makes it easy to search for individual questions according to different criteria – such as subject matter, learning objectives or outcomes, or on whether the question has been re-used.

Question re-use is a central concept in the PAR system. Questions that have been re-used in previous presentations are clearly identified and significant information on these questions can be entered into the system. Student scores and performance on previous uses of a question can be recorded, as can feedback (for example, from tutor forums).

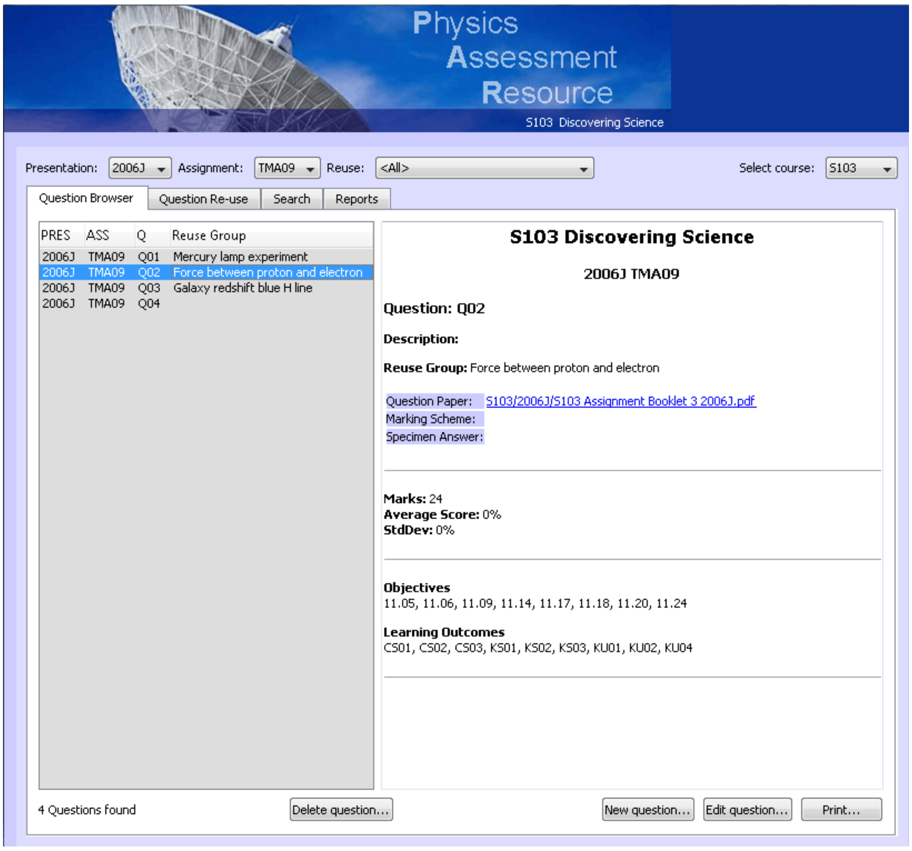
Question browser:

The question browser is the main means of presenting information from the PAR database.

The user can easily select questions from a particular presentation and assignment. The Reuse Group column highlights immediately whether a question has been used on a previous occasion.

The right-hand pane gives a detailed breakdown of information relating to this individual question, including (where available) student scores, objectives and outcomes, and links to associated documents.

The hyperlink labelled "Question Paper" opens the assignment book containing that question. More than one question can be opened at once and compared side-by-side.



Re-use tracking:

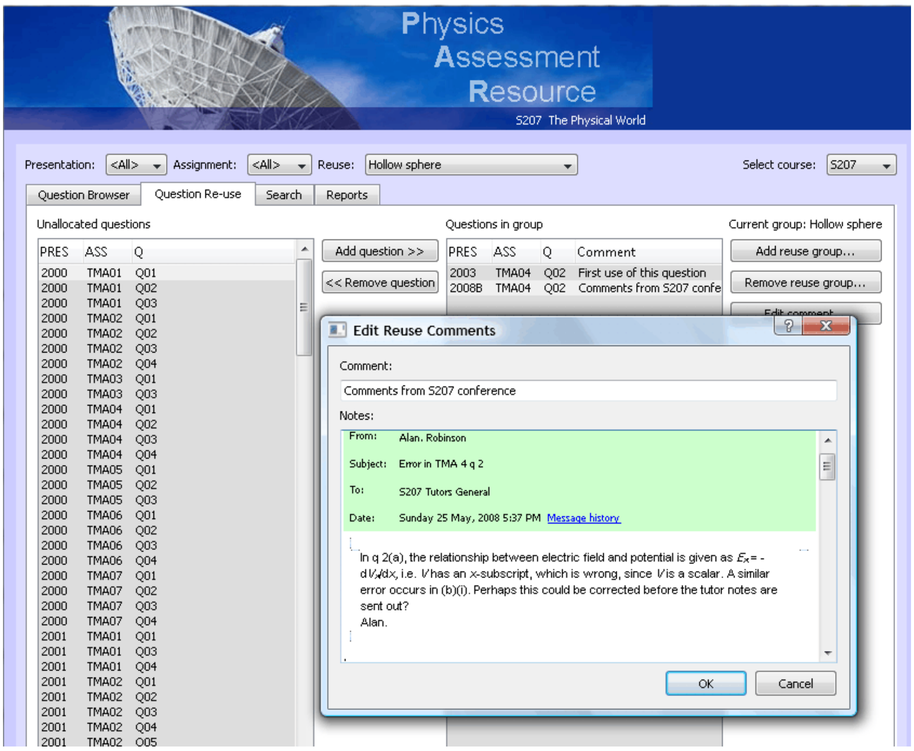
Example of tracking comments on question re-use.

