Evaluating peer assessment of practical write–ups using an explicit marking schedule - same approach, different institution

Raul Sutton, Terry Bartlett, Matthew Bellamy, Daron Fincham, John Mole and Chris Perry

School of Applied Sciences (Biosciences Division),
University of Wolverhampton,
Wulfruna Street, Wolverhampton, WV1 1SB, UK

R.Sutton@wlv.ac.uk

Background and rationale

The introductory biochemistry module at the University of Wolverhampton is studied by students taking a wide range of life science degree disciplines and BTEC programmes. As a consequence, students studying this module have a highly variable range of entry qualifications. These range from as little as one 'standard' A2 level pass grade to students with four or five passes at A2 with high grades. The module is also accessed by students with AVCE and BTEC qualifications, overseas students and students entering higher education through access courses and foundation year programmes.

We were enthused about the possibility of using peer-assessment after hearing Ian Hughes describe his method of using explicit marking schedules for peer-assessment of practical work at the University of Leeds (see Case Study 5 by Hughes). In particular, we were interested in seeing whether a similar method could replace tutor marking for our broad range of students, whether there would be a time saving element for staff and whether there was a measurable improvement in student performance. Subsequently we have developed and evaluated peer-assessment for a series of four practicals in the introductory biochemistry module.

How to do it

The first step in assessing any work is to have a clear vision of what you wish to assess. We had a well developed practical regime with schedules and guidelines in use for many years. The schedule provided general guidelines on good practice for writing practical reports. Tutor marking was traditionally done using a marking scheme, which articulated good practice, such as the proper presentation of tables and graphs and clear explanations when drawing up conclusions. However, much of proper practice is assumed to be known to experienced assessors and is not therefore clearly articulated in marking schemes. The first step was to clearly define our expectations of the standards expected by the student when preparing practical reports. We drew up specific guidelines for the student for each practical.

In constructing these guidelines we had in our mind the peer-assessment marking schemes. We thought that a close link between guidelines and assessment would both emphasise and reward good practice. For the assessment itself we drew up marking sheets that rewarded independently every item of good practice that we wished the students to adopt. In constructing the assessment sheets, we tried where possible to give no areas for ambiguity when assigning marks. We did this for a number of reasons:

- Students are not experienced assessors and will need confidence building. This is best achieved by clear unambiguous guidelines that the student can easily interpret.
- The less students rely on judgements the more accurate their marking is likely to be;
- The peer marking exercise will be carried out in class with a tutor present. We treated the exercise like an exam and allowed students to ask questions when they were unsure about awarding marks. Clear assessment guidelines meant fewer interruptions to ask questions.

Each item on the peer-assessment sheet was clearly articulated with marks awarded accordingly. Although each item did not contribute much to the overall total the fact that every student had to consider each item independently made each student focus on good practice.

How do we encourage students to take the peer-assessment task seriously?

Our previous experiences with peer-marking of oral presentations raised a concern that students did not always take the exercise seriously. Students had appeared hesitant of awarding the full range of marks, not wishing to fail a peer or not confident enough to award top grades when they were deserved. The assessment sheets addressed this to some extent. However, in any group of undergraduates there are some who do not approach such activities with due seriousness. The first step at mitigation was to allow each student to take ownership of the marking of another's work by identifying themselves as the marker on the peer assessment sheet. The second step in emphasising that each student should treat the task with due respect was to inform students that each script would be second-marked by the tutor. The tutor would then be in a position to penalise any students marking unfairly. The system we used for penalties was that students over-marking another's script would have these marks removed from their piece of work, whilst under-marking would transfer marks from their work to the assessed work. Thirdly, to create an appropriately serious atmosphere, students were asked to work individually in silence and only asking the tutor for advice.

How could we enable students to see this as a positive learning experience?
Each time the assessment took place a consistent message was reiterated that peer-assessment was a learning exercise, that student performance improved and that it was important that students are involved in the assessment process.

