Expanding and personalising feedback in online assessment: A case study in a school of pharmacy

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Abstract

In the Manchester Pharmacy School, we first adopted summative on-line examinations in 2005. Since then, we have increased the range of question types to include short answers, short essays and questions incorporating chemical structures and we achieve time savings of up to 90% in the marking process. Online assessments allow two novel forms of feedback. An anonymised spreadsheet containing all the marked exam scripts is made available to all students. This enables students to see a variety of answers than are awarded good marks, rather than a single model answer. Secondly, "Smallvoice" a novel app provides confidential personalised feedback. Feedback statements, though written by the instructor, are selected by a computer in response to various aspects of a student's performance. Evidence of improved student satisfaction comes from the unit questionnaires and from the National Student Survey. Evidence of improved learning comes from comparing pre- and post-feedback assessments (typically course tests and end of unit examinations.).

Keywords

On-line summative assessment; feedback; short answers; personalised feedback; whole class feedback; full disclosure.

Introduction – perceptions of online assessment

Around examination time, when backbreaking piles of answer booklets are carried from one place to another, carefully counted to ensure that the only copy of any student's script does not go missing, and finally pored over in the hope of understanding what was meant by a particular squiggle, online assessment seems very attractive. Online assessments are easily stored and legible, answers by different students can be readily compared, and files can be organised in ways that facilitate feedback.

Yet decades after the introduction of online assessment, it is still practised by a small minority of higher education institutions (Bull and McKenna 2004). Both the published literature and our own experience suggest that there is widespread doubt that online assessment is secure, flexible or reliable.

This paper describes our experience in online assessment over 15 years. We have sought to maximise the security, flexibility and reliability of our assessments, especially our summative assessments. Staff have benefitted from the speed and accuracy of online assessment but students have benefitted crucially from a range of novel feedback available as a result of online assessment.

Security, Flexibility and Reliability: The Manchester Experience 1998 – 2012

In 1997 we began a project entitled "What makes a student succeed?" (Sharif et. al. 2003; 2007a and b), requiring the use of several assessments in the first week of the MPharm course. The results

were used to assign students to foundation groups, and the assessments were therefore high stakes, though not summative. The start of this project coincided with the University's introduction of so-called CBA (computer based assessment) software, which was a modification of the commercially available Questionmark software.

Students sat the password-protected tests in University computer clusters. Passwords were issued immediately prior to the tests, which were invigilated and conducted under standard examination conditions (no books, paper, coats etc permitted). There is no evidence of any security breach at any point.

Question types were limited to automatically-marked multiple choice, text match and numerical questions. While this was adequate for the purpose of assigning students to foundation groups, it would not permit a full range of assessments in a Pharmacy programme to be conducted online.

During this period, all our worst fears about computer reliability were realised. In the period 1998-2004, the testing proceeded smoothly only in 2002. In every other year there was a failure of some sort. These ranged through network failures due to excessive traffic, a virus affecting the whole university system, human error during system maintenance, and a leak in the roof above the computer cluster.

In 2005, we began to explore the use of WebCT (later to be superseded by Blackboard 8 and Blackboard 9) for summative assessment. This was prompted by an increase in student numbers in a first year Cell Biology and Biochemistry class to over 200. The teaching time on the unit was 48 hours, but the paper-based assessment was taking 60 hours to mark. The paper-based assessment was replaced by an online examination in which the questions were all automatically marked, a mixture of multiple choice and text match questions. Human intervention in the marking process was now minimal, with less than one hour required.

We were satisfied that students would not be able to access the assessment prior to the examination, but we were initially concerned that students might be able to access unauthorised websites during the assessment. Invigilators were trained to check the computer taskbars for minimised icons and to investigate any that looked suspicious. The architecture of the clusters also gave cause for concern – these had been designed for teaching and private study, with collaboration encouraged. Invigilators also had to be wary of students looking at one another's screens.