Here, a comment from the S207 tutor group forum has been attached to a particular question that was first used in 2003.

It can be seen at a glance that this is the second occasion on which this question has been used, and that a problem has been raised on the tutor forum. The exact text of the problem report, together with the response of the course team, is available in the same format as originally posted.

This information would be immediately visible to anyone intending to use the question in future assignments.

Visible behind the Reuse Comments box is the Question Re-Use screen, which allows questions to be allocated to groups of related questions that have been re-used.



Contents

The PAR database now contains a total of 827 questions, broken down by course as follows:

Course	Questions
S103 Discovering Science	509
S207 The Physical World	260
SXR208 Observing the Universe	52
[Others]	6

In the case of S103 these cover tutor-marked assignments from the 1998 to 2007B presentations, and for S207 all presentations from 2000 to 2008B are currently included. Both courses are periodically updated as new assignments are produced.

Course structures (presentations, assignments etc.) for a number of other courses including S282 (Astronomy), S283 (Planetary science and hte search for life), S357 (Space, time and cosmology) and SMT359 (Electromagnetism) have been set up in the database, although questions for these courses have yet to be added. Because of the way that questions are indexed using hyperlinks to the original electronic documents, a wide variety of formats and question types can be accommodated – for example iCMA questions, CMAs, traditional written TMAs and so on. Question texts in HTML, OpenOffice, Microsoft, PDF or Latex can all be included in the system – all that is required is that the appropriate viewers are available on the computer where PAR is being used.

Setting up further courses is a simple process involving entering the course structure, presentations, assignments, learning outcomes and other course-specific details.

Part II – Existing Issues and ideas for further development

Following a brief pilot scheme earlier in 2009 we have obtained comments and feedback from the users of the system which are now being used to further develop the system and prepare it for wider deployment. During this pilot the system was used for an evaluation period by a course team and assignment authors.

The system is now ready for a final phase of development to address the feedback from this pilot, followed by deployment and ongoing use by the respective course teams.

At this stage there are a number of issues still under consideration, largely relating to data security and the resource required for maintaining the database.

- **Version control:** all documents (such as assignments, exam scripts, marking schemes etc.) should be available through links to the official original versions of the documents, ensuring that there are not multiple copies of the same document in circulation.
- **Document security:** The PAR system contains sensitive documents such as exam scripts and marking schemes, which clearly need to be held in a secure fashion. Access to the documents through the PAR system should be governed by the same rules and authorisations as access to them by any other means.
- **Easier updates:** as new documents are produced and released, these need to be made available to everyone using the system. All users should automatically have access to the same information and the same versions of documents at all times.
- **Ongoing maintenance:** To date, data entry has been carried out by the development team. Following deployment this will need to be done on an ongoing basis by individual course teams. Suitable training will be provided, but the course teams will need to provide the

necessary resource to add new assignments into the system and track feedback from sources such as tutor forums during subsequent presentations of each course.

- **Expansion to cover other courses:** Courses not currently represented in the database can easily be added. There is a one-off effort involved in setting up the course structure but once this is done for a given course, ongoing maintenance will consist of entering assignments and tracking feedback as for the existing courses.

The ideal solution to the security and version control points would be for the PAR system to be installed on the OU internal server. Links to local documents in the development system will be replaced by links to the original documents in secure locations on the internal server. The ability to view or modify the documents would then be controlled by the existing system of permissions as set up on the server. This however requires significant resource from the OU IT department. In the interim, an alternative solution involving distribution via password-protected CD is being investigated.

Part III – Conclusions

The Physics Assessment Resource represents a significant volume of knowledge: in a single system a large library of assignments and questions from several courses have been correlated and cross-references with results and scores, feedback from students, tutors and course teams on how well the questions have performed and suggestions for improvement if re-used.

This valuable resource is now at the stage where it is ready to be put into use for its intended purpose of assisting course teams and assignment authors in the process of producing assignments. With a little additional resource it could be deployed across the department and perhaps even for the use of course teams throughout the University.

Alan Cayless

Jean McCloughry

Marking on the Go – a trial in the use of PDAs for marking at residential schools

Chris Barrett, Anne-Marie Gallen and Ulrich Kolb.

Abstract/Summary

SXR208 "*Observing the Universe*" is a second level residential school course complementing second level astronomy and planetary science courses. The examinable component of the course relies on assessment of student performance in practical sessions, marked by the supervising tutors.

