

CASE STUDIES

This case study is one of a collection of six bioscience case studies from the publication *Effective Use of IT: Guidance on Practice in the Biosciences*, written by Lorraine Stefani and published by the Centre for Bioscience, The Higher Education Academy. All the case studies have been written by bioscientists who have used IT in their own teaching. The case studies are organised around common headings ('Background and rationale', 'Advice', 'Troubleshooting', 'Does it work?' and 'Further Developments'), but each study reflects the author's individual style and preference.

6

Using frequent computer-based assessment to 'set the pace' in a first-year bioscience module

Richard Rayne and Glenn Baggott,
School of Biological and Chemical Sciences,
Birkbeck College, London, WC1E 7HX.

E-mail: r.rayne@bbk.ac.uk

These case studies illustrate a range of approaches to using technology to teach bioscience. It is envisaged that these cases studies will provide guidance, inspiration, as well as practical advice on implementing e-learning in the biosciences. There is also an accompanying website to this guide (<http://www.bioscience.heacademy.ac.uk/TeachingGuides/>). The website contains further practical material to aid the reader in using technology in teaching. The site includes expanded versions of the case studies, video clips, further bioscience case studies and supporting material.

Using frequent computer-based assessment to 'set the pace' in a first-year bioscience module

Richard C. Rayne and Glenn K. Baggott

The problem and the context

All of our 4-year BSc programmes in biological sciences (and related subject areas) at Birkbeck are offered solely by part-time study in the evening to mature students. Most of our students are in full-time employment and many have families; moreover, many are returning to education after a significant break. For such students, time is an especially precious commodity and it is essential for them to settle into a study routine that is efficient and effective. We have observed that for many of our students, particularly those in their first year, establishing such a routine represents a major challenge. Although we cannot speak from experience on the issue, colleagues who teach elsewhere report that many 'ordinary' (i.e. ca. 18 years-old, full-time) first-year students will find establishing a study routine similarly challenging!

As an attempt to ameliorate this problem, in 2001 we launched a new first-year module, Molecular Cell Biology (MCB), designed around an assessment system that aims to dictate a steady pace of study and at the same time to provide opportunities for focused revision over the ca. 20 weeks during which the class is constituted (i.e. from the start of the module until the final exam). The central element addressing these aims of our assessment regime is a series of computer-based assessments (CBA) that will be described in more detail in the next section.

MCB is valued at 0.5 course units (cu); 10.5 cu are the minimum required for a BSc in our 4-year, part-time programme. It is rated at Certificate Level in the FHEQ. The module is taught annually in the Spring Term to 1st-year students on BSc Biological Sciences, BSc Biomedicine, BSc Molecular Biology, BSc Biochemical Sciences, Foundation Degree (Science), and various named Certificate courses. There are usually about 60 students taking the module. MCB meets on 11 consecutive Thursday evenings (January to March) and on 3 further evenings over the first 5 weeks of Summer Term (April to July). MCB is obligatory for progression, but is 0-rated in the Schemes for BSc Honours; in other words, although a grade is awarded, the unit is effectively pass-fail.

Having taken part in this module, students are expected to gain a secure knowledge of basic molecular genetic/biochemical processes (DNA replication, transcription, translation, chromosomal basis of inheritance) and an understanding of principles underlying key laboratory techniques in molecular biology (electrophoresis of DNA, Southern blotting, PCR). They must apply this knowledge and understanding by solving problems in the form of small 'case studies' involving human genetic diseases.

Our solution

Most important in 'setting the pace' and in providing revision opportunities for students on the MCB module is a series of computer-based assessments (CBAs) given on Weeks 3, 6, and 11 of the 11-week term. Although it happens that we use TRIADS to author and deliver the tests, there is no reason why other assessment and delivery systems could not be used with equal effect. (For more information about TRIADS, see <http://www.derby.ac.uk/ciad/>).

A critical feature of our approach is that these CBAs are first encountered as summative tests, given in timetabled sessions. The fact that the tests are summative (each contributing 10% to the overall grade) gets students' attention – this is the 'stick' that sets the pace! Holding the tests in timetabled sessions ensures that students undertake them with only the aids that we supply (e.g. codon tables, diagrams, etc., as required). We do not have enough workstations for all the students to take the tests simultaneously, so we hold test sessions in shifts. Time allowed on the respective tests in 2005 was 35 min (13 questions), 40 min (13 questions) and 45 min (11 questions), so up to 3 shifts are feasible within our 3 h evening time slot. Within a day or two of a test, we report to students their scores on individual items, and on the test as a whole, via WebCT mail.