How did we conduct the peer-assessment process with our students?
Students worked individually, generating their own data sets for subsequent analysis. They attended practical classes every other week and submitted their practical reports at the following practical class. The reports were then redistributed to other benches to ensure that no student marked either their own work or that of a working partner. The marking schemes were then distributed and students filled in the top sheet with their name and the name of the student whose script they were assessing. Each section of the mark scheme was then described by the lead demonstrator, and students completed the marking of that section. Students could ask for help, but in giving help an effort was made to encourage students to use their judgement. Questions like, 'Should I award a mark for this?' would receive a reply along the lines of 'Well what to do you think?' or 'In your opinion does this deserve a mark?' We did this to avoid a situation where the students were too reliant on the teaching staff and to get students to use their own judgement. This process was repeated until each section of the report had been assessed. The marks for each section were then added, an overall mark given and a grade awarded.

Does it work?
How do we test the validity of peer-assessment by students?
The validity of peer-assessment was tested by second marking a representative sample of scripts at each of the grades A (first-class) to F (clear fail) and comparing the second grades with the peer grades. For the first practical marked, students scoring well in the practical produced reliable assessments, less poorly performing students did not. However, by the second practical, students across the whole range of abilities marked reliably. Our major conclusion was after experiencing one complete cycle of peer-assessment all the students were able to produce as reliable an assessment as our staff could achieve (Bartlett *et al.*, 2003).

Is there a measurable improvement in student performance?
We compared student performance in this module with that in a companion first year module as a control. In the control module there was no significant difference between practical grades in 2002/03 compared with 2001/02. In contrast, analysis of the mean grades for this module shows that the cohort that was peer assessed in 2002/03 performed significantly better (95% confidence) than the previous year's cohort that was tutor marked. The mean grade improvement was from the bottom to the top of the upper-second class level.

The major factors yielding success included:
1. impressing on the students that the task was to be taken seriously,
2. careful construction of the guidelines for student report writing and the peer marking sheets,
3. emphasising the educational value of the process,

Careful thought and preparation made the whole process relatively trouble-free.

There were a number of problems that we encountered. These included student resistance to the marking process. Despite reiteration of the positive values of peer-marking, some students were reluctant to engage with the process with statements along the lines of they were "doing our work" or "the process was hard work". We feel that the benefits to staff and student alike outweigh these negatives and are continuing with the process in this academic year.

Further developments
The scheme was partially successful as we operated it. The staff marking time was reduced by two thirds. Although the exercise was easy to manage when integrated into practical sessions, this took away from the positive experience of practical sessions which most students find rewarding. This also meant that some practical sessions were restricted for time. We are reducing the actual assessed part of the work in order to reduce repetitive parts of the marking and the time taken. We will complete the marking of each practical in a lecture room, with all the students and four lecturers, in a single session. This will reduce marking time using peer-assessment by a further half.

Peer assessment Marking Scheme

Practical 2:
Separation of Haemoglobin and Cytochrome c by Ion Exchange Chromatography

Your name
Student name
Grand total

Name, Date, Title of practical		Marks available 3
a) Name	Full name should be clearly displayed •	
b) Date	Date should be clearly displayed •	
c) Title	Should be very similar to the one given in the practical manual, *i.e.*, Separation of haemoglobin and cytochrome c by ion exchange chromatography •	
	Total	

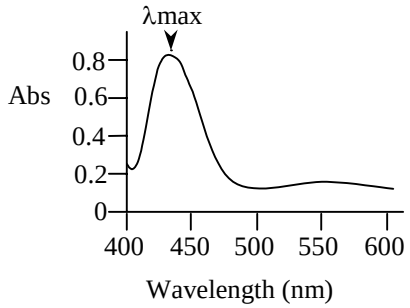
Abstract		Marks available 8
Example: "The aim of this experiment was to separate two proteins using ion exchange chromatography. A mixture of haemoglobin and cytochrome c was loaded onto a carboxy-methyl (CM) sephadex ion exchange column and the proteins eluted using 50mM phosphate buffer, followed by high salt (1M NaCl) 50mM phosphate buffer. Fraction 1 had a λmax of 430 nm (haemoglobin). Fraction 2 had a λmax of 415.5 nm (cytochrome c). The recovery of cytochrome c was calculated to be 95%. The procedure therefore successfully separated the two proteins.		
a) Aims	This should state the purpose of the experiment, *i.e.*, to separate haemoglobin from cytochrome c •	
b) Methods	using "ion exchange chromatography" (or similar) •	
c) results	Should give the λmax values for fractions 1 and 2 • % recovery of cytochrome c •	
d) conclusions	Fraction 1 was haemoglobin, fraction 2 was cytochrome c • The haemoglobin and cytochrome c were successfully (or unsuccessfully) separated •	
e) Presentation	Concise presentation (one or two sentences per point a to d above) • Less concise (more than two sentences for some of the points) • Too long or too short (more than 2 sentences for all of the points, or not enough/ no information for some or all of the points) – **0 marks**	
	Total	