Feedback on their individual performance is given to students after each session. In order to make the marking and feedback more accurate and focused, we have investigated the use of handheld PDAs (personal digital assistant; a small handheld computing device) by the supervising tutors. Results of the trial and the eventual integration of the 'Marking on the Go' scheme using these devices are presented here.

Whilst analysis of student questionnaires reveals no significant evidence of an improved student perception of feedback when the PDA is in use, the development of additional features and growth in familiarity with the device have reaped rewards for the teaching and administrative staff at the residential school. Despite early signs that limited time available for the trial and certain external factors (technical problems, inexperienced tutors) may have affected early results, it is now clear that more detailed and explicit tutor guidance on the marking feedback has helped to unlock the full potential of the PDAs.

Furthermore, innovative applications of the PDA have opened up new ways of working at SXR208 whilst ensuring more accurate and reflective feedback for individual students.

1 Introduction: SXR208 and original marking practice

SXR208 is held at the Observatorio Astronomico de Mallorca (OAM) in Mallorca twice a year, and typically caters for 36 students in each week; a total of 180 students per year.

SXR208 operates a staff-intensive assessment system reliant on tutor and demonstrator observation of students throughout a project night. Core work includes 4 sessions on dedicated telescopes or microscopes and data processing computers, with assessment taking place in each of the sessions and with additional group assessment on the final night. Students, organised into groups of 5-6, are supervised by a tutor/demonstrator covering the night's observational activity.

Originally, student project-specific marks on key performance indicators (Learning Outcomes) were assigned to spreadsheets at the end of the night, after students had left the observatory. Tutors entered marks directly into Excel spreadsheets held on computers within the OAM. There was one workbook per tutor group and activity, with a sheet for each student.

On completion each night, the spreadsheets were transferred by a course administrator onto a central computer, and marks were collated for all students over the week of activities.

Students received verbal feedback on their performance at the end of the night just before leaving the observatory. A formal feedback session took place before tutors completed marking sheets. This resulted in tutors giving only a general impression of each group's performance at the various stages of the night's activities and did not allow for comparative feedback.

Giving feedback at the end of each session, and before assigning marks, was a major issue as it was felt that accuracy may be decreased and that students might not be assigned appropriate marks or even that marks might be incorrectly assigned to the wrong student. It was also felt that marking during the session would force tutors to consider the performance of students more carefully prior to the feedback session. Additionally, tutors would be able to use the marks collected to guide their comments to students during the feedback session.

PDAs were seen as a useful tool for achieving this, as a portable device for collecting and assigning marks whilst the student activity is observed. Total marks or averages could be calculated automatically for use by the tutors in giving targeted feedback. Completed spreadsheets would then be automatically transferred to the administration computer.

2 The PDA

The PDA is a small (11cm x 7cm x 0.5cm) handheld computer running a simplified Windows operating system, such as Windows Mobile (Figure 1). Many programs are available that have been designed for its operating system. PDAs are familiar devices used by a range of people and hence would be familiar to the majority of users.

PDAs have low power consumption, and so can be used for several days without recharging. They have a small (5.5cm x 7cm) touch screen and stylus for input and control, and have slots for Compact Flash and Secure Data memory cards.

Many also have Bluetooth and WiFi interfaces for connecting to a main computer.

Figure 1. *The opening screen of the PDA. The buttons below the screen can be used to launch programs.*

3 Proposed advantages of the PDA for “Marking on the Go”

It was planned that Tutors and Demonstrators should carry PDAs throughout sessions, and use them to assign marks throughout the night when performance relating to specific learning outcomes was demonstrated. The expectation was that this would improve the accuracy of practical skill marking on SXR208. Tutors could mark throughout sessions whilst observing behaviours and understanding on the part of the student rather than at the end based on their remembered impressions.

The marking sheets on the PDAs offer the tutors a set of marks on which to base their feedback, ensuring feedback comments which are consistent with their actual mark. Tutors also have the opportunity to use note-taking programs to make notes of key points to address in feedback sessions.

Further benefits include the use of additional programs such as “Pocket Stars” for teaching specific observing skills.

Timed prompts can be set for marking, and alarms can be set for ends of sessions.

Administrative advantages

Rapid and secure transfer onto the administration computer is desired, and this can be achieved by the use of the PDA recharging cradle, and software such as Microsoft ActiveSync. On placing the PDA in its cradle, ActiveSync backs up all data on the PDA. Completed spreadsheets are held in a folder on the PDA, and copied to the administration computer. ActiveSync takes about 1-2 min per PDA to backup data, and so data from the six PDAs used each night can be rapidly downloaded. In addition, it is possible to upload simultaneously the next evening's marking sheets.

4 Use of PDA at SXR208

For this project, 10 Dell Axim X51 520 MHz PDAs were purchased, along with 10 1Gb Secure Data memory cards, spare batteries and leather flip cases, and synchronisation/charging cradles. In addition, an Ezurio "Go Blue" USB Bluetooth adaptor was purchased. The latter was installed on the administration computer, to provide wireless communication for the ActiveSync backup programme as an alternative to the wired connection provided by the synchronisation cradle.