We gradually increased the range of question types available. Short answers and even short essays are supported by the Blackboard 9 assessment software. These can be marked either online within Blackboard or by downloading a csv file and marking in an Excel spreadsheet. Marking in a spreadsheet is undoubtedly quicker than marking online because students' answers to a particular question are arranged in a column; scrolling from one answer to the next is much quicker than closing one file and opening another (see Fig. 1)

B	C	D	E	F	G
Mrs LP, diagnosed with ankylosing spondylitis, has suffered gastro-intestinal problems whilst taking the NSAIDs. The prescriber would like to try the patient on the selective COX 2 inhibitor celecoxib. What should the initial dose be if Mrs LP has moderate hepatic impairment? (1 mark)	q41/1	The half-life of celecoxib is normally around 8 hours but can increase to around 13 hours in hepatic impairment. What range of time would you expect it to take till steady state plasma levels are reached? (1 mark)	q42/1	Question text with student answers in a column The apparent volume of distribution is around 450 L which is a relatively high value. What does this tell us about the distribution of celecoxib? (1 mark)	q43/1
			Column of marks awarded		
100mg daily in 1-2 divided doses.	1	40 to 65 hours.	1	Most of the drug is in tissues (Extravascular fluid) and not in the blood plasma.	
100mg daily in 1-2 divided doses	1	5 half lives so 40-65 hours	1	Celecoxib is highly distributed from the bloodstream into extracellular tissues. There is a higher concentration of Celecoxib in the extracellular tissues than in the bloodstream.	
100mg daily	1	24-39 hrs	0	At any given time the majority of celecoxib is distributed throughout the tissues	
100mg daily in 1-2 divided doses. She can either take 100mg once per day or 50mg twice a day.	1	5 hours	0	Large amount of Celecoxib drug is distributed into the body tissues most of the time, small amount of Celecoxib drug is distributed in the blood.	
150mg	0	40-65 hours (13x5=65 and 8x5=40)	1	It is ditributed to most tissues in the body	0
100mg (in 1-2 divided doses)	1	24 hours	0	Because the volume of distribution is relatively high, it means that the majority of the Celecoxib is distributed within the tissues rather than in the blood.	
100mg	1	40 hours to 65 hours	1	At any one point in time, there is a high extent of distribution of celecoxib around body tissues.	
100mg in 1-2 divided doses.	1	40-65 hours	1	The high volume of distribution means the drug is mainly in the tissue rather than the systemic blood circulation.	

Figure. 1. A part of an Excel spreadsheet used for marking. The examiner sees all answers to a question in a column and marks (quickly) in a column alongside the answers. The spreadsheet can be sorted (for example by mark awarded) for checking. The same spreadsheet (with all identifiers removed) can be returned to the students as a form of feedback.

We developed a bank of chemical structures such that the answer to a question could be a chemical structure. 153 structures were classified according to the heteroatoms (atoms other than C, H, N, O) they contain, the number and size of rings and functional groups. Filters allowed students to select appropriate structures quickly (see Fig. 2).
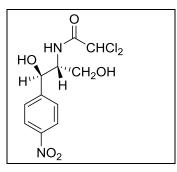

Figure 2. Chloramphenicol: the structure contains two chlorine atoms, one six-membered ring and an amide function.

Both the University IT systems and Blackboard proved very reliable during the period up to 2011. We developed various pieces of bespoke software that allowed us, for example, to upload examination papers directly from Word, incorporating diagrams and chemical structures.

During the January 2013 examination period, several examinations were hit by a failure to save answers, affecting about 17% of students. This was tracked to a failure in the six Blackboard servers

to transfer load effectively when traffic was high. The problem took several weeks to identify, at which point it was quickly corrected.

The Advantages of Online Assessment: Accuracy, Speed and Feedback
The 2013 failure resulted in a significant loss in confidence in online assessment, and a reduction in the number of examinations conducted online. It prompted a reconsideration of the advantages of online assessment, as well as the development of additional security features.

The advantages of online assessment have been clearly outlined by McGee Wood et al (2005) and latterly Briggs (2015). The first and indisputable advantage is that computers are good at adding up – they total marks awarded quickly and accurately. Although academics like to think they are good at adding up, the evidence (Aojula et al 2006) is that they are not. Andrews (2005, personal communication) demonstrated that the error rate is typically 5% in a moderately complex assessment. It is therefore imperative that an assessment that is marked manually be totalled at least twice.

