The Effectiveness of Self-Assessment as a Tool to Enhance Learning in the Laboratory

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Abstract

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A project was designed to find out if standards-based self-assessment, applied to laboratory reports, enhanced learning for first and second year biology students. Student participation, report grades and student feedback were analysed to measure the effectiveness of a self-assessment process.

As the term progressed, almost all (>90%) first year students with A or B+ grades (≥70% mark) used self-assessment. Over time first year student participation in self-assessment increased and their ability to accurately self-assess improved. Self-assessors achieved a higher average laboratory report mark compared to non-participants. The study concluded that the introduction of self-assessment had a positive impact on first year engagement and performance.

The findings were less clear for the second year cohort. Evidence that students with low-grades did not know how to improve their work showed that the self-assessment intervention alone was insufficient to enhance learning for this group.

Student surveys indicated a positive reaction from both cohorts of students to the standards-based self-assessment pro-forma. Recommendations are made for the application of self-assessment in laboratory report writing for junior undergraduates. Self-assessment training and improved feedback methodologies are proposed to deepen the efficacy of self-assessment as a tool to enhance learning in the laboratory.

Keywords: Self-assessment; laboratory report writing;

1. Introduction and Motivation

Practical work is a critical aspect of science education. Students value laboratory practicals both for their role in skills acquisition and illuminating theory (Willmott, 2005). Generic learning outcomes for science students include the ability to present and interpret experimental results. The traditional assessment methodology of correcting weekly laboratory reports and giving general feedback to the group is time-consuming but simple to employ as a form of summative assessment. Race (2006) highlights as one of the disadvantages of report-writing as an assessment tool, the danger that students spend too much time writing reports at the expense of getting to grips with their subject manner. Whilst moving away from report writing as a laboratory assessment method is one possible course of action, report-writing is a skill relevant to many science-based jobs. Laboratory reports also provide evidence of useful learning activities such as data analysis and comparison of measured findings with literature values (Race, 2006). The question for me as I considered how to improve laboratory assessment in a first year and second year biology modules was thus not the validity of laboratory report-writing but how to strengthen that validity.

Students writing laboratory reports often do not understand what is expected of them (O'Donovan *et al*, 2001). Amongst a series of guidelines for setting assessed report writing, Race (2006) recommends the inclusion of a standard assessment feedback grid to return to students with marked reports. Cathers (2007) used 'feed-forward' self-assessment of laboratory reports with first year science students. Timely feedback was provided so that students could use the information to improve subsequent work. He found that the requirement for self-assessment caused most of the students to give thought to what they had written. Students differ in the degree to which they generate their own internal feedback by reflection and self-assessment of their progress. Nicol (2008) argues that formal procedures such as requiring students to self-assess their work prior to assignment submission, helps to strengthen self-awareness and generate the internal feedback that is integral to learning. The impetus for introducing self-assessment was in part the gap I perceived between my expectations of clarity and insight and the students' understanding of what was required for a biology laboratory report. Hounsell *et al* (2005, p50) identified this need to assist students in coming to a conception of what constitutes good quality

work in the subject area which broadly matches that held by staff as practicing bioscientists.

This study was designed to introduce a formative element to the assessment of biology laboratory reports and find out if standards-based self-assessment enhanced learning for first and second year biology students. The objective was to encourage students to evaluate their laboratory reports prior to submission in a way that enhanced their understanding of the experiment.

2. Methodology

2.1. Participants

The first year biology class used in the study were a mixed group of 32 first year students of Higher Certificate Biology and Ordinary Degree and Honours Degree Bioanalytical Science. The second year students studying biochemistry were a group of 28 students with the same course mix as the first year group.