The marking spreadsheets are held on PDAs carried by tutors throughout each evening's activities. Tutors enter marks into the spreadsheet against specific criteria as the practical work is observed.

A tutor takes the PDA into the feedback session with the student group. A summary sheet of marks is called up on the PDA, although actually marks are not given to students. Notes taken by the tutor can also be referred to during feedback.

At the end of the working night, each PDA is docked with the charger cradle, which is connected to the Admin computer. Microsoft ActiveSync software is configured to synchronise data on the PDA with that of the computer, which transfers the Excel spreadsheet into a directory on the computer. In addition, ActiveSync creates a backup image of each PDA in case of failure.

Admin staff can then retrieve data from the spreadsheets placed onto the Admin computer by this process, and collate the evening's marks for each student with those from previous evenings.

Sufficient PDAs where purchased for each tutor to be issued with one, and for spares to be available in case of faults. Student groups are named (**Sun, Moon, Mercury, Venus, Mars, Jupiter, Saturn**). Each PDA is labelled with the name of a group, and the tutor covering that night's activity uses the named group PDA. The background image on the PDA screen prominently displayed the OU logo and group name to make it readily identifiable. Further, the name of the group is marked prominently on the outer cover of the PDA. In addition, PDAs were password protected, with a short timeout. Thus, the tutor can access student detail, but if the PDA is inadvertently left around, data would not be accessible to students.

Before the trial began, the ruggedness of the PDAs was felt to be an issue. OAM has many hard surfaces, including the concrete pads on which telescope domes are built. Dropping a PDA onto these surfaces could cause irreparable damage to it. PDAs were therefore fitted with leather cases, and lanyards to give some protection and prevent accidental dropping. More rugged protective cases are available, and one was purchased for assessment, but was thought to make the PDA too bulky, and difficult to operate.

5 Views of PDA, Including "Pocket Stars"

Figure 1 (above) shows the opening screen of the PDA. An image was setup on each PDA, which identified it as OU property, and identified the group for which it would be used. Tapping the start menu with the stylus causes the menu to drop down and show a list of programs including the mobile Excel programme, Plan Maker (see section 6 and below) and Pocket Stars. Also displayed are the date and local time as well as remaining battery charge. The clock can be set to provide alarms for specific events during the evening.

Because of the relatively small size of the screen on the PDA, it was decided to make data entry as straightforward as possible. To that end, proprietary software for use with PDAs, and called ‘Plan Maker’ was used. Figure 2 (below) shows an example from Plan Maker. This software uses Excel spreadsheets but allows data entry methods similar to those available on PC versions of Excel as compared to the limited functionality of the Excel version supplied with the PDA. The shot shows a spreadsheet designed in Excel and transferred to the PDA. Cells are shown containing text for each marking criterion, alongside the score. The score cells were programmed to give a drop down list of values. Selection of the required value is made with the stylus, and confirmed by tapping elsewhere on the screen. On the right hand side is a slide control, which allows scrolling down the list of marking criteria. Labelled worksheets are set up for each student, which contains the set of marks. The student name and reminder of the marking categories are shown at the top, and these cells are frozen so they remain visible when scrolling down the spreadsheet. Finally, the tab for each sheet is programmed with the student’s name, to ease movement between worksheets. Only the marks cells can be changed, the other cells being locked.

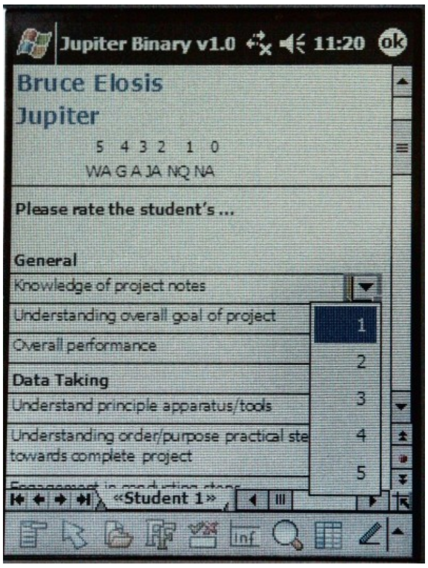


Figure 2. *The data entry screen of Plan Maker, showing the selection of the score for the student’s knowledge of project notes.*