Once completed for a grade in a timetabled class session, each CBA then becomes available for formative use via the Internet in two forms (these are the 'carrots!'): a self-test reporting a score only, but no feedback, and as a revision instrument with feedback

supplied following submission of each item. Students are encouraged to use the feedback tests to revisit items on which they scored badly in the corresponding summative test. The self-tests are intended primarily for revision prior to an end-of-module CBA (25% of the final grade) that reflects back on the course as a whole. An incentive to use these formative tests for revision (another 'carrot') is provided by the fact that approximately one third of the items on the final CBA are very similar to items that appeared on the 3 previous tests; another third the topics covered on the earlier tests, but the items approach the topics differently. (The remaining third, as implied, are new items, on topics not addressed in the earlier tests.) This construction has another benefit: it allows us to monitor students' improvement (or not!) from earlier tests to the final exam by comparing scores on the corresponding items. We have found in several cases over the years that such analysis has given us clues that have helped us to improve our instructional approaches.

Further advice

Give clear guidance to the students. We also take pains to give explicit advice on how and what to study, particularly for the first two tests. This advice falls well short of revealing any of the test items (!), but we think an open, clear approach helps students of all abilities and backgrounds to reveal their potential and provides encouragement that builds confidence.

Ensure that students have had adequate prior experience of using the CBA system. This is achieved for MCB students, who will already have encountered 3 similar tests in a preceding module (in the Autumn Term) where the tests are easier and also much more 'low stakes' than in MCB. This prior experience helps to quell anxiety and ensures that students have no difficulty in dealing with the manipulation and navigation tasks that the tests require (e.g. dealing with question style behaviours, submission of answers and revisiting answered questions). Toward the same goal, the time limit on the first CBA in the module is deliberately generous; this again helps to reduce test anxiety and allows students time to get fully acquainted with the operation of the test without feeling rushed.

Consider carefully the test interface. In accordance with the aim of ensuring students are being tested by the items, not by the interface itself, we have also spent time working on the presentation of the items and on the design of the question shells. We feel the key here

is to think about the usability of the test, as this will help all test-takers, but will be particularly critical for students who have problems with their mobility (e.g. mouse control) and/or eyesight (whether 'ordinary' poor eyesight or more serious impairments). A highly usable test will likewise be helpful to students with dyslexia. Above all, a consistent and clean interface with an organised and reasonably predictable layout is essential to meeting this goal. (For another aspect of this concern, see Issues of Item Presentation in the next section.)

For students having more serious disabilities, of course it may be necessary to provide an alternative assessment. (We have yet to encounter such a situation.) A question arises as to how one might create an alternative assessment of approximately equivalent difficulty and validity to the CBA that the majority of students will use. Here, we have no easy answer, but we can offer a suggestion regarding how to make a start. We have always taken care to prepare an inventory of our CBAs on an item-by-item basis with respect to the learning outcomes addressed and to the item's place in a 'learning taxonomy' such as the well known taxonomies of Bloom *et al.*, (1956) and Imrie (1995). (We have stuck with Imrie's ReCAP taxonomy because it is simpler: Recall, Comprehension, Application, Problem Solving.) Two experts rate each item against criteria set forth for ReCAP and then meet to agree a rating. Having recorded such an inventory, we can then form a picture of the learning outcomes addressed and the level of learning reached by each item. Whilst we recognise that this may be a crude reckoning (the taxonomies themselves are in fact contentious), we are sure that such information would be better than none if we needed to author some kind of alternative test that would: (a) be fair to the student(s) and (b) would give the teacher a secure indication of the students' achievement.

Delay the reporting of the test scores. Above it was mentioned that we set up our tests so they do not return an immediate score when the student finishes the test, but rather we compile the marks and send them out later (within a few days) by WebCT email. Although this reduces the immediacy of the feedback, we think this is a good policy for a number of reasons. First, we know all too well that test authors (ourselves in particular) are fallible and there is a possibility of a mistake in the weighting or scoring of a test item or items (yes, we have done this!). Having a look at the scores before releasing them allows for correction of such mistakes and of course this saves many

potential headaches. Similarly, the delay affords us the opportunity to undertake item analysis that may indicate a poorly performing item; such analysis might lead to a decision to exclude the item from the overall score reported to the student. We have also encountered situations where no students were able to attempt all the items before the test timed out (e.g. maybe of 18 items, the majority did the first 16, but none got further); in these few cases we have excluded the excess items when calculating a score. One could also envision the nightmare scenario of a network crash between test sessions. In such a case, some students might have completed the CBA and others might have needed to undertake the paper-based version of the test that we always have at the ready, just in case (thankfully, never needed). In such circumstances some consideration may need to be given to the scoring of particular test items. Lastly, delaying the reporting of the score allows for some synoptic feedback from the instructor to accompany the scores. This makes for 'friendlier', more helpful and richer feedback to the student. Imagine how bad a student would initially feel having seen a score of 40% on their test and then how this might alter if they were later to find that the median score had been 25%!

