Journal of the Scholarship of Teaching and Learning, Vol. 15, No. 2, April 2015, pp. 70 - 82.
doi: 10.14434/josotl.v15i2.13271

Training final year students in data presentation skills with an iterative report-feedback cycle

Heather Verkade[1]

Abstract: Although practical laboratory activities are often considered the linchpin of science education, asking students to produce many large practical reports can be problematic. Practical reports require diverse skills, and therefore do not focus the students' attention on any one skill where specific skills need to be enhanced. They are also time-consuming to write and mark, limiting the speed at which feedback can be returned. To focus students specifically on the skills of data presentation and interpretation, a weakness noted in many reports in the past, students were required to produce a results figure, as would be found in a journal article, one for each of four practical topics. The students found this a challenge, but their skills improved markedly over the semester due to an efficient feedback cycle. Students were very engaged with this assessment, as it caused them to re-consider what they understood about the results of the practical. As this assessment is a small focused version of a practical report, it allows faster marking and return of practicals. This is therefore a successful method of focusing students' attention on presenting and interpreting practical results, in an efficient and cost-effective manner.

Keywords: practical reports, formative, interpretation

Practical laboratory activities have been considered central to teaching laboratory-based science since the 1890s (Adams, 2009; Hofstein & Lunetta, 2004; Hughes, 2004; Lerner, 2007). Practical activities allow a hands-on and social learning approach, provide meaningful context for both concepts and content, and allow students to exercise their observational and analytical skills (Collis, Gibson, Hughes, Sayers, & Todd, 2008; Gratz, 1990; Kirschner & Meester, 1988; Wilson et al., 2008). The learning outcomes that can be achieved from practical activities can be summarised as the following: students learn to present their practical data in a meaningful way through graphs, tables and figures; students learn to describe and interpret their results; and students learn how to consider the implications of their results in the context of the extant literature. As these components are all demonstrated in the standard professional forum for scientific results, the primary journal article, practical class written assessments can sometimes take this form. However, in undergraduate teaching a standard practical report is often used as a surrogate for the primary journal article (Corradi, 2012). Regardless of the format, formal scientific writing contains significant challenges for undergraduate students (Tilstra, 2001; Whelan & Zare, 2003). Intensive training in writing practical reports (Jones, 2009; Tilstra, 2001) or scaffolded writing approaches (Deiner, Newsome, & Samaroo, 2012; Greenbowe, Rudd, & Hand, 2007) are some of the proposed solutions to this ongoing challenge (Hughes, 2004; Walsh, Parry, & Larsen, 2010). Here, the practical report as been deconstructed, and only the results section has been used, in order to focus students on the presentation and interpretation of results.

[1] School of Biological Sciences, Faculty of Science, Monash University, Australia, heather.verkade@unimelb.edu.au

A. Advantages and disadvantages of full practical reports

Practical reports have long been a standard assessment task in laboratory (and field) based science undergraduate teaching (Lerner, 2007). The following learning outcomes from writing practical reports can be identified:

1. Writing the introduction of a practical report gives students practice in accessing and utilising the scientific literature to summarise and present relevant information.
2. Writing a practical report requires a student to consider the purpose of an experiment in order to clearly present the results and interpretation.
3. Writing the results section of a practical report gives students practice in the presentation and analysis of experimental results.
4. Writing the discussion section of a practical report requires students to link their observations with the scientific literature and to consider the broader implications.

There are, however, some important limiting factors when using practical reports as assessments:

A. Practical reports are time-consuming for the student to write. In a unit/class with both practical and lecture/tutorial components, the lecture-based final examination is often heavily weighted in the final mark, causing students to become frustrated at the large amount of time spent writing multiple large practical reports.
B. Practical reports are time-consuming to mark. Paying teaching associates for marking is a significant component of many teaching budgets, especially with large (and increasing) class sizes. For many providers of higher education, there is pressure to reduce teaching budgets without compromising learning outcomes (Hughes, 2004; Watson & Knight, 2012).