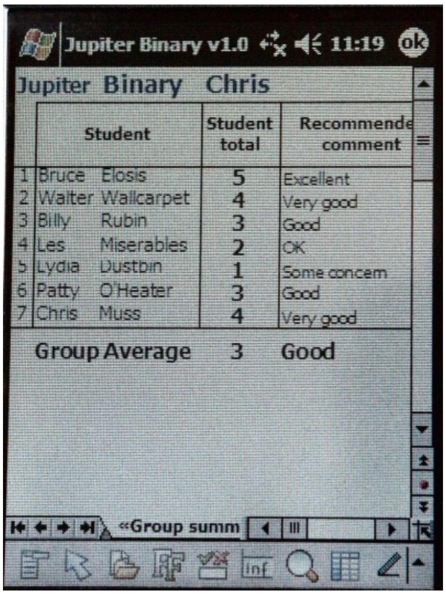


Figure 3. *The summary screen for all students shown in Plan Maker.*

Figure 3 shows the group summary page for the marking spreadsheet. This is a summary worksheet setup within Excel which provides data for each student worksheet. The student totals are calculated using a simple learning outcome based formula rather than the more complex final mark determined by the administration spreadsheet, and are intended to give the tutor an indication of performance for the feedback session. The recommended comments are automatically derived from these scores, and again are a guide for the tutor. The scores and comments are not themselves disclosed to the students. Along the bottom of the screen are icons for program functions such as zooming, file operations, formatting etc.

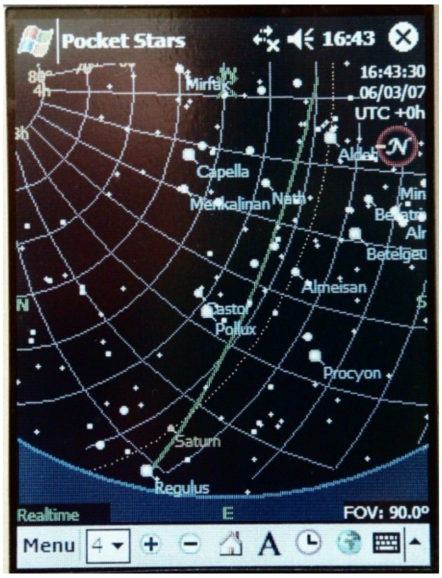


Figure 4. *A screen view of Pocket Stars, showing an eastward view of the sky at OAM.*

Figure 4 shows a screen shot from Pocket Stars, a useful tool for teaching star finding. The program displays the night sky for any world location and is normally set to the OAM location. The display updates in real time from the PDA clock. The viewing direction can be changed, areas of the sky zoomed in, and the range of star magnitudes displayed can be set. The display can be set to be red filtered to preserve the user's night vision. As well as a real time display, the software can show time lapse views to demonstrate motion of objects in the sky, mimicking the Planetarium orientation program.

6 "Plan maker"

Windows Mobile V5 operating system includes "Pocket Excel" as standard.

However, Pocket Excel does not have the full functionality of PC based Excel; specifically it limits the entry of the numerical scale used for marking. Table 1 shows the scores available.

Well Achieved (5)	Use this if the student shows signs of excellence
Good (4)	Use this if the performance is above average with some noticeable strengths
Achieved (3)	**Use this as the default mark – this is the average student**
Just Achieved (2)	Use this if the performance deserves a pass but shows noticeable weaknesses
Not Quite Achieved (1)	Use this only if you think the student just misses a pass and shows significant weaknesses
Not achieved (0)	Use this if the student does not actively take part or if they are absent

Table 1 *Marking scores and notes for tutors*

Drop down choice lists for the numbers 1-5 were the preferred option in order to make data entry as easy, accurate and quick as possible on the relatively small screens of the PDAs.

“Plan maker” by Softmaker Software GmbH offers an Excel compatible package, which includes many of the facilities available on PC versions of Excel. It uses Excel format files, which can therefore be loaded directly into Excel on Administration PCs. Figure 2 above shows the spreadsheet, displayed on the PDA for entry of student marks. A major problem is the small screen size and hence the length of the criteria entries displayed next to the marking cell. Whilst some effort went into designing the marking spreadsheet, including text and cell sizes, colours, and fonts, there was ultimately a compromise as to what could be displayed on the PDA screen. Thus, it was not possible to display simultaneously all the criteria and marks for a student. The tutor needed to scroll between sections of the marking sheet in order to complete it. This is something that could be addressed in the future as touch screen technology develops.

7 Student experience of “Marking on the Go”

One guiding principle for the introduction of PDA based marking was that it should provide better feedback to the student, but also that the students should not feel a greater level of scrutiny taking place during the activity itself. Thus, it was intended that the students should largely be unaware of marking. Clearly the operation of a piece of computer equipment within view of the student should be kept to a minimum and be relatively discreet. In order to check these aspects a questionnaire was issued to the students at the end of the final session in each of the two trial weeks in 2007. The questions asked are listed in Appendix A.

Overall, the result of this analysis was inconclusive, but suggested that students were generally unaware of the way in which they were assessed; worrying more about *when* they were assessed. We conclude that there is generally little change in student’s experience of marking because of using PDAs. There is however the factor of the tutors experience of using PDAs for marking and feedback to consider (see below). It appears that overall many tutors did not use the marks in forming feedback for the students, and so the benefit of having such marks available during feedback would not affect the student’s reports. This suggested early on that more training of tutors in the use of the PDAs for marking and feedback is needed to gain the full benefit for students.