A second advantage of online text-based examinations is that students' handwriting is often difficult to decipher. It is much faster to mark typescript, which is inherently legible. McCann (2010) has demonstrated that these obvious advantages may not be sufficient to persuade academics to invest the initial effort in mastering the logistics of e-assessment.

The real insight made by McGee Wood et al is that computers are good at *finding* script. Figure 1 shows three questions, answered by many students, with the answers arranged one above the other in a spreadsheet. When answers are arranged in this way there is no time spent rifling through answer books trying to find the answer to a particular question. Academics who mark on a spreadsheet normally estimate time savings of a factor of between 2 and 10, depending upon the length of the typical answer (the time savings are less with longer answers where more time is spent marking and less is spent finding the answer). That most of the time saving arises from finding the script quickly is evidenced by a direct comparison. In Blackboard, it is possible to download the students' answers as a csv file, but it is also possible to mark directly onto an online document resembling an examination script. The former is much faster; we estimate a factor of 2, based on three academics marking similar assessments using each method.

The same spreadsheet format permits improvements in accuracy of marking. After marking a question, it is easy to sort the spreadsheet by mark and to confirm that answers achieving the same mark are comparable. This is very difficult to achieve in a paper-based examination.

All Student Feedback
Marking on a spreadsheet leads to such confidence in consistency of marking that complete transparency is possible. Beginning in 2008, after securing the permission of the students, we stripped all identifiers from the marked examination spreadsheet and made it available to all the students who had sat the examination; essentially students saw figure 1, but extended for all questions. Thus students could not only see where they gained or lost marks, but could see a range of very good answers for each question. In a class of over 120 second year students, all but one reported this feedback to be useful or very useful.

This type of feedback gives students valuable insights into the marking process which model answers cannot give. Very good answers, especially longer answers, look very different from one another and are, at least in theory, more valuable than model answers.

In many years of using All Student Feedback large classes the present authors have received no complaints about their marking. One third year student summed up the student response verbally "I thought you were a bit harsh in question 2, but that I got lucky in question 3." On one occasion, a student noticed that a question had not been marked. She alerted the examiners immediately, and the mistake was rectified.

More Feedback – The Smallvoice App
It is quite common for a student to approach an academic following an assessment and to say "Where did I go wrong?" Armed with an online assessment, the academic may scan the row corresponding to the particular student's assessment and offer some analysis.

Typical comments include:

- You haven't answered all the questions.
- You haven't revised a particular topic
- Your English is poor

Very often, even usually, such analysis could just as well be given by a well-programmed computer, as in the examples above. We therefore developed Smallvoice.

Smallvoice provides rapid, automated, completely personal feedback on performance to students in large classes. It analyses many different aspects of a student's performance and synthesises accurate, confidential advice. Smallvoice is a freestanding tool, able to integrate with commonly-used data systems around the world.

Smallvoice analyses an examination paper (either a computer-based examination paper or a transcript of marks from a paper-based examination) in the same way as an instructor might analyse a paper following an examination. It reports on a student's performance in different topics (for example different diseases), different question types (e.g. factual recall, multiple choice, critical argument). In addition it analyses performance in ways that are much easier for a computer program than for an instructor. It incorporates a powerful algorithm for discrimination values, so is able to comment on whether a student fared batter in the easier or more difficult questions relative to the rest of the class.   It correlates performance in summative assessment with attendance and with performance in past formative and summative assessments. Students receive a detailed email showing where they are in the class, trends in their performance, and incorporating links to sophisticated statistics about individual questions. The feedback is made up of text inputted by the instructors and is therefore personal in tone; it is at its most powerful when used to congratulate good students, to encourage average and weaker students and to give advice about preparation for future learning.

