Innovative use of Blackboard® to assess laboratory skills

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Abstract

A novel application of the popular web instruction architecture Blackboard Academic Suite® is described. The method was applied to a large number of students to assess quantitatively the accuracy of each student's laboratory skills. The method provided immediate feedback to students on their personal skill level, replaced labour-intensive scrutiny of laboratory skills by teaching staff and identified immediately those students requiring further individual assistance in mastering the skill under evaluation. The method can be used for both formative and summative assessment. When used formatively, the assessment can be repeated by the student without penalty until the skill is mastered. When used for summative assessment, the method can save the teacher much time and effort in assessing laboratory skills of vital importance to students in the real world.

Keywords
Blackboard, computer-aided assessment, evaluation, laboratory skills

Introduction

Manipulation of very small volumes (1-1000 microlitres) of aqueous solutions with a high degree of accuracy is a fundamental skill required in undergraduates destined for clinical and research laboratories in Biochemistry and related fields. Identifying poor technique often is made difficult when students work in small groups or in classes where the student: demonstrator ratio is high. Failure to master this skill impacts greatly on all biochemical practical work completed by an undergraduate and could have adverse diagnostic repercussions for postgraduates in the clinical analytical laboratory. Computer-supported (on-line) assessment has been trialed since the 1960s but these typically do not assess practical performance (Newhouse, & Njiru, 2009). The study described in this paper was conducted to investigate whether an automated on-line system could be used to provide immediate, quantitative and formative feedback to students on their skill level in a specific laboratory task.

Blackboard Academic Suite® is a web-based Learning Management System (LMS) used widely in secondary and tertiary education. One of the functionalities of this system is the availability of a Multiple Choice Test to assess students' theoretical knowledge. The functionality of this tool often is greatly under-used by teachers. In Blackboard® version 7.0 each question may have up to 20 answer options and each answer may be weighted individually. This paper describes how this functionality may be fully utilised in a wet laboratory in a novel way that may have a range of applications for both secondary and tertiary teachers, easing the burden of assessment and providing immediate and formative feedback to students.

Steps in learning experience

There were three steps in developing this learning experience:

Step 1. A sample laboratory practical exercise.

A group of 163 university science students enrolled in a second year Biochemistry subject each were provided with a coloured solution. Working independently, they each performed four different dilutions of the solution with the aid of devices called micropipettors. The micropipettors were calibrated to transfer small aqueous volumes with an error not exceeding 5%. Students then measured the colour intensity of their dilute solutions using an instrument called a spectrophotometer to obtain digital readings corresponding to the final concentration of the four dilute dye solutions. A number of spectrophotometers were checked for wavelength and photometric error immediately prior to the exercise and four identically calibrated units were made available to the students.

Step 2. Developing the multiple choice quiz.

A Multiple Choice Quiz (MCQ) was prepared by the academic using Blackboard[®]. In the study, four MCQ questions were created, each describing one of the four laboratory dilution exercises and each contributing 25% to the student's combined assessment for the four dilutions. For each of the four questions, 20 answer options were provided that corresponded to narrow RANGES of readings that could be obtained from the spectrophotometer. By selecting the "Partial Credit" option when composing the quiz, each answer was weighted individually with the degree of penalty for incorrect results at the discretion of the academic.

Instructions for Blackboard[®]:

- From the subject's Blackboard site, select *Assessment* from the main menu. With the *Edit Mode ON*, select the *Evaluate* icon and *Create Test*. Select the *Create* icon and enter a name, description and instructions for students. Now select the *Submit* icon.
- Select the *Create Question* tab and specify *Multiple Choice NOT Multiple Answer*. Enter the question text.
- Change the *Point Value* e.g. to 25 for a test with four MCQs each awarded 25 points = 100 points total.
- Answer Numbering = *Uppercase Letters;* Answer Orientation = *Vertical*
- *Allow Partial Credit*
- *Number of answers = 20.* Enter all 20 answers and assign the percentage score (0-100) for each answer.
- *Note that by default, answer A has a green dot (assumed correct answer). Activate the radio icon for ONE of the true correct answer(s) to your MCQ (you may have several correct answers). It will be weighted 100%. You then can enter a 100% score for any additional answer(s) if you approve more than one correct answer. Blackboard requires that ONE radio icon must be active.* Return to *Answer A* and select the *Remove* tab on the right to cancel the incorrect default answer. Select *submit*.
- The software will display a list of the answers. *Ignore the fact that one will be highlighted with a green tick as this will not be displayed to students.*
- *Edit the Test Options* controls: when and how it will be displayed to the students. Select the *number of attempts* permitted, specify *when* you want the test to become available and *Include this Test in Grade Centre Score Calculations.* Select *Score* for the type of feedback displayed upon completion, and *All at Once* for the presentation mode.
- Finally, select *Submit*.

Figure 1 illustrates the range of options for just ONE of the four MCQ used in the study (i.e., one of the four dilutions performed in the test) and how, for a correct spectrophotometer reading of 0.350, partial credits were applied. Two answers spanning approximately ± 5% of the correct reading (consideration for 5% possible calibration error of the micropipette) both were awarded 100% partial credit. Credits decreased progressively as readings deviated from the correct result, with zero partial credit awarded to any experimental results exceeding a 10% error that would be of concern in real-world diagnostic analysis of biological fluids.