8 Tutor experience of “Marking on the Go”

In the first trail in 2007, which ran for two weeks, the 11 tutors involved returned questionnaires. From these, only two had previously used PDAs. In this batch, tutors found the overall size of the PDA to be acceptable, but were concerned about the likelihood of dropping or losing it. They found the screen size to be small but clear and easy to read. However, they also found the screen size made reading the marking criteria, and data entry, difficult.

Overall, the second week reported that they found the PDA harder to use than the first week tutors did, but they did not have the support of the experiment instigator to help them with functionality problems.

Support during the week was by printed sheets giving notes on using the PDA, a tutorial, and support from staff familiar with the PDA. The tutors found the tutorial more useful than the handout. They seemed generally satisfied with the support given.

Some tutors found Pocket Stars useful, whereas many others found the program less useful. This may be a result of the different level of support given on this package in the two weeks. The tutors found Plan Maker software easier to learn to use than pocket Excel.

Generally, tutors in both weeks found marking using the PDA to be acceptable. However, at this stage, tutors in both weeks reported that marking on the PDA was harder than the normal method of completing an Excel spreadsheet on a desk computer. Both groups found entering and reviewing data to be hard, but had few problems with confidentiality and marking in the presence of students caused no problems.

Several tutors did appear to have used the summary data and marks to guide their feedback sessions, whereas many other tutors did not appear to have used the data. No tutors really felt they give better feedback as a result of using the PDA, nor did they feel there is a benefit to the students. But there may well be a benefit to tutors.

The results of the 2007 survey were inconclusive. However, the benefits to the administrators at the school were enough to merit the continued use of the PDAs. This also allowed time for regular tutors to get use to using the PDAs before a further survey could be arranged

In 2009, a second survey of 10 tutors and demonstrators was carried out. Once again, the results were mixed but there was definitely a much stronger feeling that the PDAs were of value both to the tutors and the administrators. One development that was commented on by several tutors was the introduction of a photo bank to each of the PDAs.

Photos were recorded during the student's registration session. These were then downloaded to the computer, the file name saved as First Lastname.jpg and then they were loaded onto the PDAs by group. During marking sessions, photos of the students could be called up to ensure that tutors had the correct individual when marking contributions.

9 Discussion of 2007 trial

The initial PDA trial in 2007 was affected by various external factors that may have influenced the overall student and tutor perception of the tool. Five of the 11 tutors involved attended SXR208 for the first time, and had little prior tutoring and marking experience. (They were recruited from the OU's astronomy and planetary science PhD students - who take on the SXR208 role as part of their training – and postdoctoral researchers). It is clear that these first-time tutors experience a steep learning curve, so initially they tend to be more concerned with mastering the hardware and software aspects of the projects than with optimising formal feedback to the students. Ideally, SXR208 takes on only 1 new tutor/demonstrator per week allowing for mentoring support, but staffing constraints do not always allow this.

In 2007, the week 1 trial was certainly dominated by the technical challenge to set up the PDA system on site. As a result, the PDA marking was rolled out to all tutors only at the last project session.

The week 2 trial used PDAs from the start, but experienced some technical problems which either had gone unnoticed in week 1 because the PDA system was not used as often, or perhaps did not develop into full-blown problems because the week 1 supervisor (see author Chris Barrett) had first hand experience from installing the PDA system and hence a greater expertise with PDAs than the week 2 supervisor (see author Ulrich Kolb). The administrator, who would be primarily responsible for setting up and maintaining the PDAs, had less involvement in this initial trial.

In this first trial, one of the problems occurred with the automated data transfer between the Admin PC and the PDAs. This was eventually abandoned in favour of a simple manual transfer, which was perceived as more straightforward and in fact quicker as soon as the required procedure became clear and streamlined. The downside is that human error could, in the worst case, lead to the loss of previously registered marks. On one occasion, all of the marks in a completed spreadsheet were lost when the tutor closed the application without saving any changes. This can be easily avoided if the PDA is set up such that closing the application does not in fact terminate the spreadsheet program, but on this particular PDA, the corresponding set-up was different. The problem here seems to be that the PDAs are very versatile tools, and tutors are easily prepared to experiment with them, risking changing default settings.

This highlights the need for a regular check of basic PDA set-up features throughout each school week. It is possible to maintain a backup file for the PDAs so that any PDA can be relatively easily reset to its original configuration. This approach has subsequently been adopted although it has proved unnecessary to date.

In week 2, 2007, much effort went into adapting existing spreadsheet macros that compile multiple marks from the student cohort and convert them into the overall examination score. This meant that less time was available for routine checks of the setup of individual PDAs.

The analysis of the questionnaires and anecdotal evidence shows that the potential and benefit of the PDA marking system had, at the end of the 2007 trial, not yet been fully exploited. We believe that this was mainly because the training of tutors in the use of PDAs, and the actions of the project supervisors, were focussed on resolving teething technical problems. We expected that once the PDA system was fully established, the anticipated benefit for a more objective marking experience could be achieved. Based on the trial results at the end of 2007, we proposed to test this by adopting the PDA system as the default system in future presentations.