Smallvoice hugely increases student satisfaction. We have received numerous emails of appreciation from students. In the pilot course unit about 10% of the cohort sent unsolicited messages of thanks and the feedback score was 4.69 /5 in the University's course evaluation questionnaire. We have also seen average marks rise 10-20% between successive examinations following feedback. Smallvoice lends itself to feedback that advises students about improving performance, which (like the personal tone) is a hallmark of current perceptions of good feedback (Price et al 2010; Boud & Malloy 2013).

Sample Output

Dear [Forename],
Here is some feedback following your semester one exams. Your weighted mean for semester 1 was 65.4% and the mean for the cohort was 67.2%. Your position in the group was therefore 98=. This was a good solid 2.1 performance in semester one. Well done! Your semester 1 mark is significantly higher than your year 3 mark so very well done!

The opening text is common to all students except that the computer inserts individual marks

The second year contributes 10% to your final degree classification and the third year contributes 20%. In the fourth year so far you have completed 50 credits out of 120, that's another 29.2% of your degree. 40.8% remains.

General comments on performance vary according to the overall mark and there is also a comment comparing this assessment to previous performance. By the end of the first paragraph, the feedback is significantly personalised.

Table 1 shows you the average mark you need in semester 2 to get each class of degree.

Table 1
Averages required for the rest of your degree

to get a first you need	to get a 2.1 you need	to get a 2.2 you need	to get a third you need
80.1%	55.7%	31.2%	6.7%

Students often express gratitude for this item of feedback. For this final year student, it is clear that a 2.1 can be achieved by doing more of the same.

Do remember though, that the average is not quite the whole story. You have to pass all the modules!

Table 2 shows a summary of your module marks compared with the class averages. Your mark in Law was especially commendable.

Table 2:
Summary of your module marks

Module	Law	Dispensing	Social Pharmacy	Micro-biology	Neuro-pharmacol
Your Mark	80.9	79.2	63	68	58
Your Position	47=	112=	128=	64=	20
Number in class	170	170	170	152	29
Class mean mark	75.2	81.5	69.9	64.8	61.0

Some modules in Pharmacy have pass marks of 60% and high class means. It is helpful to students to have the class mean and their own position in order to assess progress.

You're progressing very well. Good luck with the rest of the semester.
Best wishes
Jill and Steve

Figure 3. Part of a Smallvoice email sent to a final year student following semester 1 examinations.

Figure 3 shows an example of part of the feedback used to support the end of semester one examinations for fourth year students. Smallvoice can also be used to give very fine-grained feedback (for example a discussion of individual questions in a single course assessment.

The Future of Online Assessment
Given the advantages of online assessment to both academic staff and students, progress in delivering secure, flexible, easily-managed and (above all) reliable assessment has been disappointing. The delivery of online assessment requires an enormous amount of care, and the support of local in-house IT experts.

Examination infrastructure
To ensure security during examinations, the University of Manchester has developed computer clusters specifically for examinations. Computers are widely spaced and screens cannot easily be seen by a student's neighbours. A specific "examination desktop" is loaded onto the cluster machines prior to the examination period and websites outside Blackboard cannot be viewed.

This feature has led to the development of a novel online open-book examination format, in which students are able to access specific materials contained within the same Blackboard folder as the examination.

The conduct of online examinations is now coordinated by a specific member of the Examinations Office. Protocols for paper-based examinations have evolved over many decades to accommodate several examinations taking place in the same very large room. Online examinations present a new paradigm. A single examination may be housed in several different remote rooms. Ensuring consistency between rooms is a significant challenge, requiring efficient communication between several rooms (carried out via online messaging).

Load testing

The 2013 failure prompted us to develop load testing protocols to be carried out ahead of every examination period. The intention during load testing was to provide evidence that the current deployment of our virtual learning environment was fit for purpose and that there was a relatively low risk of encountering any load related issues during the setup or running of our online exams. Several clusters of desktop machines were used in the testing with a combined provision of approximately 400 machines. A version of the Mozilla Firefox browser was modified so that it could simulate individual student activity during setup and running of an online examination, this browser was started on each machine so that the behaviour of 400 virtual students could be arranged and synchronised during the period allocated for testing.