2.2. Self Assessment Methodology

A generic self-assessment pro-forma was initially designed for use in all the relevant biology practicals (Cycle 1). The format was based on the feed-forward assessment tables used by Cathers (2007). The rows contained the individual components (*Introduction, objectives, materials & methods, results, discussion, conclusion*). The columns described the grading criteria for each component. After the first round of use, the pro-forma was revised to make it task-specific (Fig 1) i.e. there was an individual pro-forma produced for each relevant laboratory practical. Students were asked to return a completed self-assessment pro-forma along with their laboratory report. Participating students were self-selecting (i.e. there was no control group). Student and tutor judgement on the standard reached for each component was indicated by ticking the diamond and the circle respectively, in the appropriate column.

First-year students were asked to use the self-assessment pro-forma for three biochemistry laboratory practicals (Termed Pr2S2, Pr3S2 and Pr4S2, where S2 stands for Semester 2) and one microbiology practical (Pr5S2). Self-assessment was used with the second year biochemistry students for three of their laboratory practicals

(Pr2S4, Pr3S4 and Pr4S4, where S4 stands for Semester 4). The self-assessment sheets were returned with corrected reports. The overall mark and a list of letters referring the student to the relevant section of a comments sheet were indicated in the laboratory notebook. Individual verbal feedback was given to students who underestimated or overestimated their performance.

Fig 1: Example of Self Assessment Sheet

Student Name: Student Number:

Tick the diamond (◇) that best describes your assessment of each section of your report.

Section	Contents	Review	Pass	B	A
Introduction	*Explanation of the principles of the procedures.*	No introduction or Verbatim from the manual. ◇ ○	Introduces the general topic but does not explain the principle of the procedures. ◇ ○	States the principle of the experimental procedure in their own words. ◇ ○	States the principle of the experimental procedure and also explains the methodologies in the context of the samples being tested. ◇ ○
Objectives	*Statement of the aims of the experiment.*	No or incorrect objectives stated ◇ ○	All of the objectives listed but poorly worded. ◇ ○	n/a	Correct objectives clearly worded. ◇ ○

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2.2. Student Feedback on Perceptions and Usage of Self Assessment

Students were surveyed about their usage level and perception of the self-assessment process. Informal interviews were also carried out with both self-assessors and non-participants during laboratory sessions.

2.3. Analysis of the Data

Student participation, report grades and student feedback were analysed to measure the effectiveness of the self-assessment process. Average grades for self-assessors and non-participants were compared using an unpaired t-test ($p \leq 0.05$ indicates a significant difference). Student participation levels in the self-assessment process were measured as a percentage of the students who submitted reports.

3. Findings, Results and Analysis

3.1. Student Participation

For both student groups, participation in self-assessment increased as the term progressed (Table 1). Positive word-of-mouth may have played some role in the increase in engagement with the self assessment process over time. Changes introduced as the study progressed to improve clarity and specificity may also have contributed to increased participation. Some students (15.6% of first years and14.3% of second years) did not use the self assessment pro-forma at all over the term. Reasons given for non-compliance included absenteeism and forgetfulness. Informal discussion comments on the difficulty in understanding the pro-forma, low initial usage and some mistakes in pro-forma completion suggest that there was a training deficit at the start of the process.

Table 1: % Return of completed self-assessment (S.A.) pro-forma

	First Year Students				Second Year Students		
Practical	Pr2S2	Pr3S2	Pr4S2	Pr5S2	Pr2S4	Pr3S4	Pr4S4
% S.A. Usage	52%	66%	69%	83%	43%	52%	67%

Table 1: % Return of completed self-assessment pro-forma by first and second year biology students
(Codes: S.A. = self assessment; Pr2S2=Practical 2, Semester 2; Pr2S4 = Practical 2, Semester 4)

3.2. Laboratory Performance using Grade as the Performance Indicator

The average mark for Self-Assessors was higher, in three of the four laboratory practicals (Table 2). However, the difference was significant only in the case of Pr4S2 (Table 2).

