Electronic marking (e-marking) of student work is now well established within UK education, especially for GCSE and A-level assessment, and in parts of The Open University (OU), the UK’s leading distance-learning university. However, e-marking presents particular challenges for practitioners in symbolically rich curriculum areas (of which mathematics and statistics are prime examples). This is especially true when the marker provides extensive feedback, as with the OU’s correspondence tuition open-learning methodology, with its emphasis on individualized, tailored feedback. Despite great advances in mathematical typesetting over the past 40 years, the input of mathematical equations for most users is slow and laborious compared to text.

As part of continuous assessment, the OU Mathematics and Statistics Department handles 45,000 tutor-marked assignments (TMAs) annually. Most of these assignments are still sent by post, from student to tutor to university (where a proportion is selected for ‘monitoring’, the OU quality assurance mechanism) and then back to the student. The method is well tried, but slow and expensive. For some years the OU has embraced electronic submission (e-submission) in other curriculum areas, enabling students to upload their TMAs to a central server, from which markers download the assignments and then upload the marked TMAs (with the marks recorded in separate files). The University’s electronic tutor-marked assignment (eTMA) system successfully handles many thousands of TMAs annually.

There have been several experiments in electronic marking with digital ink technology at the OU [1,2] and elsewhere [3,4] including a trial of electronic marking in mathematics, covering a wide range of OU mathematics and statistics courses from Level 1 up to Level 8 [5]. Building on this previous work, it was decided to pilot e-marking in the Mathematics MSc programme. The MSc programme was chosen because of its size (only 2,200 TMAs per annum) and the mathematical sophistication of the students taking the courses. The pilot took place from February to September 2009 covering a single presentation of the Mathematics MSc courses.

The OU mathematics e-preparation and e-marking system

The guiding principle of the OU’s mathematics eTMA system is that electronic preparation (e-preparation) of mathematics assignments should not be a necessary precursor to e-submission and e-marking. For a whole raft of pedagogical and practical reasons it has been felt that students should not be unduly encouraged, let alone required, to prepare their assignments using a mathematical typesetting system. In particular we wish to encourage students to concentrate on the content rather than appearance of their assignments. Some students (especially at the MSc level) choose to typeset their assignments, but the mathematics eTMA system allows students to...
submit their work in a variety of formats, such as MS Word 2003/2007, Open Office or LaTeX-generated pdf, as well as scanned (or photographed) digital images of handwritten work.

On the other hand, the formats required for e-marking are much more restricted, since individual tutors will not be experts in each of the possibilities permitted to students by e-submission. In essence, the mathematics eTMA system is a pre-processor that converts a student’s e-submission to two formats: pdf and docx (MS Word 2007 format). Where necessary, to ensure that the submission conforms to the University’s eTMA file-size limits, the student’s scanned work is degraded to reduce its resolution and colour variety. The resulting files are then passed to the University’s standard eTMA system for transmission to tutors in the normal way. Further details on the mathematics eTMA pre-processor are contained in [6] and [7].

Organisation and tutor choices

In 2009 there were 32 tutors on the MSc programme covering 9 courses and each was individually contacted prior to the pilot. Although several tutors had reservations they all agreed to participate in the pilot. A well-attended staff development day was dedicated to the pilot (with tutors being able to try out the equipment available) and further online synchronous training was given. Each tutor was given the option of using a 12” Toshiba tablet PC or a 15” Wacom LCD tablet, both costing (at the time of purchase) just under £1K apiece. The equipment was prepared and dispatched by the University. All but two tutors opted for the laptop, despite its smaller screen size.

Since electronic marking increases the time tutors spend at the tablet screen significantly, there are health and safety concerns that need to be addressed. Advice is provided on appropriate setting up of work areas, taking short breaks and so on. The use of tablet PCs is an added issue, as they can cause other problems. Putting a cushion under the writing arm to give it support or angling the tablet so that it is comfortable are useful tips, but beware the bottom of the tablets can get very hot! Sitting on the sofa hunched over the tablet is not a good idea!

The tutors were provided with both PDF Annotator and MS Word 2007. Both Annotator and Word allow for easy annotation using a tablet PC or other digital pen input device. Word 2007 has the advantage of high quality mathematical word-processing capability, whilst Annotator is particularly versatile for annotating pdfs of work that originated as handwritten or as LaTeX-produced documents. The tutors were given a free choice of software package to use. As reported in an end-of-pilot survey, PDF Annotator proved to be by far the most popular amongst the tutors: 19 mainly used Annotator, 1 mainly used Word and 1 used both.

