ONLINE ASSESSMENT OF LABORATORY COURSEWORK IN MICROBIOLOGY: A CASE STUDY

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Abstract

This study was undertaken to examine the feasibility of assessing an undergraduate laboratory microbiology project solely online, instead of students submitting and discussing their data in an extensive written report. PHP scripts were used to construct the web forms and the data submitted by the students were stored in a MySQL database. The online assessment proved to be time-efficient for both students and tutors, albeit that the marks achieved by the cohort were higher than expected and were considered to have given a slightly optimistic assessment of the students' abilities, compared to two previous cohorts who had to submit written reports. Analysis of an anonymous student feedback questionnaire revealed that the online method of assessment was well-received by the students.

Introduction

As part of their coursework assessment in a second year Pharmaceutical Microbiology module, MPharm undergraduates are required to undertake a four-week laboratory-based project in which they perform a series of microscopical, cultural and biochemical experiments in an attempt to identify an unknown bacterial culture. After they have acquired all their data, they are expected to use an online bacterial identification program to deduce the identity of their unknown organism. Students work on their own culture and report their results individually. Traditionally, each student has had a 10 minute consultation with a tutor to verify any problematical results before presenting their data for assessment in an extensive written report. This paper describes the transition to online assessment of this project with the perceived benefits of removing the need for a consultation with the tutor, reducing the marking load for the tutor and the assessment load for the students, but without reducing the rigour of the assessment itself or the quality of feedback given to the students.

Method

The operation of the new, online, method of assessment of the project was to be a three-stage process. Stage 1 would involve the students each submitting, online, the results of 25 of their key identification tests for assessment. Upon submission, they would receive immediate online feedback stating the mark they had achieved for their results and an indication of which, if any, of their results were incorrect. Stage 2 would involve students using the existing online bacterial identification program to match their corrected results to a particular organism and so arrive at its identity. The final stage would be for each student to submit, online, for assessment, the proposed identity of their unknown culture by specifying its genus and species names.

Key requirements of a software application to handle this task were:

- a simple means of utilising electronic student data, obtained from a download file from Blackboard® - the virtual learning environment deployed by the university;

- the validation of the submitted data both in terms of the student's ID (i.e. their university 'P number') and the Code Number of their unknown culture (unique for each of the 149 students in the cohort) - in line with the QAA Code of Practice, with particular reference to assessment in flexible and distributed learning (1);

- a means of comparing each student's experimental data with the expected results for their organism and awarding a mark;

- storage of each student's submitted data, the dates of submission and the marks awarded;

- prevention of students submitting their data on more than one occasion;

- the ability to force the students to perform the tasks in the correct 3-stage order; in other words, they should not be able to submit the name of their organism (Stage 3) before they had submitted their test data (Stage 1).

Since Blackboard® itself could not fulfil all these requirements, the initial intention was to pilot the use of QuestionMark Perception® v3 as the platform for the online submission of the project for assessment. This was seen as timely since the university was intending to roll out this assessment software as a Blackboard® plug-in. Initial trials showed that QuestionMark Perception® could be adapted to do most of the above tasks, but the author found that the software was clumsy to use and that it would be difficult to upload data on students and organisms. Moreover, trialling the authored pages required their constant uploading onto the university server which was very time-consuming, particularly since much of this development work was to be done off-campus. Finally, the difficulty experienced by the university in integrating of

QuestionMark Perception® into Blackboard® led to this software being rejected for this project.

The use of Microsoft Excel® was then investigated as a means of submission and assessment of the data and spreadsheet templates were produced for this purpose. These spreadsheets would be made available for the students to record their data and submit to the tutor, by email, for assessment. The tutor would then run the Visual Basic code within Excel® that he had written to assess the data, record the mark and add comments to the spreadsheet before emailing it back to the student. Whilst this method proved to be feasible in dummy trials, in reality it would involve considerable input by the tutor to open each emailed spreadsheet, assess it using the Visual Basic code and return the spreadsheet to the student by email. Allowing macros to run on university computers to automate the procedure had unacceptable security implications. It was also uncertain whether all students were competent enough to do all this faultlessly or whether the tutor could prove or confirm the safe receipt of the students' work, in line with the QAA code of Practice (1). Accordingly, these issues led to this method also being abandoned.