Effort put into the construction of items will be effort well-spent. We would advocate taking some pains to construct quality test items and to avoid purely recall items except, perhaps, for a few facts deemed truly essential. Although the majority of the CBA items on our tests have been rated as assessing comprehension (i.e. a step above recall in Imrie's [1995] taxonomy of educational objectives), some items extend further, testing application and problem solving. In short, our CBAs are certainly not just tests of pure recall (although of course accurate recall is normally necessary to show comprehension or other higher outcomes!). Bear in mind that if a test is well-targeted, you can learn a lot about students' learning from a relatively short test – you will not need a huge question bank. Crafting with great care a rather smaller number of items, targeted to truly essential topics/issues/concepts, is also likely to save you time and effort in the long run: these will probably have a longer lifetime and won't need frequent updating.

Don't rely just on CBA! It should be noted that our CBAs address a significant subset of the overall learning outcomes in MCB, but other assessments – a lab report, 15%; a short written test, 15%; and two short question sets, 15% – are used to assess the rest. We would always advocate a "mixed" economy of assessment methods, but also that attempts should be made to ensure that the different methods converge on the same learning goals.

Troubleshooting

Issues of item presentation. We should mention that in TRIADS, tests offer one item at a time – there is no option to provide a huge scrollable 'page' whereby all the items reside somewhere above and/or below the one item presently in view. Once the test taker reaches the end of the test, he/she is presented with a list of all items; any unanswered items are noted and any item can be revisited by clicking its name in the list.

In our 'early days' of using TRIADS CBA in MCB, we set up the tests to offer a sequential, one-way delivery of test items so that there was no opportunity to skip an item without submitting a response and no opportunity to go back to an earlier item until reaching the end of the test. The precise reasons underlying the decision to disallow the skip and go back features are beyond memory, but it was soon apparent that students hated being restricted to this format! On the basis of student feedback, we therefore changed the behaviour of the tests so that every item could be skipped without submitting an answer and, similarly, it became possible to go in reverse to reach an earlier item from any point in the test. An advantage of this mode of presentation is that test-takers can allocate their time more rationally. For example, it is possible to skip items that might take a long time to complete, meanwhile polish off a few 'easy' pickings and finally go back later to the 'harder' items. Interestingly, although this arrangement makes it possible to flip all the way through the test first – to get a look at all items before starting to answer any – we have never observed a single test-taker to approach a test in this way!

Issues of item presentation have been addressed in the literature; particularly pertinent is a report by Ricketts and Wilks (2002b). In their experience, offering a CBA with a long scrollable presentation negatively affected students' performance. Students preferred and scored better on tests where items were offered one at a time. However, it was not mentioned in this paper whether or not test-takers were offered the opportunity to skip items or to return to previous items at any point in the test. In short, it is good to be aware that item presentation is a critical issue and that some fine-tuning in accord with student feedback and performance indicators is likely to be necessary.

Time allowance. Another key issue that we grapple with is 'How much time should we give for completion of a summative test?' We cannot claim to have an easy answer for this. In early runs of some of the tests, we did find that substantial numbers of test-takers were failing to reach the last 2 or 3 items on a test. (In

which case, we moderated the marks to discount the few items that no one had attempted; more on this point is found above in 'Further Advice'). Certainly, we have improved our estimates over the years as we have gained a sense of how long particular sorts of tasks are likely to take for our students. Given that only experience can enable a reasonable reckoning, we advocate tests that are unlikely to put the students under severe time pressure and suggest that teachers remain open to moderation of grades for tests that have had only limited field testing.