The students in this final year unit/class are already proficient at the research skills described in advantage 1. However, they need improvement in the middle-order skills of demonstration, analysis and interpretation, which form part of advantage 2 and 3, and which would be specifically encompassed in the results section of a practical report. They also need practice with the higher order skills of evaluation and comparison, advantage 4, which is encompassed in the discussion. These discussion skills, however, can be assessed by a series of carefully constructed 'analysis questions', requiring students to consider the practical results in light of the information from the lectures, and the scientific literature. This is a commonly used method to guide the students' thinking and analysis (Hughes, 2004). In this study, reduced-size practical reports were used to balance the advantages of practical reports with the disadvantages of the time spent writing and marking. The aim was an assessment task that provides meaningful practice to students in advantages 2 and 3 (the demonstration, analysis and interpretation of results) as well as retaining advantage 4 in the form of analysis questions, while reducing the student and marker workload.

B. Replacing full practical reports with a Results Figure and Analysis Questions

In 2012, this unit/class contained four practical classes with written assessments and a lecture component with a final exam. In previous years, this unit/class only required a full practical report for one of the practicals. The other three were assessed with guided analysis questions, which aimed to probe the students' understanding of the concepts covered in the

practical, and to some extent, their ability to use the literature to find information. The analysis questions thus provided practice in advantage 4, listed above. However, the students did not spend time considering their experimental results. In 2012, the assessments of the practicals were altered so that all four of the practicals required the students to present and interpret the practical results. This written assessment was designed as a much smaller assessment task than a full practical report. The assessment task consisted of:

1) Answers to guided Analysis Questions: 75% of the mark. Questions designed to probe the students understanding of the content and concepts from the practical class and the associated lectures, and their interpretation of how the experimental result fits in with current knowledge
2) A Results Figure: 25% of the mark. The students presented and interpreted the results from one of the experiments in the practical class. The Results Figure required:
   a) Figure panels showing the data as labelled graphs or images with suitable labels and/or arrows
   b) A figure legend explaining the figure panels, as would be expected in a journal article
   c) A results paragraph describing the experiment and the results, with the level of interpretation expected for the results section of a journal article

Teaching associates marked the assessments using the marking guide (provided to the students in advance), giving written feedback and referring to a general feedback sheet, the 'guide to common mistakes'. These were returned to the students before their next practical assessment was due. As the formats were standardised, and the students received timely feedback, these assessments provided a formative opportunity for improvement across the four practical assessments.

The educational (and administrative) aims guiding these changes were:

Aim 1. To provide the students with the level of practice in demonstration, analysis and interpretation of results that they would get from four full practical reports.
Aim 2. To limit the marking by tutors or academics (to less than four full practical reports).
Aim 3. To increase the efficiency of marking such that each practical assessment can be returned to the student with clear feedback before the next assessment is due, so as to develop a formative feedback cycle.

I. Methods

The class was a final year (3rd year) unit/class taken predominantly by Bachelor of Science students. Ninety-three (96%) students took part in this study. The four practicals were: one week examining *C. elegans* vulval development and two weeks each examining *Drosophila* terminal patterning, zebrafish neural specification and *Arabidopsis* flower patterning.

The assessments were marked by Teaching Associates using a marking guide (Appendix 1). Together, these four practical reports contributed 24% of the mark for the unit/class. As the results figures are 25% of each practical assessment, they therefore contributed 6% to the final mark of the unit/class. For the final assessment task, the students were required to select one of their four results figures on which to write a full practical report, with the intention that they would take their results figure, which they could improve based on the feedback, and add an introduction and discussion.

The marks of the practical assessments were analysed in Microsoft Word Excel 2007 and IBM SPSS Statistics 20. A Kolmogorov-Smirnov test of normality returned Asympt. Sig. (t-

tailed) = 0.169, 0.408, 0.221 and 0.020* for the distributions of results figure marks from the four practicals respectively, and 0.191, 0.101, 0.070, 0.139 for the distributions of the analysis questions marks from the four practicals respectively. These tests indicate that all are in normal distributions except for the fourth results figure marks (shown with an asterisk), so it was decided that these data could reasonably be represented using the parametric descriptives of mean, standard deviation, standard error and quartiles. However, non-parametric statistical tests were used for the fourth results figure marks.

Two questionnaires were administered to the students, in the first and last week of semester. The first was administered in class by paper, and returned 89 responses (96% of 93 students). The second was administered online, and returned 57 responses (61% of 93 students). Effect sizes for Wilcoxon signed-rank tests were defined using the Cohen (1988) criteria (Cohen, 1988).