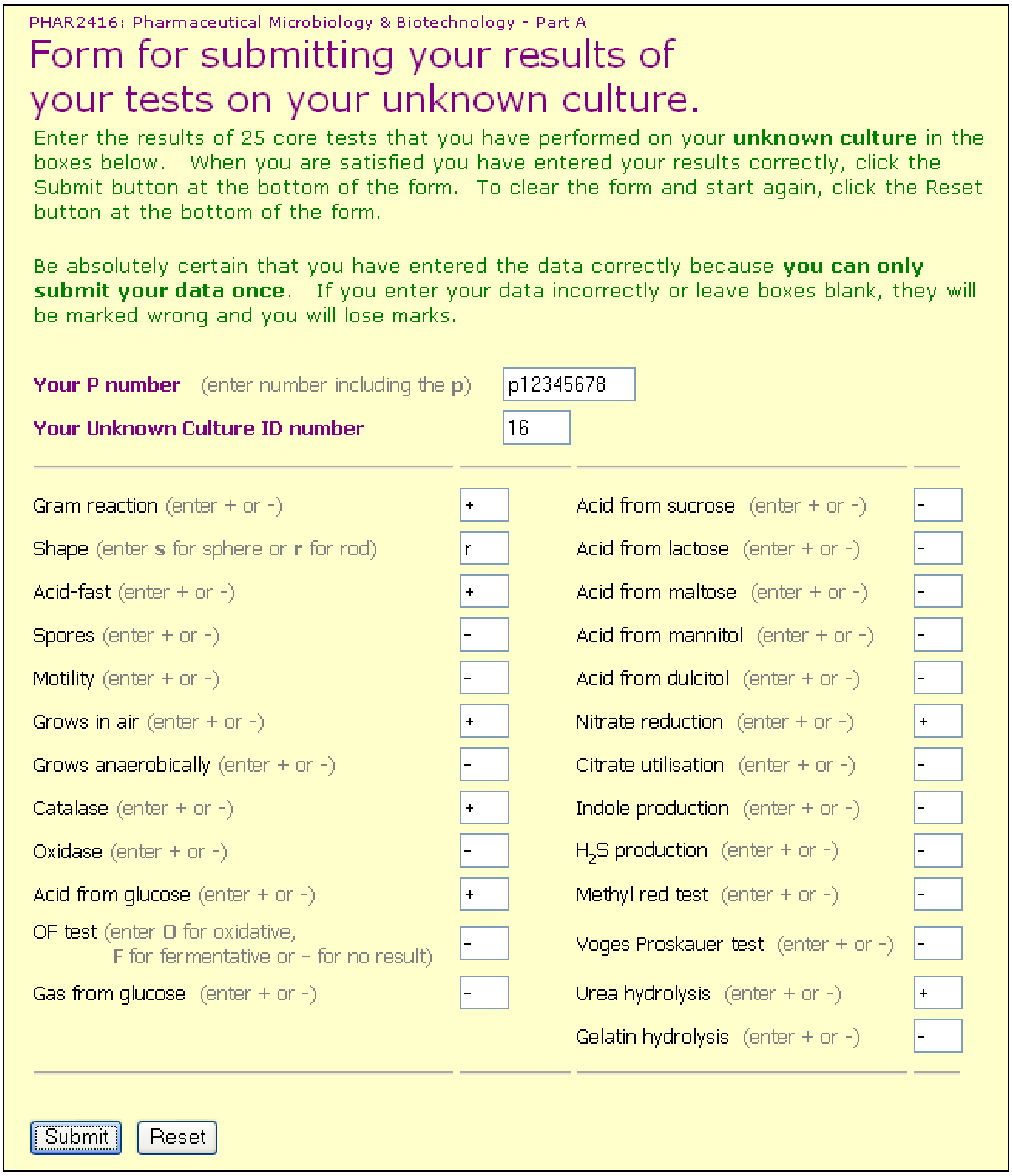
The initial intention had been to use existing software to handle this online assessment to which other staff had access and which they could re-use and/or adapt for their own purposes. Despite this, the method eventually adopted involved the tutor learning to write PHP scripts to produce custom-made web page forms (2). These worked in conjunction with a MySQL 5.0 open-source database (3) running on a university web server. A direct link was then made for students to access these web page forms from within the Blackboard® website for the module.

PHP (hypertext pre-processor) script is a widely-used, general-purpose, server-side scripting language that is especially suited for web development and can be embedded into HTML (2). Although it requires a server capable of running PHP scripts, there are numerous such open-source distributions freely-available on the Internet. *XAMPP* from Apache Friends (4) was the one chosen to be installed on the author's own, home computer, (running Microsoft Windows XP®) where most of the development work took place.

