COMPUTER-BASED AND COMPUTER-ASSISTED TESTS TO ASSESS PROCEDURAL AND CONCEPTUAL KNOWLEDGE

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The use of Computer-assisted and Computer-based Testing to Assess Procedural and Conceptual Knowledge

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It is well known by those at the 'chalk face' that learning is not necessarily an outcome of teaching. "Students often fail to spontaneously use what they have learned in a new setting despite the fact that it is highly relevant" (Schwarz et al., 1999) a phenomenon Whitehead referred to as "inert knowledge" (Whitehead, 1929). However, judicious and appropriate use of assessment, as a way of checking for learning rather than to reveal what students don't know (i.e. for 'punishment'!) or simply to produce a rank order, can ameliorate this problem by promoting conceptual understanding and encouraging students to employ deep learning approaches.

As the biosciences are essentially practical and experimental subjects, it is important for bioscience undergraduates to develop abilities to acquire and apply procedural knowledge ('how to do something') as well as to demonstrate the conceptual knowledge that underpins procedure (cf. Biosciences Benchmark statement). Having learnt from examples, it is then hoped that the student, when faced with a novel problem, should be able to apply his/her knowledge and understanding to the new situation. Ideally, repeated exposure to such experiences of application and analysis will, with appropriate guidance from the teacher, instigate more advanced cognition, revealed in the form of synthesis.

A question arises as to what extent can computer-assisted and/or computer-based assessments (CAA and CBA) can inform our judgment of a student's performance at these mid- to high-levels of cognitive complexity. It is commonly assumed that CAA/CBA is suitable only for testing recall and comprehension, although this view has been challenged by a number of authors (e.g. Bull & McKenna, 2003; King and Duke-Williams, 2001). In our view, there is little doubt that by taking advantage of modern assessment authoring tools—which may incorporate simulations, animations, game scenarios, etc.—CAA/CBA can be designed to test higher order skills.

We have used TRIADS-based CBA (see Mackenzie, 1999) in several undergraduate biology modules for a number of years. Here, we will report on

work undertaken in a first-year, BSc-level molecular cell biology module of ca. 70 students. This module features a regime of frequent CBA which has proved especially beneficial for students whose first language is not English, as we reported previously (Baggott & Rayne, 2001). Most of the CBA in this module have been targeted to building foundational knowledge, with tests comprising items primarily designed to assess recall and comprehension. From this year, we will extend the use of TRIADS CBA by including a new, additional test focusing on a 'classic experiment' (Meselson & Stahl, 1958). This test will take the form of a computer-based tutorial and will be used as a formative exercise. It will consist of learning materials displayed within a TRIADS shell interspersed with test items. Questions eliciting recall of relevant basic knowledge will precede supplemental questions that address understanding of the same topic. Dynamic elements, including animations and randomisation of variables, will require students to respond to novel scenarios, raising the cognitive complexity of the tasks. A complete version of this tutorial/test was not available in time for this year's class (Spring and Summer Terms, 2004) to take advantage of it. In lieu of this, we provided supplementary paper-based materials for students to use in preparing for a summative TRIADS test containing items designed to reveal understanding of the key principles of this experiment. Analysis of results from this summative assessment will inform refinement of the new tutorial/test before it is deployed in next year's class.

Also in the same module, we have extended our assessment approach to include what is probably best-termed a computer-assisted (rather than computer-based) technique. For two years running, we have made use of the freely available (for academic use) CaseIT! simulation package (Bergland et al., 2004) in a practical test. CaseIT! includes a component in which basic DNA manipulation techniques are simulated, including restriction digestion, DNA electrophoresis and Southern blotting. Using the software, it is possible to simulate an experiment to determine the genotype of individuals (the 'case') with respect to a given genetic disease (e.g. sickle-cell anaemia, Duchenne's muscular dystrophy, and many others). About 1 month after a class-based session using CaseIT!, we administer a computer-assisted test. This involves presentation of an unseen 'case' on a paper-based test. Students must analyse and solve the problem using the CaseIT! software to generate the data; they use this data to answer the paper-based test items.

These approaches, we believe, tap cognitive processes in test-takers that draw upon conceptual and procedural knowledge relating to reasonable mimics of 'real-life' scientific problems. We will present our analysis of the student responses (over two academic years) to these new assessment approaches and will describe the principles we followed in constructing these assessments, e.g. through application of logical task analysis (cf. Shavelson et al., 2002).

References

Gibbs, G. & Simpson, C. (2003) Measuring the response of students to assessment: the Assessment Experience Questionnaire. 11th Improving Student Learning Symposium. pp. 1-12.

Baggott, G.K. & 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 (eds. M. Danson & C. Eabry), pp. 9-20.

Bergland M., et al. (2004) DNA Electrophoresis Module for CaseIT!, version 4.0.2. <http://www.uwrf.edu/caseit/caseit.html>

Bull, J. and McKenna, C. (2003) *Blueprint for Computer Assisted Assessment*. RoutledgeFalmer.

King and Duke-Williams (2001) Using Computer-Aided Assessment to Test Higher Level Learning Outcomes. 5th International Computer Assisted Assessment Conference, pp. 175–187.

Mackenzie, D. (1999) *Recent Developments in the Tripartite Assessment Delivery System (TRIADS).* **in**: Proceedings of the Third Annual Computer Assisted Assessment Conference, 1999, Loughborough University, Danson, M. and Sherratt, R. (eds.). For information about TRIADS, see: <http://www.derby.ac.uk/ciad/>

Meselson, M. and Stahl, F.W. (1958) The replication of DNA in Escherichia coli. Proceedings of the National Academy of Sciences, USA, 44 (7), 671-682.

Shavelson, R.J., Li, M., and Ruiz-Primo, M.A. (2002) Evaluating new approaches to assessing learning. Keynote address to the Joint Northumbria/EARLI Assessment Conference, Newcastle, UK. August 2002. <http://www.stanford.edu/dept/SUSE/SEAL/Presentation/Presentation.htm>

Schwartz, D.L. et al. (1999) Software for managing complex learning: Examples from an educational psychology course. *Ed. Technol. Res. Dev.* 47, 39-60.

Whitehead, A.N. (1929) *The aims of education and other essays*, New York: Free Press.