Introduction		Marks available 12
Note: The information in the table below shows the sort of topics that should be covered by the introduction, *i.e.*, the **background theory** to how ion exchange chromatography works and a statement as to the **purpose/aim of the experiment**. There is **no need** for detailed information about what haemoglobin and cytochrome c are, or what their function is in the cell. The important thing is they are proteins with different charges and absorption spectra. ***You** have to decide if the important points have been covered/explained correctly, as the introduction you mark will obviously not use exactly the same wording as the examples below.*		
a) Experimental Theory	Proteins can be separated based on their charge • Ion exchange chromatography/beads • in a column • is a practical way to do this Cellulose beads can have attached groups that have a positive or negative charge • CarboxyMethyl cellulose has a negative charge (at pH 7.0) and binds positively charged proteins • Haemoglobin and cytochrome c will bind differently to CM cellulose • , so can be separated by passing the mixture down a column packed with CM cellulose beads • Adding high salt buffer will remove bound protein from the beads allowing it to be collected •	
b) Aim(s)	To separate haemoglobin from cytochrome c based on binding to CM cellulose beads •	
c) Clarity of writing	If the introduction section was clearly written and easily understandable • If however it was a bit unclear in places give • instead If it was poorly written • hard to understand or didn't make sense – **0 marks**	
	Total	

Results part 1: Spectrophotometer traces

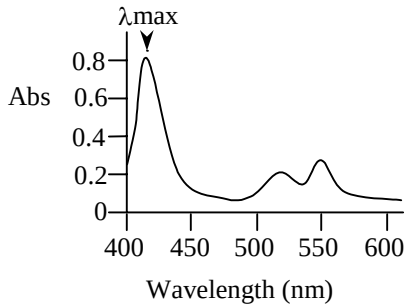
Note: You may be marking a practical script which has both spectra printed on the same trace. If this is the case, simply duplicate the marks you award for "trace 1" to "trace 2" below

Example trace:
The absorbance values will be different on the one you mark



Results part 1: Trace 1	Marks available 8	
a) Title	Should be labelled "*Trace 1*" • Should mention fraction number • Should mention absorption •	
b) Axes	Should have the scale values marked on (400, 0.4 etc.) • X axis should be "*Wavelength (nm)*" • Y axis should be "*Absorbance*" or "Abs" •	
c) λmax	The highest peak on the trace should be labelled "λmax" •	
	Total	

Example trace:
The absorbance values will be different on the one you mark



Results part 1: Trace 2	Marks available 8	
a) Title	Should be labelled "*Trace 2*" • Should mention fraction number • Should mention absorption •	
b) Axes	Should have the scale values marked on (400, 0.4 etc.) • X axis should be "*Wavelength (nm)*" • Y axis should be "*Absorbance*" or "Abs" •	
c) λmax	The highest peak on the trace should be labelled "λmax" •	
	Total	

Results Pt 1 - Table 1	Marks available 12	
Example Table: The **values** shown are examples. The **identity** of the protein in each fraction should always be as shown.		
a) Title	Should be labelled "*Table 1*" • Any sensible title •	
b) Column Headings	These should be similar to: "*Fraction*" or "*elution*" • "λmax" • "*Protein*" or "*Identity*" •	
c) Units	For λmax, units should be nanometers (nm) •	
d) λmax values	Around 425-435 for fraction 1 • Around 410-420 for fraction 2 •	
e)Correct identfication	Fraction 1 is Haemoglobin • Fraction 2 is Cytochrome c •	
f) Presentation	Very good • Okay • Poor/messy – no marks	
	Total	

Fraction	λmax (nm)	Protein
1	430	Haemoglobin
2	415.5	Cytochrome c

Results Pt 2 - Table 2 — Marks available 10

Example table
The absorbance values will be different in the table you mark

Example Title:

Table 2
Absorbance data for protein standards

Amount of protein (mg/test vol)	Absorbance (410nm)
2.0	0.7
1.6	0.497
1.2	0.366
0.8	0.255
0	0

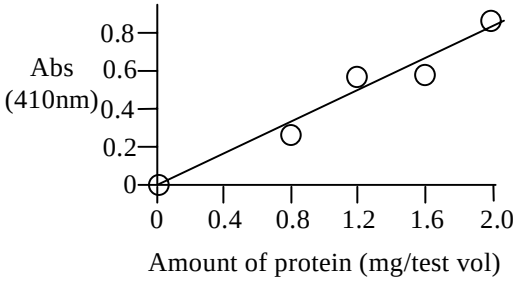
a) Title	Should be labelled "*Table 2"* • Should mention **"***absorbance***"** •	
b) Column headings	These should be similar to: *"Amount of protein"* or *"Concentration"* • *"Absorbance"* •	
c) Units	(mg/test volume) or (mg/10 cm^3) for protein column • (**410 nm**) for absorbance column •	
d) Values	• for a complete set of **protein** standards values that matches the set in the example table (including 0) • for a complete set of **absorbance** values	
e) Presentation	Very good • Okay • poor/messy – **0 marks**	
	Total	

Results part 2. Graph 1 — Marks available 20

a) Title	Should be labelled "*Graph 1"* • Should mention **"***calibration***"** or **"***standard curve***"** • Should mention cytochrome c •	
b) Axes	**absorbance** should be plotted on the Y axis •	
c) Axis labels	X axis should be "*Amount of protein*", or similar • Y axis should be "*absorbance*", or similar • Use of units (410nm, mg/test volume or similar) •	
d) Scale	Should start at **zero** on both axes • Sensible range (not too much empty space) • Values accurately plotted on scale •	
e) Points	There should be 5 points plotted • If all the points are plotted accurately give • (for 1 or more errors, give •)	
f) line of best fit (LOBF)	Should be a **straight line** • starting at the origin • It should be as close to the points as possible (award • for a very good fit, • for a less good fit)	
g) plotting unknown protein	Accurate horizontal line from Y axis to LOBF, Accurate vertical line from LOBF to the X axis •	
h) presentation	Very good • Okay • poor/messy – **0 marks**	
	Total	

Example graph:
The Y axis range will be different on the one you mark

Graph 1. Calibration curve for cytochrome c



Results Pt 2 - Calculation 1 — Marks available 5

% recovery = Recovered amount x 100
Original amount

Example calculation
Figures taken from example **Table 1** and **Graph 1.**

% Recovery = 1.9 mg/test vol x 100
2.0 mg/test vol
= 95% recovered

a) Equation	Correct equation used •	
b) Values	Correct values used •	
c) Answers	% recovery correctly calculated •	
	Total	

Discussion — Marks available 12

The Discussion could include comments on:

The colour changes during the process as a demonstration of the separation •	
The requirement for salt to elute the cytochrome c •	
Use of λmax for identification of the protein in each fraction •	
How well the process worked or reasons why it didn't (more than just 'experimental error') •	

Question

The recovery is often less than 100%. How would one account for the cytochrome c apparently lost during chromatography? There are 3 possibilities:	
1) It didn't bind and came out in fraction 1 with the haemoglobin •	
2) It wasn't eluted by the salt elution and is still stuck to the beads •	
3) The readings for the calibration curve were inaccurate/the line of best fit was poor •	

Clarity of writing

If the discussion section was clearly written and easily understandable • If however it was a bit unclear in places give • instead If it was poorly written, hard to understand or didn't make sense – 0 marks	
Total	

References — Marks available 2

References should be listed as **Surname, initials (date) Title of book. Edition. Publisher details.**
e.g. CAMPBELL, M.K. (1995) *Biochemistry*. 2nd edition. London: Sanders College Publishing.

• for correct format, • if there were parts missing or they were in the wrong order (**edition** may not always apply)

Total

When you have marked all the sections, add up the totals **of each section to give a** mark out of 100 **and enter it in the box on page 1, along with** your name **and the** name of the student whose work you marked**.**