Fig. 1 shows part of the web form produced to enable students to submit their test results. On submission of this form, the student's university identification number (P number) was verified, together with their Culture ID Number. If either of these failed verification, or if the data had been submitted on a previous occasion, the submission was rejected and the student was given an explanation for the rejection. Otherwise, the information on the form was stored in the MySQL database, together with the submission date, and the submitted data were compared with the expected results for the bacterium concerned.

The student then immediately received a web page of feedback (Fig. 2) indicating the mark they had achieved and any of their results that were incorrect, together with comments on any problematical tests (if appropriate). They were encouraged to print off this page for future reference and told to use their corrected data with the existing online Bacterial Identification Program (Fig. 3) to attempt to identify their unknown culture. In this program, students had to choose a column of a primary table which best fitted their data to identify their genus (e.g. Column 4, the genus *Neisseria,* in Fig. 3) then click to move to a similar secondary table to identify their species.

Once they had done this, they were required to use a second form to submit, online, a genus and species name as their tentative identification of their unknown culture (Fig.4). After verification of their personal details and a check to make sure that they had already submitted their test results but had not submitted their suggested identification on a previous occasion, these data were marked and stored in the database. They then received a further feedback web page informing them of the correct identify of their unknown culture, together with their mark for this second part of the project. Standard biological nomenclature requires the genus name to have a capital initial letter and the species name to be all lower case. If students did not conform to this convention, they were told they would receive a mark of zero for the naming of their organism.


PHAR2416: Pharmaceutical Microbiology & Biotechnology - Part A

Form for submitting your results of your tests on your unknown culture.

Enter the results of 25 core tests that you have performed on your **unknown culture** in the boxes below. When you are satisfied you have entered your results correctly, click the Submit button at the bottom of the form. To clear the form and start again, click the Reset button at the bottom of the form.

Be absolutely certain that you have entered the data correctly because **you can only submit your data once**. If you enter your data incorrectly or leave boxes blank, they will be marked wrong and you will lose marks.

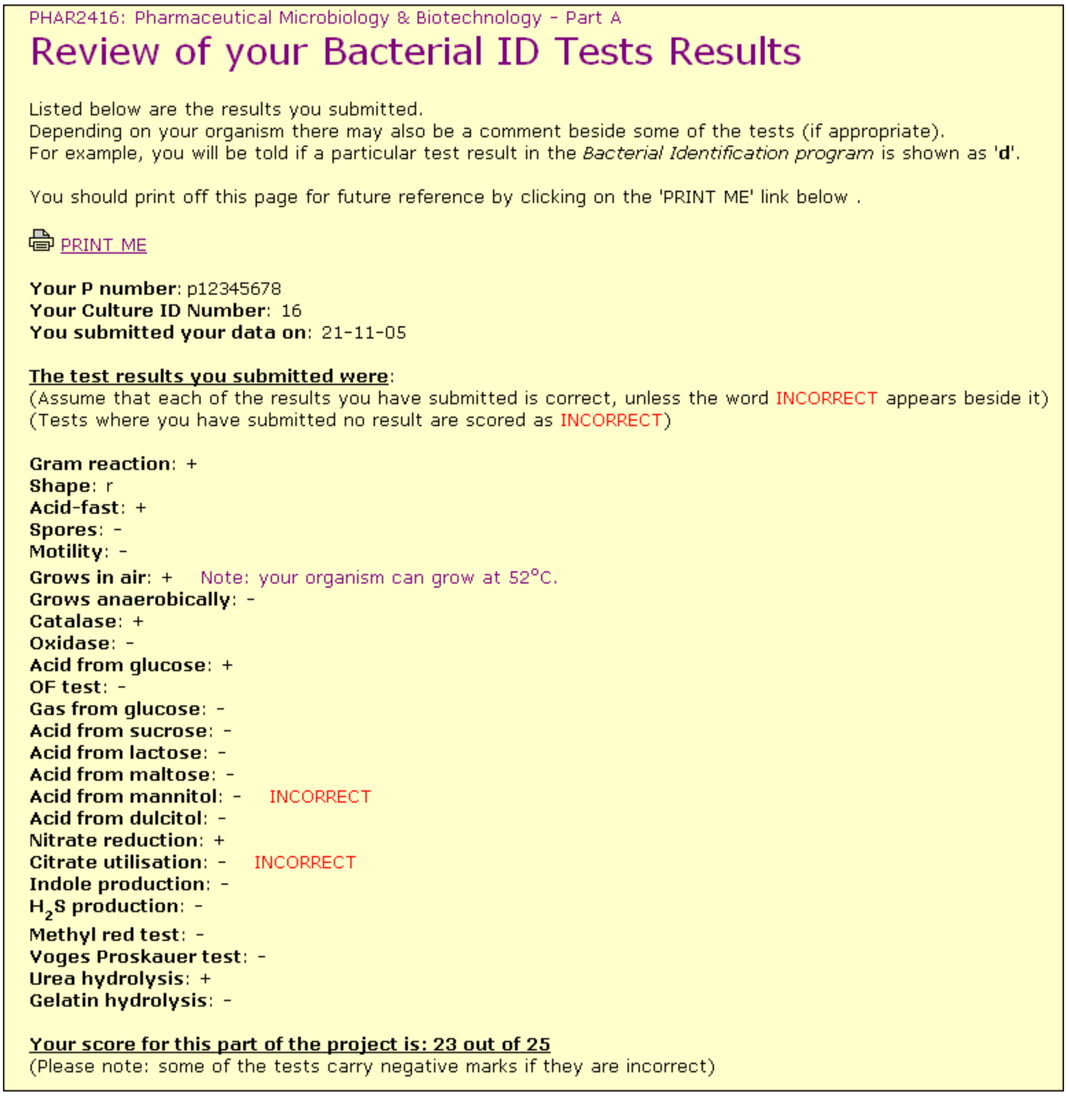
Your P number (enter number including the **p**) p12345678

