ASSESSING STUDENTS:
COMPUTER SIMULATION VS MCQS

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Abstract
A novel form of computer assisted assessment has been introduced into a course, Introductory Human Bioscience, at the University of Newcastle (Australia). It involves assessing students in undertaking some computer simulated experiments on the functions of the cells of the nervous system. To successfully carry out these experiments students need to employ higher order cognitive skills. A comparison of student performance in this form of assessment with that in multiple choice question (MCQ) exams shows a lack of correlation between the two.

Background
Introductory Human Bioscience is a compulsory component of the degree programs for Health Science students at the University of Newcastle and in the past ten years has been taken by 500 – 700 students. Assessment of such large numbers of students is a major task. It has necessitated some form of automated assessment and until recently we had used multiple choice questions (MCQs) exclusively.

However, MCQs involve mainly factual recall and for this reason are criticised as encouraging only surface learning. We have been interested for some time to put in place other assessments which may complement the MCQ exams and encourage deeper learning. While essay-type and other written forms of assessments may be more desirable in achieving these ends they do place a heavy burden on academic staff in terms of marking. Laboratory-type assessment, in which students have to submit reports on experiments undertaken, place a dual burden on resources. Not only is there a similar marking burden to that of essay-type assessment but as well physical resources need to be provided to enable students to conduct the experiments. We believe we have overcome many of these problems by developing a computer simulation of a laboratory, NeuroLab, in which students can conduct experiments and be tested on their performance in this situation.

Description of Content of NeuroLab
NeuroLab is a computer simulation of an electrophysiology laboratory in which students are able to undertake experiments on neurones. A laboratory has been 'created' that contains the type of equipment found in a normal electrophysiology laboratory. There are microelectrodes, amplifiers, a cathode ray oscilloscope (CRO), a stimulator etc - all of the necessary equipment to stimulate and record electrical activity of neurones. Students are guided through the use of the equipment in a 'hands-on' fashion so that they learn what these controls do and how to manipulate them.

NeuroLab is introduced by 'Professor Neurone', an animated cartoon character, who explains what the students will be required to do when using the package and who acts as a tutor to help them when they are having difficulties. Much attention has been given to the graphical and instructional design of NeuroLab in order to create a realistic simulation of an electrophysiology laboratory in which the user needs to manipulate the equipment in a knowledgeable way to obtain meaningful results. This generates a strong sense of realism throughout and, in turn, encourages high-level interactivity between the student and the software. Extensive feedback and audio instruction is provided to the user. The feedback is immediate and highly specific to each particular situation.

NeuroLab uses the metaphor of a book and is divided into seven chapters. Students are able to browse any chapter in any order. At the heart of NeuroLab is a series of simulations that allows the students to experiment with neurones. To begin each experiment the student must impale a neurone with a microelectrode. Not all attempts are successful – microelectrodes can break or slip right through the neurone or recordings can become unstable etc. These scenarios closely simulate the real situation. However, once they have obtained a successful impalement they can then carry out the following:

i) Measuring resting membrane potential of neurones. Students have to learn to discriminate between good and bad impalements and to make accurate readings from the CRO.
ii) Stimulation of neurones and recording of responses to elucidate the 'all-or-none' principle of action potentials. The threshold potential is varied at random within a range of realistic values each time a neurone is impaled.
iii) Measurement of relative and absolute refractory periods of neurones through introduction of a second stimulus.
iv) Investigating effects of alteration of membrane permeability on membrane potential by artificially changing sodium and potassium ion conductances.

In these exercises and simulated experiments the data that one student obtains will differ from that of other students and so require independent interpretation and evaluation of their validity. After the student has considered the acceptability of the data or determined the appropriateness of results obtained, they then receive personalised advice and instruction on their decision-making through specific feedback provided by NeuroLab.

Student Feedback

In a period of three academic years a total of 1,541 students used NeuroLab. Of these, about 1,044 (68%) returned completed questionnaires about the course, including specific questions about NeuroLab. Overall, the computer simulation has been very well received by the students. The majority found it to be a satisfying learning experience, and perhaps even more importantly, believe that it had increased their level of understanding of neurone function (McGrath, Kucera and Smith, 2003). In the same study it was shown that

students who had used NeuroLab performed significantly better in MCQ tests than students who had not.

Availability of NeuroLab Prior to Assessment

Students are able to practice using NeuroLab before they are assessed on it. A CD of NeuroLab (Experiments With Neurones) has been created and is packaged as an optional extra with the recommended textbook for this Introductory Human Bioscience course. NeuroLab has also been placed on a server in the University with student access through one of the University computer laboratories.

Student Assessment using NeuroLab

For the last two years students have been assessed using NeuroLab. A one hour session has been scheduled into the course for groups of about 20 students at a time to undertake assessment in a staff-supervised University computer laboratory. For this assessment mode NeuroLab has been modified so that students no longer receive any computer instructions on how to use the equipment nor any feedback about the results they obtain. However, each station is still independent of the others and the results that are obtained by one student differ from those obtained by the next. When the student exits NeuroLab their results are sent to file and are imported into a spreadsheet for automated marking.

NeuroLab has allowed automated assessment of higher order skills. In doing the experiments students need to

(i) make decisions about the validity of data they obtain. To do this they need to understand criteria that determine the acceptability of data and this incorporates the need to be able to recognise errors and differentiate between artifacts, technical flaws and natural biological variation;

(ii) undertake computational processes, such as, accurately read recordings from a 'cathode ray oscilloscope' and then mathematically convert those readings into sensible results;

(iii) illustrate their understanding of several important physiological concepts, by showing that they can undertake the experiments in a meaningful way.

Comparison between Student Performance in MCQ Exams and NeuroLab Assessment

Students undertake a final MCQ exam that covers all of the body systems. A comparison of student marks obtained in their final MCQ exam and NeuroLab has revealed the following: there is no correlation between the MCQ exam compared with the NeuroLab test results. The Spearman rank correlation between Neurolab result and MCQ result for questions dealing with the nervous system (NS) is 0.006 (se 0.64); and between Neurolab and total MCQ result is -0.24 (se 0.06). The weighted Kappa statistic when comparing quintile rank between the two assessments is equally poor for Neurolab compared to NS only in MCQ exam (0.2, 95% CI -0.05 to 1.02) and for

Neurolab test and total MCQ result (-.13, 95% CI -0.19 to -0.06). The Kruskal-Wallis test confirms no rank order associations between NeuroLab results and MCQ results (p=0.30 Neurolab vs CNS, p=0.40 Neurolab vs Total MCQ).

This analysis indicates one of two things: either NeuroLab is serving a valuable function in assessing important but quite different student skills to those assessed using the MCQ exam or the lack of correlation is indicative of students' differing abilities in the process of undertaking assessment on computer compared with the process of answering MCQ tests.

References

P McGrath, R Kucera and W Smith: *Computer Simulation Of Introductory Neurophysiology* Adv Physiol Ed (submitted 2003)