II. Results

A. Students showed improvement in the skills of results presentation and interpretation

Of the 93 students, 84 (90.3%) submitted all four practical assessments, 6 (6.5%) submitted three and 3 students (4.3%) submitted only two. Across the semester, only 10 students failed to submit a results figure when they did submit answers to analysis questions (2.8% of the total of 360 submitted assessments). The general trend from previous years was that, if practical assessments consist only of analysis questions, the students achieve similar marks across all four assessments. This is presumably because each of the practicals tests different knowledge and concepts, as they each use a different model organism and study a different developmental process. This trend was observed in the students' marks in 2012. The mean marks of the students' analysis questions were very similar across all four practicals, at 79.0% ±2.0, 75.9% ±1.5, 77.6% ±1.4 and 75.2% ±2.0 (standard error of the mean) respectively (Figure 1). In contrast, the results figures improved over all four practicals, with means of 59.6% ±2.5, 63.3% ±2.3, 66.9± 2.4, and 76.1% ±2.3 (standard error of the mean) respectively (Figure 1). For this analysis, the 0 marks for students who failed to include a results figure for their report were removed. Interestingly, for their first practical, the students' results figure marks were significantly lower than their analysis question marks by a paired-samples t-test, t (88) = 7.969, p <0.001 (two-tailed). Indeed, the mean of the first results figure marks was 59.6 ± 2.5 compared to a mean of 79.0 ± 2.0 (standard error of the mean) for the first analysis questions, suggesting that this is a challenging assessment and many students were not yet clear on what to do.

A different way of visualising the improvement in student marks can be seen in the medians of the results figure marks, which increased from 60.0 to 80.0 (Figure 2). The overall improvement in the results figure marks can be seen by the increase in the quartiles (Figure 2), showing an increase of 40% to 65% in the 25th quartile, and an increase of 80% to 90% in the 75th quartile. The long tail down to very low marks was retained across the four results figures, indicating a small number of non-engaged students.

Considering each student individually, 68 (77.3%) of the students scored a higher mark for their fourth results figure compared to their first. Another 8 (8.6%) of the students scored the same mark for each, and 17 (18.3%) scored lower marks for their fourth results figure. Of these 17, 5 had submitted less than 4 reports, leading to less opportunity for practice. A Wilcoxon signed-rank test revealed a statistically significant increase in each students' marks for the results figures

from practical 1 to practical 4, z = -5.815, $p < 0.0001$, with a medium effect size (r = 0.43), compared to a small but statistically significant increase in each student's marks for the analysis questions from practical 1 to practical 4, z = -2.151, p = 0.031, with a small effect size (r= 0.16).

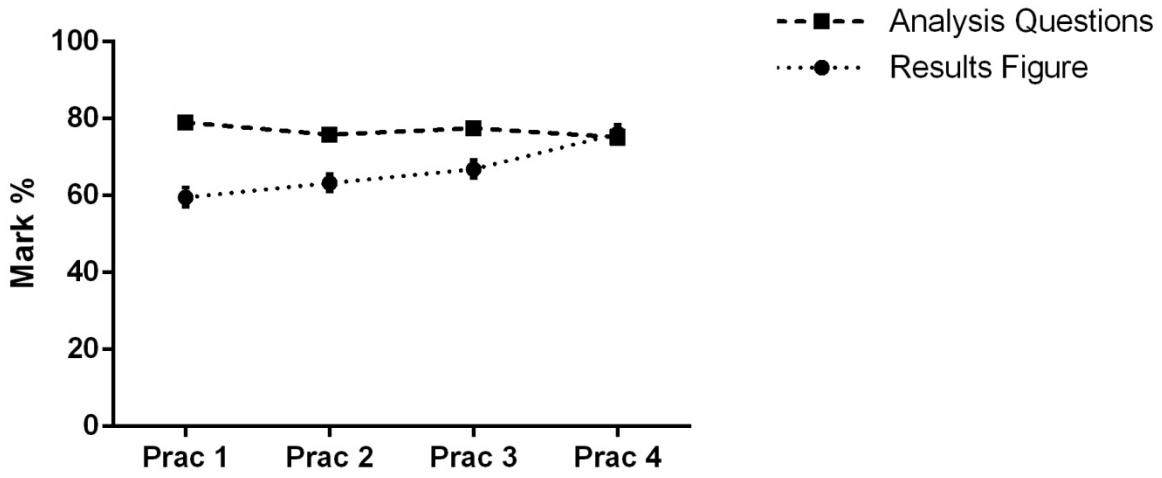

Figure 1. A comparison of the mean (and standard error of the mean) marks for the analysis questions components and the results figure components of all four practical reports.