Your Unknown Culture ID number 16

Gram reaction (enter + or -)	+	Acid from sucrose (enter + or -)	-
Shape (enter **s** for sphere or **r** for rod)	r	Acid from lactose (enter + or -)	-
Acid-fast (enter + or -)	+	Acid from maltose (enter + or -)	-
Spores (enter + or -)	-	Acid from mannitol (enter + or -)	-
Motility (enter + or -)	-	Acid from dulcitol (enter + or -)	-
Grows in air (enter + or -)	+	Nitrate reduction (enter + or -)	+
Grows anaerobically (enter + or -)	-	Citrate utilisation (enter + or -)	-
Catalase (enter + or -)	+	Indole production (enter + or -)	-
Oxidase (enter + or -)	-	H_2S production (enter + or -)	-
Acid from glucose (enter + or -)	+	Methyl red test (enter + or -)	-
OF test (enter **O** for oxidative, **F** for fermentative or - for no result)	-	Voges Proskauer test (enter + or -)	-
Gas from glucose (enter + or -)	-	Urea hydrolysis (enter + or -)	+
		Gelatin hydrolysis (enter + or -)	-

Submit Reset

Figure 1: Web form for students to submit their test data



PHAR2416: Pharmaceutical Microbiology & Biotechnology - Part A

Review of your Bacterial ID Tests Results

Listed below are the results you submitted.
Depending on your organism there may also be a comment beside some of the tests (if appropriate).
For example, you will be told if a particular test result in the *Bacterial Identification program* is shown as '**d**'.

You should print off this page for future reference by clicking on the 'PRINT ME' link below .

PRINT ME

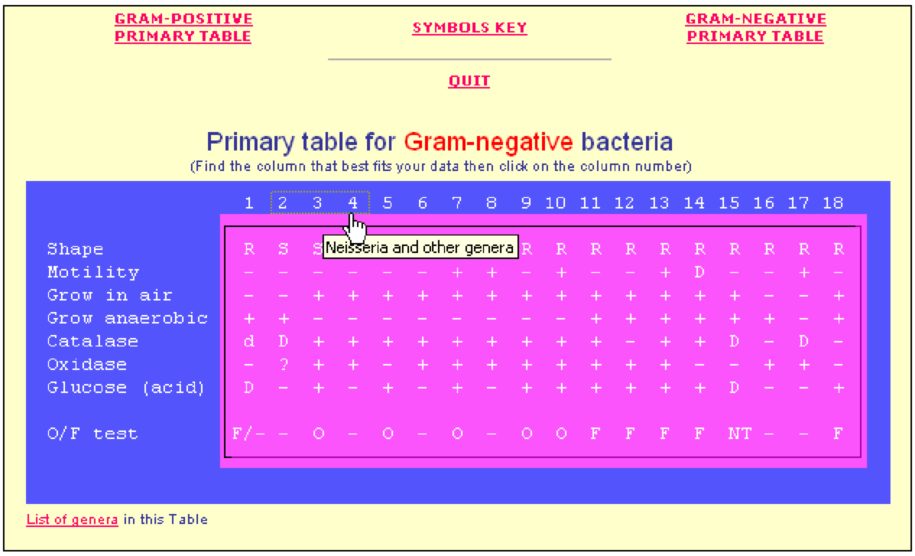
Your P number: p12345678
Your Culture ID Number: 16
You submitted your data on: 21-11-05