10 Discussion of 2007 trial

Two years after the PDAs were introduced to SXR208, and after 8 weeks of presentation, a subsequent review was carried out in September 2009. This time 10 tutors and demonstrators were asked to respond to a questionnaire similar to that was used in the original trial. However, they were also asked to provide further feedback on the use of the PDA. In addition, several Course Director's Assistants (CDAs), the administrators responsible for setting up and maintaining the PDAs and assessment at SXR208, were asked to share their opinions on the system.

It was clear from the feedback received that the role of the PDA as an assessment tool, had been fully integrated into the residential school, with most tutors happy that the PDA was not too small, was portable and robust, and allowed them to maintain confidentiality when marking.

The programs used for marking were well received, easy to use and few tutors showed any anxiety at the use of the PDAs. No tutor thought that the PDAs detracted from teaching times although most agreed that marking in front of students was difficult.

Most of the tutors in this second review indicated that they believed that the PDAs provided benefit to them as markers and, most of the cohort, that they benefit the students through more accurate marking and feedback.

However, it was the introduction of the group based photo databank that yield the most positive qualitative feedback, with many tutors adding comments to the feedback form as detailed after appendix B.

11 Recommendations for future use of PDAs on SXR208

The trial of PDAs in the spring 2007 presentation of the course was limited to two weeks. However, the mixed results of those two weeks gave enough evidence to warrant the continued trialling of the PDAs. Administratively, preparing the spreadsheets and handing them out to the tutors at the start of the evening is less challenging for the CDA and reduces the chance of deleting a marked sheet by accident when transferring data at the end of the night.

A further survey of tutors was carried out in September 2009, using a modified questionnaire, with a few questions, relating to non-scoring based functions of the PDA, removed. The ambiguity evident in the students' responses in 2007, suggested that they were generally unaware of how grading was carried out; their anxieties relating mainly to the fact it is carried out! It was therefore decided that no further student data would be collected.

In the 2007 trial, downloading completed spreadsheets to the administration computer was performed differently in weeks 1 and 2, and data was not linked to the existing spreadsheets. By 2009, the synchronisation procedure had been reviewed, and a redesign of the spreadsheets carried out. Over the period 2007-2009 spreadsheet bugs and problems were ironed out and the data transfer procedures improved. Hence, the trial in 2009 was carried out with a more controlled approach, and the procedures transcribed for all CDAs. The use of the PDAs in the period up to, and including, 2009 has become an integral part of SXR208 with most CDAs and tutors happy to use these devices rather than the computer based system in use before 2007.

12 Generalisation to other practical courses

SXR208 has a relatively small number of students (roughly 30 per week over 5 week annual cycle), and very specific projects with close working between staff and students. Other residential courses may well find PDAs useful for marking, but there are likely to be aspects of marking specific to each course. However, experience of schools like SXR103 *Practising science,* with student numbers close to 140 students per week, suggests that this sort of device could be ideal for recording satisfactory participation in a variety of lab and filed based activities. Conversations with third level course staff, also suggest that this type of ‘marking on the go’ could be used well.

A case by case examination of the applicability of PDA marking to each course will be necessary if PDAs, or similar devices like the iPod Touch©, may be useful for courses with a large student to tutor ratio where nonetheless the tutor is asked to mark, through observation, the individual performance in a large student cohort. The experience of working with PDAs at SXR208 has been a positive one in general and does suggest that handheld devices can make the recording and administration of residential field or lab based courses simpler, more effective, and more accurate.

Appendix A. Student Questionnaire

Week 1: 7 groups. 26 out of 29 students returned questionnaires.

Question	No. students rating >3	No. students rating <3
Were you aware of marking taking place during the project work? (5 - Very aware, 1 - Not aware)		
Beginning of week	7	15
end of week	15	7
How useful was the feedback for each evening? (5- Very useful, 1 - Not useful)		
Monday	20	3
Tuesday	20	1
Wednesday	18	5
Thursday	20	6
How useful was the feedback for these aspects? (5- Very useful, 1 - Not useful)		
Beginning of week?		
Key skills	15	5
Group performance	17	3
Individual performance	6	11
Experimental results	19	3
End of week?		
Key skills	18	4
Group performance	22	2
Individual performance	11	8
Experimental results	22	2
Difference		
Key skills	+12%	-4%
Group performance	+19%	-4%
Individual performance	+19%	-12%
Experimental results	+12%	-4%

2nd Week, 21 students in 5 groups.

Question	**No. students rating >3**	**No. students rating <3**
Where you aware of marking taking place during the project work? (5 - Very aware, 1 - Not aware)		
Beginning of week	8	9
end of week	14	2
How useful was the feedback for each evening? (5- Very useful, 1 - Not useful)		
Monday	17	0
Tuesday	18	0
Wednesday	15	0
Thursday	16	2
How useful was the feedback for these aspects? (5- Very useful, 1 - Not useful)		
Beginning of week?		
Key skills	11	3
Group performance	10	6
Individual performance	5	11
Experimental results	15	1
End of week?		
Key skills	13	4
Group performance	15	2
Individual performance	4	10
Experimental results	20	1
Difference		
Key skills	+10%	+5%
Group performance	+24%	+2%
Individual performance	-5%	+10%
Experimental results	+20%	0%

Appendix B Tutor Questionnaire

First survey, 2007. Two tutors out of eleven polled had previously used a PDA.