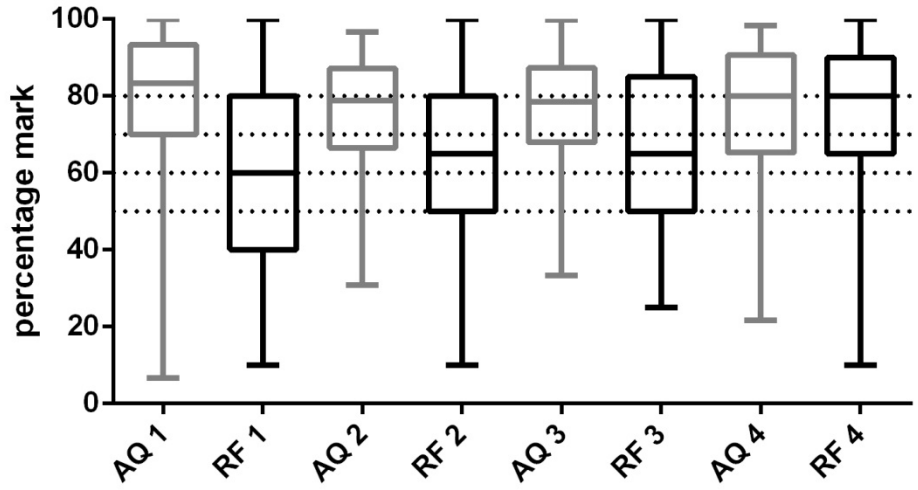

Figure 2. The distributions of marks with median and quartiles (box) and range (whiskers), for the analysis questions (AQ) and results figures (RF) of the four practical reports.

B. Students used feedback to improve their results figure for the final practical report

As a final assessment task, the students submitted a full practical report. They selected one of their four results figures and incorporated it into a full practical report by adding an introduction and discussion. Interestingly, only 53% chose their highest scoring results figure as the starting point for their full practical report. Twenty percent used their second highest scoring

results figure, with 14% each choosing their third or fourth. Seventy-six percent of them altered the results figure for their final prac, presumably based on the feedback they received for the initial submission. However, only 73% of these students improved their mark for the results component of the practical report. Twenty-seven percent ended up with a reduced mark, suggesting that the feedback was not uniform in its quality, and so didn't allow some of them to improve the results figure in the context of a full practical report. Overall, the students' score for the results section of the final prac report when compared to their first submission of the results figure was improved from a mean of 73.7 ± 2.1 to 79.45 ± 2.1 (n=87, standard error of the mean). A Wilcoxon signed-rank test revealed that this is a statistically significant increase in the marks between the results figure submission and the final practical report, z = -2.188, p =0.029, with a small effect size (r = 0.23). Taken together, these data indicate that many students did use the feedback to improve their final mark.

C. The content of the results section improved when students could re-submit it in a full report

Isolating the results section of a practical report might cause students to invest effort in the presentation of a result, but not in the interpretation of the result. It can be argued that a results section should contain a discrete experimental conclusion (eg. The staining is higher in the mutant strain compared to the wildtype strain), but should not contain a broader conclusion, or a conclusion relating this finding to the literature. The final practical reports were examined to determine whether the results contained conclusions appropriate for a results section. This was compared with practical reports that the same cohort of students submitted in a different genetics unit/class (which is taken the semester before this unit/class). In this unit/class, 95.4% (n=87) of them provided an experimental conclusion. In their practical reports for the other genetics unit/class, 95.8% (n = 48) of these same students provided an experimental conclusion in the results. There is no statistically significant difference between these proportions (Chi-squared = 0.02, n = 48, df=1, p = 0.887).

In practical reports, students often confuse the purpose of a results section and a discussion section. For example, they use the results section to compare the results they obtained to the literature. They often provide a conclusion that cannot be derived from their results, but is rather derived from the literature. This has been defined as a 'broad conclusion'. In their final prac report in this unit, 19.5% (n = 87) incorrectly gave a broad conclusion in their results section. In their practical report in the other genetics unit, 25% of the same students also gave a broad conclusion in their results section, with no statistically significant difference (Chi-squared = 0.91, n = 48, df = 1, p = 0.34).