The test results you submitted were:
(Assume that each of the results you have submitted is correct, unless the word INCORRECT appears beside it)
(Tests where you have submitted no result are scored as INCORRECT)

Gram reaction: +
Shape: r
Acid-fast: +
Spores: -
Motility: -
Grows in air: + Note: your organism can grow at 52°C.
Grows anaerobically: -
Catalase: +
Oxidase: -
Acid from glucose: +
OF test: -
Gas from glucose: -
Acid from sucrose: -
Acid from lactose: -
Acid from maltose: -
Acid from mannitol: - INCORRECT
Acid from dulcitol: -
Nitrate reduction: +
Citrate utilisation: - INCORRECT
Indole production: -
H_2S production: -
Methyl red test: -
Voges Proskauer test: -
Urea hydrolysis: +
Gelatin hydrolysis: -

Your score for this part of the project is: 23 out of 25
(Please note: some of the tests carry negative marks if they are incorrect)

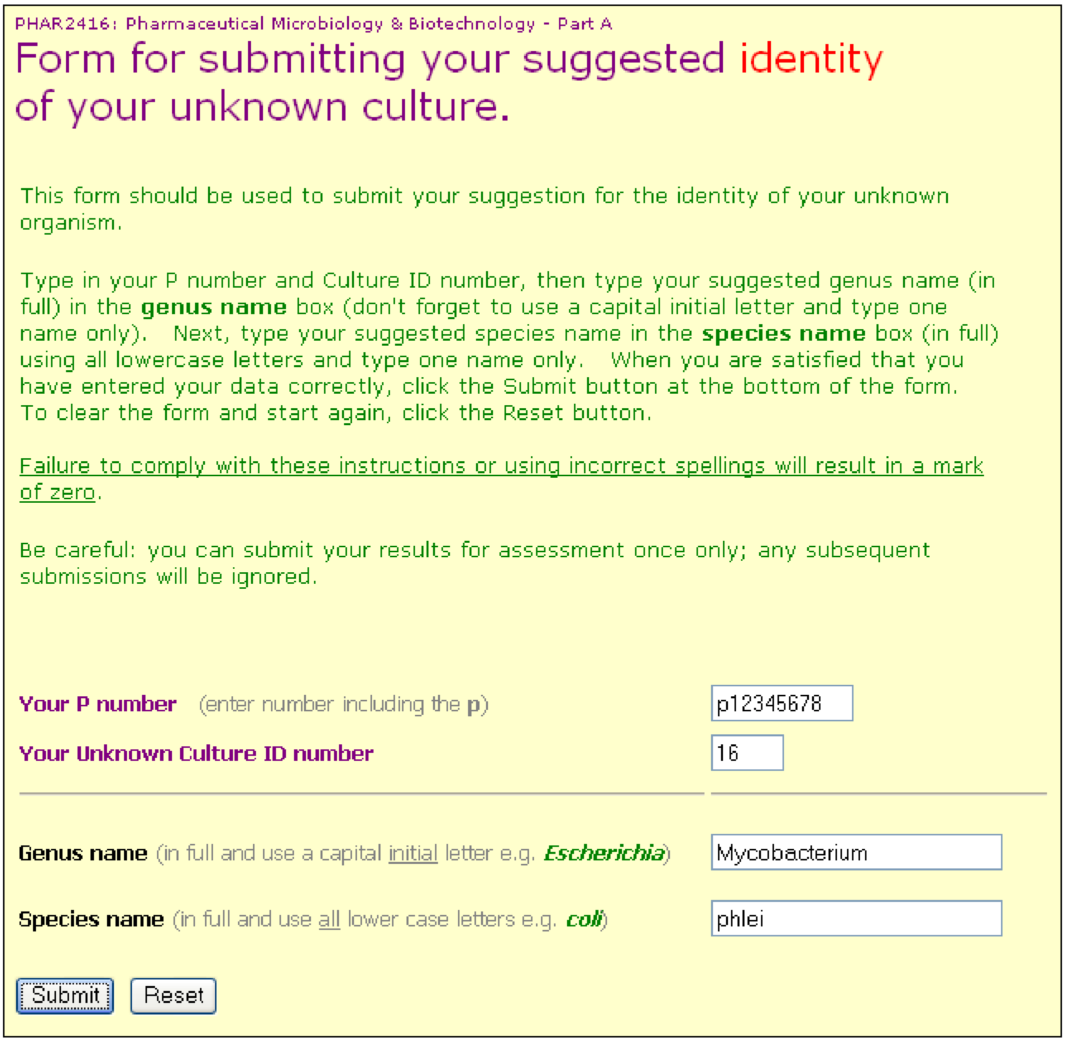
Figure 2: Feedback web page received after a student submits their test data