Practical	Average Mark Overall	Average Mark (SAs)	Average Mark (NonSAs)	Measure of Difference p-value (p<0.05 significant)
Pr1S2	5.3	n/a	n/a	n/a
Pr2S2	7.0	7.3	6.7	0.170
Pr3S2	5.8	6.1	5.3	0.176
Pr4S2	4.5	5.4	3.0	**0.009**
Pr5S2	7.0	6.9	7.3	0.414

Table 2: Comparison of the laboratory report marks for first year self-assessors and non-participants
(Codes: SA = used self assessment: non-SA: Did not use the SA form. Pr2S2=Practical 2, Semester 2)

Second-year self-assessors achieved a higher average mark (Table 3) than non-SAs, which correlates with the findings for the first year cohort. However, the differences were not statistically significant. Average marks decreased as the term progressed (Table 3) which may be attributable to increasing experiment complexity.

Practical	Average Mark Overall	Average Mark (SAs)	Average Mark (NonSAs)	p-value ($p<0.05$ significant)
Pr1S4	6.5	n/a	n/a	n/a
Pr2S4	6.3	6.7	5.9	0.2215
Pr3S4	5.5	6.0	5.0	0.1487
Pr4S4	5.3	5.5	4.9	0.3614

Table 3: Comparison of the laboratory report marks for second year self-assessors and non-participants *(Codes: SA = used self assessment: non-SA: Did not use the SA form. Pr1S4=Practical 1, Semester 4)*

3.3. Analysis of Student Performance

The range of grades for the first practical (Pr1S2) for the first year students suggested a diversity of ability and/or engagement, which concurred with this group's Semester 1 biology practical performance. The narrower range and significantly ($p<0.0002$) higher average mark recorded for the second practical (Pr2S2) is indicative of differences in complexity between the experiments rather than an effect attributable to the introduction of self-assessment. There was no significant difference between the average marks of SAs and nonSAs in Pr2S2 (Table 2) and almost as many non-SA students achieved a mark greater than 7 (70%). There was thus little indication after the first cycle of self-assessment that the process was improving students' ability to report and analyse their laboratory results.

Formal self-assessment had a significant positive effect on performance in the second cycle. Pr4S2 was the most complex and difficult practical of the five first-year biochemistry practicals with an average mark of just 4.5 (Table 2). A similar average mark (4.2) was recorded by the previous year's students indicating that the difficulties were not group-specific. The higher performance of the self-assessors suggests that self-assessment helped the students to enhance the quality of their work. Most of the students who did not use self-assessment got a low grade for Pr4S2, in many cases because they failed to complete the write-up. This suggests the usefulness of the standard-based self-assessment pro-forma as a cue for students. Race (2005)

categorises students as cue-seeking, cue-conscious or cue-oblivious learners. The Non-SAs in this study could be classified as cue-oblivious learners.

For the second year group, the broad range of grades throughout the term reflected a diversity of ability and/or engagement. Students attaining low grades for the first and second practical continued to do so in their later reports. This finding suggests self assessment in itself is not sufficient to enhance learning for students struggling to grasp basic biological concepts. However, insufficient feedback may account for the neutral outcome of the intervention in this case. Overall, grade analysis suggests the first year cohort gained more benefit from self assessment than the second year students.

3.4. Feed-forward Dimension

Nicol and Mcfarlane-Dick (2006) highlighted the importance of feedback on students' attempts to self-assess their own work as a means of helping students to self-correct their own performance. Ensuring individualised feedback proved difficult. High levels of absenteeism, limited contact time and the informal manner of the feedback mechanism meant that some students did not receive the envisaged opportunity to 'feed-forward' information and improve subsequent reports. This is evidenced by the first year student who filled out the self-assessment pro-forma incorrectly on three consecutive occasions.

In judging whether students' performance improved over time, differences in the complexity of the experiments invalidate direct grade comparisons. For first year self-assessors individual student marks as a multiple of average marks for each individual experiment show a general upward trend within the biochemistry section of the module which may indicate feedback fostering improvement.