Documentation (for both student and tutor) was prepared and distributed, a non-trivial task. A buddy system was developed where four tutors were each paid a small fee to mentor a small group of tutors. In addition tutors were encouraged to attend regional staff development events covering the University eTMA system. There was a considerable amount of support offered to the tutors taking part in the pilot.

Three tutors’ views

Throughout the pilot, and at the end, tutors were asked for feedback on their experiences with e-marking. Three issues were of particular interest: (i) how well the tutors adapted to the technology required for e-marking; (ii) whether e-marking required (significantly) more or less time than paper marking; and (iii) whether tutors’ marking style had been affected by e-marking.

(i) Adaptation to the technology

The tutors adapted well to e-marking mathematics with a tablet PC. Most of the complaints were directed against the University’s eTMA file-handling system rather than against the e-marking technology itself. As one tutor put it: “I have enjoyed the new way of working with TMAs and do hope that more students make use of it.” Another commented: “It is remarkable to be able to see the marked assignment instantly when someone telephones to ask for clarification.”

One person found it hard to use a digital pen, but conceded that

“it has the potential to be a quicker way to work: I have marked in a ‘mostly typing’ way as when I tried using the pen to handwrite comments it felt quite awkward and I was not happy with the quality of the handwriting that appeared. I found it difficult to avoid placing the edge of my hand on the screen which usually resulted in stray marks of ink…”

Another praised the facility

“to delete previous entries, particularly using the eraser at the top of the [digital] pen”.


Some people attached a keyboard, a mouse and even a monitor to the tablet PC when in tablet mode, turning their tablet PC into a desktop machine.

PDF Annotator was liked for the ease of incorporating handwriting and typed text, for its 'append a page' option, for the in-built document 'stamps' that provide ticks and crosses, and for the textboxes. One tutor commented: "I think the tablet with annotator is great, a real improvement for marking pdfs. I am still happy with marking Word docs in Word."

However, one tutor found e-marking unsatisfactory, noting that "If one page of A4 is displayed on the screen it requires a magnifying glass to read it. At visible size it is only possible to see about a sixth of a page of A4." This had a serious negative effect on marking: "When longer comments are required on a script it is mostly necessary to see the student's work and the page upon which I am inserting comments. The screen is far too small to see both at once and jumping backwards and forwards between the script and the extra sheet at the bottom of the script is not practical." He concluded: "I do not think that marking eTMA scripts containing a lot of mathematical material is very easy."

Those tutors who used the mathematical capabilities of Word 2007 found it "certainly a big improvement over the equation editor found in previous versions". However, praise was qualified by the time overhead: "The excellent addition to Word to allow mathematical text to be inserted is very good and (reasonably) easy to use but it is very costly in time. So using this facility is not a real choice for comments that are not reusable (which is almost all comments). It did also 'crash' on several occasions."

(ii) Marking time

Open University tutors are paid a (modest) salary rather than by the hour, so it was important that e-marking should not greatly increase marking times. Anecdotally, it has been the general experience in non-symbolically rich curriculum areas that the introduction of e-marking (largely using MS Word for submission and marking) has, at least initially, resulted in an increase in marking times, with a possible reduction in feedback provided by tutors to students.

It was therefore interesting to note that in a (public) feedback session 9 out 19 tutors reported that e-marking was either quicker or took about the same time, while 6 reported that e-marking took 'a bit longer' and only 4 out 19 responded 'a lot longer'.

There are several factors which might be associated with this encouraging result. First, handwritten e-marking using PDF Annotator may require practice in the effective use of a digital pen, but thereafter it is on a par with paper marking, with the added bonus of easier editing, copying and erasing of erroneous comments by tutors. Second, with many courses providing model answers in electronic form, it becomes straightforward to copy snapshots of model answers direct into student work, thereby providing considerable time savings for tutors, albeit at the price of the loss of individually tailored feedback.

One tutor commented:

"... My overhead (compared to paper marking) is somewhere between 10 and 25% per script and I think it will ultimately settle on 10%. A second screen is one thing that would be extremely useful..."

Another thought that their speed would improve once "more and more students submit eTMAs" in place of paper assignments.

(iii) Marking style

Given the importance of good feedback, especially for a distance-learning university such as the OU, we were particularly interested to ask the markers whether they felt e-marking had affected the quality of their comments on the students' work. Whilst this is necessarily a subjective view (and one naturally biased on account of professional pride), the tutors' responses are noteworthy.

Overall, 9 out 19 tutors felt that their marking practice had been unaffected by e-marking. Comments included:

"I write just as much on the script, I enjoy the colours available."

"Hard to say, I have only marked three eTMAs so far and I think the style of my marking on the eTMAs follows the style I've used for the paper TMAs fairly closely. But yes, attaching pre-prepared items is very useful. I sometimes also do this for the paper TMAs as well."