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Shape	R	S	S	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	R	R	R	R	R	R	R	R	R	R
Motility	-	-	-	-	-	-	+	+	-	+	-	-	+	D	-	-	+	-
Grow in air	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+	-	-	+
Grow anaerobic	+	+	-	-	-	-	-	-	-	-	+	+	+	+	+	+	-	+
Catalase	d	D	+	+	+	+	+	+	+	+	+	-	+	+	D	-	D	-
Oxidase	-	?	+	+	-	+	+	+	+	+	+	+	+	-	-	+	+	-
Glucose (acid)	D	-	+	-	+	-	+	-	+	+	+	+	+	+	D	-	-	+
O/F test	F/-	-	O	-	O	-	O	-	O	O	F	F	F	F	NT	-	-	F

List of genera in this Table

Figure 3: Part of the web page of the Bacterial Identification Program.


PHAR2416: Pharmaceutical Microbiology & Biotechnology - Part A

Form for submitting your suggested identity of your unknown culture.

This form should be used to submit your suggestion for the identity of your unknown organism.

Type in your P number and Culture ID number, then type your suggested genus name (in full) in the **genus name** box (don't forget to use a capital initial letter and type one name only). Next, type your suggested species name in the **species name** box (in full) using all lowercase letters and type one name only. When you are satisfied that you have entered your data correctly, click the Submit button at the bottom of the form. To clear the form and start again, click the Reset button.

Failure to comply with these instructions or using incorrect spellings will result in a mark of zero.

Be careful: you can submit your results for assessment once only; any subsequent submissions will be ignored.

Your P number (enter number including the **p**) p12345678

Your Unknown Culture ID number 16

Genus name (in full and use a capital initial letter e.g. ***Escherichia***) Mycobacterium

Species name (in full and use all lower case letters e.g. ***coli***) phlei

Submit Reset

Figure 4: Web form for students to submit the identity of their unknown culture.

The change to online assessment was introduced for the 2005-2006 cohort of students. A detailed description of the nature of the assessment and the procedure the students were expected to follow was provided on the Blackboard® module website. This was augmented by a 5 minute presentation during a lecture, using screen shots similar to those used in this paper. The period allowed for online submission of the project data was three weeks from gathering all the experimental results. After this, the links to the submission forms were removed from the Blackboard® module website.

Results and Discussion

All 149 students in the 2005-2006 cohort submitted their data by the deadline, with one student completing the project within two hours of the submission forms being made available on the Blackboard® website for the module! With regard to identifying the correct organism, 133 students (89%) got the identity completely correct (i.e. both genus and species names), 6 students (4%) got just the genus name correct and 10 students (7%) failed to get either name correct. Only one student failed to conform to the convention on biological nomenclature, erroneously using a capital initial letter for the species name.

The level of attainment in this project was very high, with 83% of the student cohort obtaining at least 30 marks out of a possible 40 marks and two students obtaining full marks, so producing a skewed distribution (Fig. 5). This is far higher than in the two previous cohorts, where students had to submit a written report, instead of presenting their data online, and where the data are normally distributed (Fig. 5).