Interestingly, there was a small but statistically significant difference (Chi-squared = 4.533, n = 80, df = 1, p = 0.33) between the proportion of students who incorrectly put a broad discussion in their initial results figure (30%) compared to the proportion who had a broad discussion in the results of their final prac report (19.5%), suggesting that some students improved this for the final report. Just over twenty-five percent (25.6%) of the students also overly repeated their results in their discussion in the final practical report, indicating a misconception that the description of the results should also be in the discussion. In the other unit/class, 47.9% of these same students overly repeated their results in the discussion of their practical report, suggesting that forcing students to concentrate on the results sections before writing a full practical writing may generate a more correct distribution of information between

the results and the discussion sections. These differences are statistically significant (Chi-squared = 24.234, df = 1, p <0.0001).

D. Engagement of the students with the results figure assessments

At the start of the unit/class, 70% of the students reported that they were confident about what goes into a results section, and 67% felt confident about what goes into a discussion section (n = 89). However, 5.6% and 5.3% were not confident, respectively. By the end of the unit/class, 86% of the students reported confidence about what goes into results, and there was no change in the proportion confident about the discussion (n = 56). Despite these positive results, the smaller return rate of the post-assessments questionnaire (61%) meant that no significant difference could be found between the means of the 5 point-Likert scale for these questions, using matched responses (Wilcoxon signed-rank test, n = 56, z = 1.591, p = 0.112).

Many students gave positive comments about the practical assessments at the end of the unit/class. The following quotes are in response to: Did any of the assessments/activities in this unit help you to know what goes in the results and discussion sections of a prac report? If so, which ones?

By needing to do a report section for each practical to be handed in with practical reports and getting feedback, I gained a greater understanding of what is meant to be in a results section of a prac report.

> *All the lab reports that required a result section. With the appropriate feedback I was able to learn what does and doesn't go into the results section.*

I found that the results figures for each prac report was quite a good idea as it prepares us in making results figures that are better suited to those found in real journal articles.

> *I found the reports for each prac helped me know what to include in a results figure, and how to incorporate it into my results section.*

Yes, I kept improving my report writing skill from previous prac. The feedback in the pracs were really helpful for further improvement.

> *It actually helped me write a more structure and better presented results section for another subject as well as this one. I also feel more prepared for future assessments and feel more confident about how to go about it. SO all the feedback on all the topics.*

However, some students reported that these assessments did not give them enough practice at formal discussion writing, as there was only one full prac report and so no formative practice. Due to constraints of marking time, this unit/class has only ever had one practical report, so it is possible that the students now recognise this deficit due to the large amount of formative practice they have at writing a result section. In response to the same question as above, some students wrote:

The discussion. I still feel uncertain when writing it, especially when I am still not particularly certain I understand what I am meant to be discussing.

> *Yes it did, but I still struggled with discussion, because you have to understand the concepts, and I felt that wasn't covered. I already know what goes into a discussion and results. Buts it actually writing it and having it make sense!*

It was hard to tell was should be in discussion as I feel like I'm just repeating my introduction.

> *Although the final major report contained a discussion, we did not have any experience or relevant feedback throughout the unit in writing discussions, so this proved more*

> *difficult. Perhaps it would have helped if one of the earlier prac reports had a discussion component before the final report, in order to get feedback on our ability to write a discussion and subsequently improve.*

D. Marking time

In the 2011 unit/class it took up to 60 minutes per report to mark a full practical report. The turnaround was a little over 4 weeks, and as this report was due in week 9 out of 12, this pushed the mark return date into the exam period. In contrast, each results figure was marked in a little over a week, providing most of a week for the students to view their feedback before the next practical report was due. Writing four full practical reports would take a considerable amount of student report writing time. The exact time for writing practical reports, results figures and analysis figures in this unit/class is not known, however informal student comments did suggest that it was considerable work.

As far as marking costs, at this institution, 60 minutes per full practical for 77 students comes to $4210 in marking costs. For four full practical reports this would come to $16,840 for 77 students and $21,214 for 97 students. In 2012, the students submitted 4 individual practical reports consisting of analysis questions and a results figure. These took 15 – 20 minutes per report to mark. For 97 students, this came to $7350, which is 35% of the cost of marking four full practical reports for the same number of students. Although costs vary considerably between institutions, this costing arrangement would be similar across Australian universities, and with rising class sizes and contracting budgets, this is becoming a significant barrier for many of these institutions.