Answer	Spectrophotometer	Partial Credit
a	0.211 - 0.220	0 %
b	0221 - 0.230	0 %
c	0.231 - 0.240	0 %
d	0.241 - 0.250	0 %
e	0.251 - 0.260	0 %
f	0.261 - 0.270	0 %
g	0.271 - 0.280	0 %
h	0.281 - 0.290	0 %
i	0.291 - 0.300	0 %
j	0.301 - 0.310	0 %
k	0.311 - 0.320	85 %
l	0.321 - 0.330	90 %
m	0.331 - 0.340	95 %
n	0.341 - 0.350	100 %
o	0.351 - 0.360	100 %
p	0.361 - 0.370	95 %
q	0.371 - 0.380	90 %
r	0.381 - 0.390	85 %
s	0.391 - 0.400	0 %
t	0.401 - 0.410	0 %

Figure 1: Allocation of partial credits for one MCQ

Step 3.   *Online submission of results.*

Following the laboratory class, students accessed the MCQ online and entered their four experimental results by selecting the answer (a – t) that best matched each of their four spectrophotometer readings (see Figure 1). Following submission of the MCQ test answers online, students received in real time an immediate overall (averaged) score that accurately reflected the mean percentage error in their personal technique.

Results and Discussion

A total of 163 second year university science students took part in the trial. Pipetting accuracies of between 20 and 100% were recorded for students using micropipettes for the first time (Figure 2). Students with low scores were identified immediately and given further individual attention.
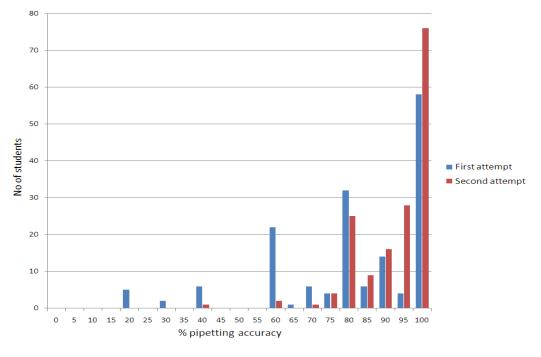

Figure 2. Pipetting trial

The percentage of students with scores below 80% accuracy fell from 26% to below 6% with just a single repetition of the exercise (Figure 2). During the second attempt, the mean accuracy rate for the class rose from 81% to 92%. 64% of students succeeded in transferring the small volumes to within 5% error.

Maintaining a high quality of academic support in an environment of increasing class sizes and declining fiscal and staffing resources remains a challenge, particularly in larger practical classes. Freeing up time for teaching and demonstrating staff to work more closely with students by relieving their assessment duties is a major advancement.

In this study, Blackboard® functionality was exploited in a way that may have a wide range of applications to many teachers in laboratories, easing the burden of assessment and providing immediate and formative feedback to students. For example, positive comments received from students included:

> *I found the use of QUT Blackboard in the measuring of our pipetting accuracy easy and beneficial. The results were quite easy to submit while having them almost instantly available online was great.*

> *I preferred using Blackboard over manual methods due both to the speed of results and the potential anonymity. I definitely think it should be used in the future.*

The predictive power of Learning Management Systems such as Blackboard® to identify "at risk" students and allow for more timely pedagogical interventions recently has been verified, for example, Macfadyen and Dawson (2010) correctly predicted 81% of students that ultimately

achieved a failing grade. However, the novel application described here extends the utility of these systems to the wet science laboratory and can be used to flag "at risk" students in time for them to refine laboratory skills and avoid the stress and sense of failure that can arise from poor practices in the laboratory.

In the Grade Centre Report provided by Blackboard®, *auto scores* for individual questions are provided so that the relative contribution of each exercise (question) can be distinguished for each student. In this way, a range of activities or skills could be assessed in the one MCQ Test and formative/summative scores obtained for each activity or skill being assessed.

In this study, multiple attempts were permitted when the MCQ was designed. Students failing to achieve a grade of 95-100% in their first attempt were permitted to repeat the exercise. As this was conducted without penalty, the instructional and non-threatening nature of this application in providing real-time feedback appeared to have a profound effect on the confidence and improved technical capabilities of the weaker students.

Unlike previous attempts to automate assessment of laboratory assignments using a LMS (e.g., Gutierrez, et al., 2010) or to implement other technology-based assessment systems (Salend, 2010), the method described here is fast and simple to implement, uses an existing management tool and does not require specialist IT skills.

The application of the learning management tool of Blackboard® described in this study may have hitherto unrealised application in situations where a host of skills may be assessed automatically, accurately, quantitatively and with minimal effort from the teacher or casual laboratory demonstrating staff. The method can be used for immediate evaluation of newly introduced teaching strategies in the laboratory, or in a remedial or repetitive fashion for students who are absent from important practical classes or require additional hands-on practice. Most significantly, this method can allow students to correct deficient laboratory skills with minimal intervention before final summative assessment is applied.

References

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