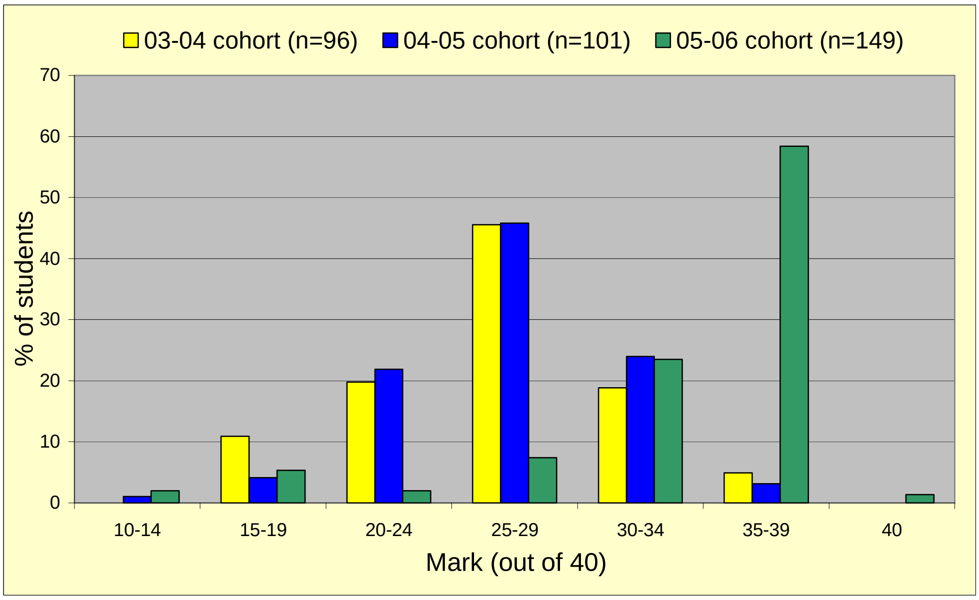


Figure 5: Comparison of bacterial ID project marks achieved by 3 cohorts of students. Only the 05-06 cohort was assessed online; the two other cohorts were assessed by submitting a written report.

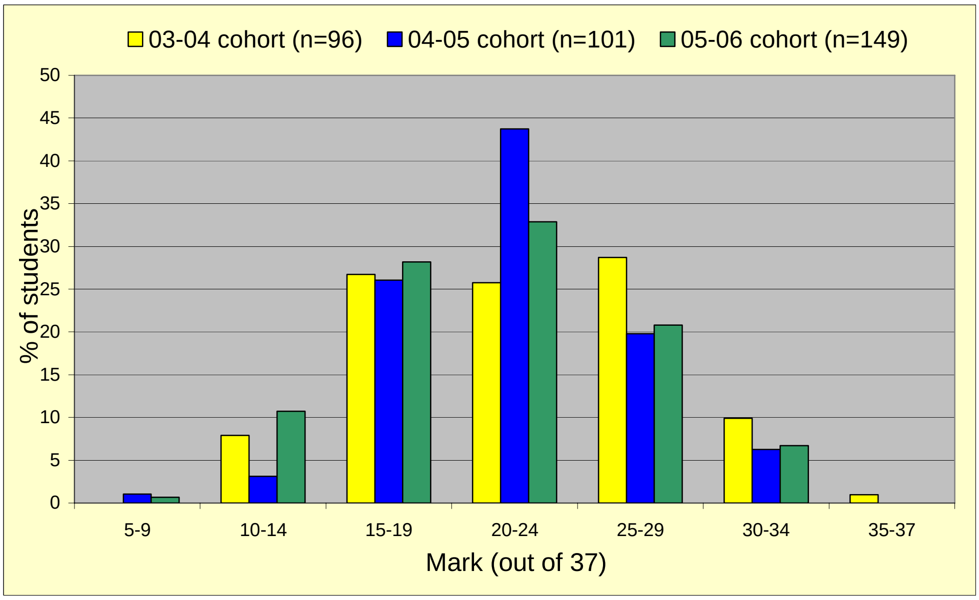


Figure 6: Comparison of non-project coursework marks by the 3 cohorts of students.

Analysis of the marks for the rest of the coursework (i.e. excluding the project), where the method of assessment had been identical for all three cohorts, revealed that there was little difference in levels of attainment between the cohorts (Fig. 6). This suggests that the online assessment of the project had skewed performance towards an over-optimistic assessment of student ability which did not match the tutors' perceptions of the students' laboratory skills during the classes. This might be avoided in future by more carefully controlling student access to various stages of the project. It was felt that students might have been using the results of their tests to tentatively identify their culture *before* submitting their tests for assessment and submitting test results that they *expected* to obtain, rather than those that they actually obtained, to increase their mark. In future, it is proposed to prevent access to the identification program until all students have submitted their test results.

Another reason for the higher marks may have been the absence of discursive discussion, construction of tables of data and diagrams in the online assessment, which were all required, and assessed, in the written report. Today's students tend to be relatively weak in these skills. A further difference between the two forms of assessment was that the results of the tests were not specifically marked in the written report, whereas in the online assessment, they represented 50% of the project mark.