Open or closed book? In the first three years of using this approach, all the tests – except the final test – were open book. Students could use whatever aids they desired, so long as they did not confer with others. We thought this might be a fair compromise given the frequency of the tests; students would still have to know the material rather well, but could look up the odd fact that was beyond their immediate recall. We abandoned this practice primarily on the basis of student feedback: in short, students felt using notes was more of a distraction than a help! Even when this practice was permitted, we observed that very few students relied much on their notes when taking the tests – the time allowed to complete the test was normally too short for extensive consultation of notes, anyway. Consequently, since employing a 'closed book' rule, we have not seen a drop in mean scores.

Does it work?

In each of the 5 years in which the MCB module has run, we have made use of our standard module evaluation questionnaires and in some years have augmented these with additional questions and/or bespoke questionnaires. These routine evaluations of student attitudes to the CBA, and to the MCB module as a whole, are invariably positive (often enthusiastically so) showing that students believe in the approach. Over 2003-2004 and 2004-2005, we undertook additional surveys of the students using the Study Process Questionnaire (SPQ; Biggs *et al.*, 2001) and the Assessment Experience Questionnaire (AEQ; Gibbs and Simpson, 2003). Our analysis of student responses to these instruments was part of a collaboration between the Formative Assessment in Science Teaching (FAST) project and the OnLine Assessment and Feedback (OLAAF) project. Detailed results from this work will be reported elsewhere (consult the OLAFF web site, listed at the end of this case study). In short, the results from the SPQ and AEQ indicated that our students were

motivated to use a deep approach in their study and that the assessment regime that we have constructed encouraged and supported the 'steady study pace' that we hoped students would adopt.

Another interesting effect of the frequent CBA approach has been the added benefit of the formative tests for students whose first language is not English (Baggott and Rayne, 2001). Typically 15 to 40% of students from a given cohort on our bioscience programmes have a first language other than English. It is quite common to find such students in the computer labs perusing a formative TRIADS test with a copy of a Language X – English dictionary in hand! Such students report that the ability to revise directly from these feedback-containing tests is most helpful. It is our opinion that we get a better picture of such students' abilities from the CBA results, given that they normally struggle to construct fully fluent written exam answers, especially in their early years of study.

We have also reported elsewhere on our analysis of the MCB module; see for example Rayne and Baggott (2004) and the materials (e.g. conference papers and presentations) on the OLAAF web site:

<http://www.bbk.ac.uk/olaaf>

The FAST project website may also be of interest

<http://www.open.ac.uk/science/fdtl/>

Acknowledgements

Much of the work reported herein (that since January 2003) has been made possible through an FDTL4 grant from the HEFCE and by additional funding from Birkbeck College to RCR. We are also grateful to the Birkbeck College Development Fund which provided a grant to RCR and GKB that enabled us to develop computer-based assessments for the Molecular Cell Biology module. Our collaborations with the FDTL4-funded FAST project have been very fruitful and have assisted us in some of the work reported herein.

References

- Baggott, G.K. and Rayne, R.C. (2001) Learning support for mature, part-time, evening students: providing feedback via frequent, computer-based assessments. In *Proceedings of the 5th International Computer-Assisted Assessment Conference, 2001, Loughborough University*, eds Danson, M. and Eabry, C., pp. 9-20

Case Study 6

Using frequent computer-based assessment to 'set the pace' in a first-year bioscience module

- Biggs, J., Kember, D. and Leung, D.Y.P. (2001) The revised two-factor study process questionnaire: R-SPQ-2F. *British Journal of Educational Psychology*, **71**, 133-149
- Bloom, B.S., Englehart, M.D., Furst, E.J., Hill, and Krathwohl, W.H. (1956) *A Taxonomy of Educational Objectives, Handbook 1: Cognitive Domain*. New York: David McKay Co., Inc.
- Gibbs, G. and Simpson, C. (2003) Measuring the response of students to assessment: the Assessment Experience Questionnaire. In *Improving student learning: theory, research and scholarship - proceedings of the 2003 11th international symposium*, ed Rust, C., pp. 1-12. Oxford: OCSLD
- Imrie, B.W. (1995) Assessment for learning and taxonomies. *Assessment & Evaluation in Higher Education*, **20** (2), 175-189
- Rayne, R.C. and Baggott, G.K. (2004) Computer-based and computer-assisted tests to assess procedural and conceptual knowledge. In: *Proceedings of the 8th International Computer-Assisted Assessment Conference, 2004, Loughborough University*, eds Ashby, M. and Wilson, R., pp 307-309
- Ricketts, C. and Wilks, S.J. (2002b) Improving student performance through computer-based assessment: insights from recent research. *Assessment and Evaluation in Higher Education*, **27** (5), 475-479