One of the features of e-marking which potentially saves time is the ability to re-use comments. This "satisfyingly efficient" way to work was liked by the tutors, but one noted that care had to be taken "not to depersonalise the comments 'in fact' as well as in appearance". Another commented: "Being able to insert previously annotated 'official' solutions is useful."

An appendix at the end of this article shows a sample of marking using PDF Annotator. In this example both the
original and the marking are handwritten. The authors wish to thank Prof. Uwe Grimm for allowing us to use this sample.

**Students’ views**

For almost all of the students, the pilot was their first experience of e-submission and e-marking, and only approximately 20% of students used the e-submission route for their TMAs. This low figure was disappointing but not unexpected for a first exposure. Of course, many students will not wish to submit their work electronically and there is no obligation for them to do so. Nevertheless, it is hoped that in future years a greater proportion of the students will choose to use e-submission. One cause of the low submission rate is an apparent confusion in students’ minds that e-submission requires electronic preparation, using a typesetting or word-processing program. The information sent to the next cohort of students will hopefully dispel this misunderstanding.

For those students who did engage with e-submission, the response has been positive. Two students commented:

“No ifs. No buts. Just excellent! No need to get a ‘proof of dispatch’ note - immediate feedback. Very very impressed.”

“Absolutely, no waiting at the Post Office queue during Lunch time! and being able to send in work at 11:30pm: priceless!!”

Another noted: “I have heard and accept that some tutors prefer handwritten, snail mail etc etc, but for me, and given my work circumstances, eTMA is a godsend … and on many occasions allowing me extra time to finish TMAs.”

In fact a large number of the students who used e-submission also prepare their work electronically. An analysis of the student e-submissions shows that over 90% of students’ submissions were prepared electronically, and, in fact, about 42% of all submissions were produced in (La)TeX, with MS Word counting for 23%. At most 10% used scanned pages of handwriting to submit their TMAs, although we would expect this proportion to increase once a larger percentage of the cohort opt for the e-submission route.

One student who used e-submission but chose to scan their work commented: “I still use pen and paper for writing the TMA, however, praise e-TMA as I scan and send my TMAs using it. I find it better to continue pen and paper approach till the pattern of exams change.”

**Quality assurance and administration**

One of the big advantages of electronic marking is that quality assurance processes and administration processes are also electronic. Assignments do not get ‘lost in the post’ and if a tutor is unable to mark a particular assignment for some reason transferral to another tutor can be quickly arranged. It is also possible to quickly track the progress of an assignment through the system.

The monitoring process (whereby scripts are selected for the marking to be checked) became completely electronic in that scripts that were selected for monitoring but not already in an electronic format were scanned. The actual monitoring was all done electronically and tutors received feedback by email. In principle this allows for a much speedier turn round than was previously available. In practice the process was slower in the first year as monitors needed to adjust to the new system. Some found monitoring more difficult with the smaller screen.

**Conclusions**

Following the success of the e-marking pilot in the OU’s Mathematics MSc programme, it has been agreed that e-submission and e-marking will continue as an option for students. But what are the prospects for e-marking in mathematics in the undergraduate programme and at other UK universities?

e-submission and e-marking has worked well for those students who have chosen to participate. Tutors have also found e-marking acceptable, because they are well equipped with kit, but this is an expensive and logistically problematic approach for the OU to adopt on the undergraduate programmes or in other symbolically rich curriculum areas. It is likely that, if a reasonably priced (say, under £500) and reasonably sized tablet/slate becomes available, then the move to electronic marking for all undergraduate courses will become more feasible.

Apart from possible cost savings in the medium term, the single greatest motivator for the OU Mathematics MSc programme to adopt e-marking is the potential for global reach in its offerings. Although the over 550 student registrations for the Mathematics MSc programme is large by UK HE standards, the Mathematics MSc programme is currently restricted to EU residents; however it is likely to be offered globally within the near future. e-submission is a necessary precursor to this move.

In a similar way, the possibility of e-submission and e-marking of assignments is of interest in other traditional UK universities, which are either offering part-time degrees or wishing to develop distance-learning degrees in mathematics.

Although e-marking of mathematics is still in its infancy, its use is likely to grow as universities become increasingly digitised and students come to expect and demand electronic submission of their assignments.
References


Notes to article

1 We distinguish e-marking (by human markers) from e-assessment (automatic marking of assignments). The latter is also a growing area in UK university practice, which we do not discuss in this article.

2 Principally as an MS Word 2003 document to be annotated using the MS Word annotation tools.

3 With third-party inking support for Windows XP users without a Tablet PC.

Appendix

Fig 1 - Sample of marking using PDF Annotator