Two tests are conducted on the Blackboard infrastructure. The first introduces gradual load (achieved by conducting a real exam on each PC) onto Blackboard up to the maximum PCs available across all the clusters used. When this capacity is reached, the exam is allowed to continue for approximately 15 minutes to test for sustained load on Blackboard. The second test starts all the exams together to simulate peak load of the system.

The virtual learning environment configuration at the University of Manchester is currently composed of 10 application servers. The advice from our hosting partners has been that this configuration is over specified for our actual use. The intention of load testing was to prove that the servers would cope without failure with the load being generated during examinations and equally important that they would comfortably do so. Whilst it is often difficult to correlate load and system utilisation, one measure that can be used is the number of queued processes within the processor of an application server. The larger the number the more likely there is to be service degradation, or service loss (either partial or full). If a sustained load of "20" was observed an investigation was triggered. If an application server reached a value of "50" an automated procedure would take it out of the processing pool so that no additional load would be transferred to it. During both tests undertaken during our recent load testing, the maximum number of queued processes observed was "6", with a typical value being between "1 and 3".

Load testing is, we believe, a necessary prelude to online examinations.

Downloads

Downloading examinations in csv format also requires specialist tools. Blackboard, for example, enables html which is not rendered directly. In general, this is removed manually.

More inconvenient still is that students occasionally use a character, such as a hyphen, as a bullet point. Excel recognises this as a delimiter, and a student's answer may be truncated as a result of its use. The solution is to brace each answer inside | characters, which can be achieved in a number of ways, by opening the csv file initially in a program other than Excel.

Drawing tools

In Pharmacy and related subjects, online assessment will only come of age when drawing diagrams and chemical structures within the assessment are enabled.

Discussion

Security of online examinations remains a concern. Nevertheless, this is a concern that Universities have so far proved able to meet. An online assessment must of necessity be mounted on a server ahead of the examination period; this means that it can, in principle, be hacked. There is a body of literature devoted to the security of online assessments (Apampa *et al.* 2009). Of course, it is, in principle possible for students to break into a University safe containing paper-based examinations, but this is a familiar risk, one that we are content to live with. Even though university online security systems are generally of a very high standard (universities maintain personal and often medical data), it is much easier for academic staff to imagine their students as computer hackers than as safe breakers.

As of 2013, online examinations did not provide the flexibility of question type that we ultimately require, but neither were they restricted to multiple choice questions.

Reliability remains the key issue that prevents many academics embracing online assessment (Warburton, 2009). Computers are inherently unreliable. A typical 50-seat computer cluster in a University might be expected to have two or three computers out of commission for various reasons at any one time. This is a level of unreliability we would find unacceptable in our cars or washing machines. The fear is always of a computer failure mid-assessment, so that student work is lost. Some of the published literature incorporates elaborate schemes for backing up student work on paper (Aojula et al. 2006).

Further, an online assessment produces dependence. An academic conducting a paper-based assessment maintains the impression or illusion of control. Academics conducting online examinations become dependent upon IT staff, whose expertise is usually quite alien. Attempts to guide academics through the process serve to reinforce dependence (Willis et al. 2009).

Online assessment has the potential to be enormously powerful, saving time, giving improved accuracy and transparency and greatly facilitating feedback. Holmes (2015) and others have also pointed to the frequent use of simpler e-assessments as a means of improving student engagement. Feedback deserves special consideration. Because an on-line assessment can be modified and reproduced, or readily loaded into another computer program, such as Smallvoice, it is possible to give students high quality feedback with reasonable throughput. When the Smallvoice prototype was introduced in 2011, we saw an increase of 19 percentage points (from 46% to 65% satisfaction) in "Assessment and Feedback" added to the School's NSS score in a single year. Progress since then has, however, been slow. Sector-wide, students find feedback less than completely satisfactory, and the current challenge is to embed feedback into the curriculum, thereby managing students' expectations. Our current effort is focussed on understanding how students respond to feedback, and developing tools to enable them to comment on their feedback, thereby opening ongoing dialogue.

Acknowledgements

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