An anonymous, online, student feedback questionnaire revealed that online assessment was popular with the 05-06 student cohort (Table 1). Those students who also offered comments, generally, were very complimentary (Table 2). From the tutor's standpoint, the online assessment method will provide a substantial saving in time, now that the software has been written and the system is in place and has been tested. It will help to cope with the increasing numbers of students being recruited to this course. An added advantage is that it is a totally objective form of assessment, whereas it is difficult to avoid some subjectivity when assessing written reports. Thus, it obviates the need for double marking. In addition, there is greater scope for the analysis of student achievement by interrogating the database, which is both simple and quick to do. Archiving the database for year-on-year comparisons is also easily done.

The input of student information at the start of the project was not a huge task, mainly consisting of downloading student data from Blackboard® then copying and pasting it into the database as a text file. Recording the Culture ID Number that each student had chosen was done in the laboratory class, using an Excel® spreadsheet on the tutor's PDA. This information was then uploaded into the relevant table in the database, again as a text file.

	With regard to the Bacterial ID Project...	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
1)	...I liked being able to present my data online for assessment	37 (54%)	27 (39%)	4 (6%)	1 (1%)	0 (0%)
2)	...I would rather have presented my data in the form of a written report	1 (1%)	2 (3%)	20 (29%)	24 (35%)	22 (32%)
3)	...I liked being able to receive online feedback on this coursework	44 (64%)	22 (32%)	2 (3%)	0 (0%)	1 (1%)
4)	...the project was a good test of my ability to analyse and interpret data	23 (33%)	38 (55%)	3 (4%)	4 (6%)	1 (1%)
5)	...the operation and assessment of the project were clearly explained on the website	29 (42%)	35 (51%)	3 (4%)	2 (3%)	0 (0%)
6)	...I found the project appropriately challenging	19 (28%)	40 (58%)	8 (12%)	0 (0%)	2 (3%)
7)	...the project was fairly assessed	25 (36%)	26 (38%)	14 (20%)	2 (3%)	2 (3%)

Table 1: Results of anonymous student questionnaire given to the 05-06 cohort about online assessment of the bacterial ID project (*n=69*).

1) I think that some people may have been at an extra advantage than others as they got a fairly easy organism and hence very good marks, and some of us had to struggle right upto the deadline.
2) I found it very interesting. enjoyed doing all the different tests etc.
3) I thought the project was really good. everyone having unknown bacteria meant we had to understand the work for urselves and it was fun. the online part was a really good idea and made everything much easier.
4) Very well organised thanks!
5) very original Dr.Andrew, liked your teaching method very much!
6) The continual application of tests to the unknown cultures we were given helped the practicals interlink with each other and gave them more purpose, since failure to complete the tests could have prevented good coursework marks.
7) Using online facilities made completeling the project more interesting and fun!
8) I found this style of assessment really refreshing.
9) Submitting online was easy an quick and enabled you to attempt the work at your own pace in your own time. However the bacterial identification program was difficult to understand, especially meanings of symbols.
10) Wonderful way of learning!
11) i didn't like the fact that you needed to get both the genera and specie correct in order to obtain the 25 marks possible. you got all 25 or nothing!
12) Excellent and interesting, thats my view on lectures, practicals and the E-learning.Its a pity that other modules do not benefit from the hardwork put in to it from the lecturers.
13) I felt that the help on Blackboard was really useful and I found it relatively easy using the ID program to identify my unknown bacteria.
14) i found this piece of coursework interesting and a good learing experience as it was new to me
15) I found this project very interesting and challenging and its was presented in a very interesting way for which I must thank Dr.Andrew, I would definately get a first class degree if all the tutors were organised like him.
16) I prefered the online report because it was quick and simple to use, which meant more time could be spent on analysing/interpreting the results obtained rather than typing out a full report.

Table 2: Student comments (literal transcription) from the questionnaire about online assessment of the bacterial ID project.

It is not intended to re-consider the use of QuestionMark Perception® or Microsoft Excel® to handle the data in future, due to the respective disadvantages of these applications (discussed above). This decision was reinforced by the ease with which a MySQL database can be maintained and re-populated, year-on-year, and the satisfaction of being able to create customised PHP web pages with little difficulty. This has led to the author using PHP scripting to create other applications, such as online student feedback questionnaires with real-time analysis of the submitted data (as used to gather the data in Tables 1 & 2).

Conclusion

It is intended to continue to assess the project online for future cohorts of students, using PHP-scripted web pages, with the attendant benefits offered by this method of assessment. However, the submission criteria and the weighting of the assessed components will be adjusted to produce, what is considered to be, a more realistic representation of students' laboratory performance.

References

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