Physical properties **(5 – agree, 1 - disagree)**	**No. tutors rating >3**	**No. tutors rating <3**
The PDA was too small	3	5
The size was OK	6	4
The PDA was easy to carry	7	2
The PDA was easy to drop	4	3
The PDA was easy to lose	1	4
The lanyard was useful	3	6
The case was useful	7	3
The screen was large enough	2	7
The screen was clear	5	4
The stylus was easy to use	7	0

Learning to Use **(5 – agree, 1 - disagree)**	**No. tutors rating >3**	**No. tutors rating <3**
The on-site tutorial was sufficient	4	2
The tutorial hand-out was sufficient	4	4
There was enough time to become familiar with the PDA	6	4
The on-site support was sufficient	10	1

Software **(5 – agree, 1 - disagree)**	**No. tutors rating >3**	**No. tutors rating <3**
It was easy to find the required program	7	2
Pocket Stars was useful	2	5
Pocket Stars was easy to use	4	3
Pocket Stars was easy to learn	5	3
Plan maker was easy to use	6	4
Plan maker was easy to learn	5	5
PDA Light was useful[1]	1	6
SlovoEd Spanish translator was useful[2]	2	5

Marking **(5 – agree, 1 - disagree)**	**No. tutors rating >3**	**No. tutors rating <3**
Finding the Excel spreadsheet was easy	9	1
Finding the student mark sheet was easy	8	2
Viewing the marking criteria was easy	3	6
Entering marks was easy	5	3
Reviewing the data entered was easy	5	5
Correcting data was easy	7	3
Reviewing the group scores was easy	4	6
Comments section was useful	3	5
Marking in presence of students was easy	3	4
Maintaining confidentiality was easy	7	1
Marking was easier than paper forms	3	4
Marks were given during observation of group	6	3
Timed prompts were useful	1	6
I did not like being prompted	2	3
Summary info was useful in feedback sessions	2	4
I was more focused on the PDA operation than on students	2	9
I will find use of PDA easier with practice	8	2
I gave better feedback as a result of using the PDA	1	5
My marking was more accurate using the PDA	2	3
The PDA does not provide a benefit to the students	5	3
The PDA does not provide a benefit to the tutors	2	4

Second survey, 2009. Five tutors out of ten polled had previously used a PDA.

Physical properties **(5 – agree, 1 - disagree)**	**No. tutors rating >3** **Agree**	**No. tutors rating <3** **Disagree**
The PDA was too small	0	9
The size was OK	9	1
The PDA was easy to carry	9	0
The PDA was easy to drop	1	7
The PDA was easy to lose	1	6
The lanyard was useful	1	5
The case was useful	7	1
The screen was large enough	7	1
The screen was clear	9	0
The stylus was easy to use	6	3

Learning to Use **(5 – agree, 1 - disagree)**	**No. tutors rating >3**	**No. tutors rating <3**
The on-site tutorial was sufficient	8	0
The tutorial hand-out was sufficient	7	0
There was enough time to become familiar with the PDA	9	1
The on-site support was sufficient	9	0

Software **(5 – agree, 1 - disagree)**	**No. tutors rating >3**	**No. tutors rating <3**
It was easy to find the required program	8	0
Pocket Stars was useful	3	2
Pocket Stars was easy to use	3	1
Pocket Stars was easy to learn	3	0
Plan maker was easy to use	5	1
Plan maker was easy to learn	5	0

Marking **(5 – agree, 1 - disagree)**	**No. tutors rating >3**	**No. tutors rating <3**
Finding the Excel spreadsheet was easy	8	0
Finding the student mark sheet was easy	9	0
Viewing the marking criteria was easy	7	0
Entering marks was easy	9	1
Reviewing the data entered was easy	9	1
Correcting data was easy	10	0
Reviewing the group scores was easy	7	1
Comments section was useful	2	3
Marking in presence of students was easy	4	3
Maintaining confidentiality was easy	7	0
Marking was easier than paper forms	7	0
Marks were given during observation of group	4	3
Summary info was useful in feedback sessions	3	3
I was more focused on the PDA operation than on students	0	10
I will find use of PDA easier with practice	4	1
I gave better feedback as a result of using the PDA	2	2
My marking was more accurate using the PDA	5	4
The PDA does not provide a benefit to the students	1	4
The PDA does not provide a benefit to the tutors	0	5

Written comments:

"With a larger PDA screen it might be possible to see more of the student's score profile in one go".

On the photos:

"…yes essential I would say…"
"I found that having a picture of each of the students on the PDA was extremely useful to speed up the marking process".
The photos of the students were useful, especially at the beginning of the week.
"The photos of the students, provided on the PDA, were very helpful".

1 (question removed in second survey)
2 (question removed in second survey)