Student surveys indicated that students found the self-assessment pro-forma useful for reviewing their work and checking that they had covered all sections. The apparent greater efficacy of self-assessment as a tool for learning for the first-years compared to second years in this study may reflect a greater resistance to change in the more experienced students. However, it may also result from the fact that the second year practicals are more complex. Students who struggle with understanding the basic scientific principles are not necessarily helped by having the opportunity to

evaluate their own work, particularly if the feedback available is sporadic or insufficient.

3.5. Student Survey Findings

When students were surveyed about their use of the self-assessment pro-forma the majority of both cohorts agreed that the pro-forma helped them to write a better report to an extent and nearly 40 % agreed strongly. The findings on grade performance reflect this for the first year cohort but the second years appear to have overestimated the efficacy of the process.

About one-third of self-assessors reported that they either did not re-read their report on initial completion or did not change anything after re-reading. Given the anonymity of the survey, it was not possible to cross-reference this cohort, with the students who (correctly) gave themselves low grades. In interviews some students highlighted a lack of understanding of the principles of the experiment as the barrier to improving their reports prior to submission.

A recurring student comment for both cohorts was the insight it gave them into how reports are marked. A random sample of students was informally interviewed about their attitudes to the self-assessment process. Attitudes were positive amongst self-assessors. There was an emphasis on its usefulness in ensuring their report contained all the necessary information which backs up the survey findings.

4. Conclusions and Future Work

Simply explaining standards is insufficient to deliver meaningful knowledge (O'Donovan et al, 2004). Self assessment gave the students an insight into how laboratory reports are assessed, a process that up to now was opaque to them. Students responded positively to being brought into the assessment process. In my opinion, this facilitation of assessment transparency should be encouraged and expanded.

The standards-based self-assessment methodology employed in this study offers a starting point for improving delivery of the practical modules described. However, analysis of its implementation highlighted potential areas for improvement. The aim should be to further develop the opportunity self assessment presents for students to experience assessment as part of learning.

It is arguable that the training deficit in the model used contributed to low initial uptake. Having completed the study, the need for training in two areas is apparent: how to interpret the assessment criteria and how to assess their own work. The model outlined by Rust *et al* (2003) provides a framework for such training. This training model would require the preparation of exemplar laboratory reports for individual assessment by students and the organisation of a workshop designed around small group discussion of the assessment.

The findings of this study suggest that the task-specific self-assessment pro-forma was more useful to students and less confusing than the generic pro-forma used in the first cycle. The survey results offer some pointers for further improvement in its design. The references to lack of time by some of the students suggest the length of the pro-forma may have discouraged participation. In the course of preparing task-specific pro-forma, care must be taken not to over-complicate them. Nicol (2008) suggests increasing student responsibility by involving them in defining the criteria. I recommend dialogue on the design of self-assessment documents with students who have used them, to help improve clarity for subsequent users.

Bevan *et al* (2008) in their investigation of staff and student perceptions of feedback recommended a well-defined personalised feed-forward approach. Providing timely personalised feedback was important to this project's aim of enhancing learning in the laboratory. The ad-hoc manner in which feedback was conveyed to students meant opportunities were lost for encouraging feed-forward reflection. Weekly formal documentation of the feedback process is a simple measure that would ensure better feedback control. Electronically delivered feedback is also an option. Individual discussions with the tutor could take place on Moodle™. The difficulty with this approach is ensuring involvement. Students are more likely to engage with feedback when they are not given the final grade (Race, 2006). I recommend students are given back the self-assessment pro-forma at least fourty-eight hours before they get their grades. In the case of students identified as in need of feed-forward intervention, their grades would then be posted electronically, once the student has discussed the feedback with the tutor (face-to-face or on Moodle™). Timely intervention is particularly critical for students who do not understand the basic scientific principles of the experiments, as implied by the findings on poor-performing second years in this study. The full potential of self-assessment can only be realised in the context of a well-structured feed-forward mechanism.

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