III. Discussion

A. This assessment succeeded in providing a formative feedback cycle

The students' marks for their analysis questions stayed generally similar across all the practicals, but the results figure marks improved. This is most likely because the skills involved in presentation and interpretation of results are generic skills, and those same skills are being applied to each of the four results figures. This gave the students the chance to practice these skills in a formative cycle, receiving feedback from each submission before the next assessment. It is common to have iterative cycles of practical report submission, but the real difference was that this assessment was small enough to allow quick marking, so that students could see their marked prac assessment before the next one was due. It is interesting to observe that many of these students did use the feedback, as this has not necessarily been the experience of others in the field (Hughes, 2004). Their results figures improved, and in questionnaire results they reported that they used the feedback for their next report. Seventy-six percent of the students changed their results figure for their final practical report, indicating that they are certainly using the feedback when it relates directly to the next assessment. The alternative approach of setting four complete practical reports as practical assessments would take the markers far longer to mark. This would dramatically lengthen the turnaround of assessment marking, and so the students would not receive their marks and formative feedback in time to correct mistakes for their next practical report submission, a vitally important part of the learning process (Kirschner & Meester, 1988; Nicol & Macfarlane-Dick, 2006; Parry, Larsen, & Walsh, 2008; Race, 2005).

B. This assessment requires less student time than four full practical reports

Despite this, the students worked hard at their results figure, often reporting that it took as long to prepare as did the analysis questions. In contrast, however, four full practical reports take far longer for the students to prepare. Indeed, lecturers have noted a reduced attendance at lectures at times when large practical reports are due. This assessment therefore provided formative practice in an important skill with four iterations, with less student time taken than with full practical reports. This frees up student time for concentrating on the lecture component of the course. This assessment was therefore successful in providing a formative feedback cycle in important skills for a relatively small commitment of student writing time as well as marking time.

C. Results figures are meaningful learning tasks

Isolating the results section of a practical report could cause students to not interpret the result of the experiment, but simply present it as a raw image/graph. However, the students did include an interpretation in their results sections in this study, and certainly they did this just as much as they would when writing a full practical report, as seen from their reports for the other unit/class. Some students also included information inappropriate for a results section, such as a broad conclusion (comparing the result to the literature), but they did so with a reduced frequency compared another unit/class, indicating that this format may improve this aspect. Indeed, some students corrected this aspect in their final practical report, suggesting that they are learning from the feedback. In addition, fewer students repeated their results in the discussion in their full practical report in this unit/class compared to another unit/class. These data indicate that isolating the results section of the practical report can actually improve students' understanding of the different components of a practical report and that the iterative nature of this assessment allows students to respond to feedback to correct their initial mistakes.

D. Problems identified

In order to successfully present and interpret results data, it is imperative that the student understand the aim of the experiment. For example, in the first practical some students interpreted the aim of the experiment as to determine the effectiveness of the experimental technique, rather than to examine the results of an experiment using that experimental technique. This is a subtle but extremely important difference. Note that a written aim was not required as part of this assessment, and so the aim interpreted by the student was inferred from the presentation of the results. In future, it is important to discuss the aim of the experiment in class and to decide on a consensus aim, so as to define the aim to be used for the results figure presentation.

Another issue was the low scores of the results figures in the initial prac. This suggests that the results figure is a challenging assessment, and that some students are initially unsure of how to prepare it. The majority of the problems arose from students not understanding the difference between the figure legend and the results paragraph (the results section describing the results and referring to the figure), many students thinking that these were the same thing. This is very interesting, because it shows that although the students are experienced at reading journal

articles, but they were not able to apply this understanding to producing their own complete figure. Clearly, this needs to be addressed in a more formal activity in which students examine the assessment instructions, marking guide, and figures in journal articles in order to make sense of the requirements. In future years, a tutorial examining the structure of a results figure in a journal article will be carried out, emphasising the three components of the figure panels, figure legend and results paragraph.

An interesting problem is that the students tend to discuss the analysis questions in the practical class with the teaching associates and the academic, but not discuss or ask about the results figures. Very few of them worked on the results figures in class, leaving them to work on them at home when they cannot ask questions. More discussion of the results figure in class needs to be actively encouraged in order to provide immediate feedback on their ideas and plans.

One downside to this approach is that the students have less practice at the important skills in writing a discussion, a problem that has been noted in similar studies (Tilstra, 2001). However, the analysis questions were designed to overcome this lack of discussion, by asking specific questions about the interpretation of the results and the broader implications based on the literature. In addition, the students in this class are already quite practiced at the skills of literature search, and summarising relevant information. The skills that they lack are the presentation and interpretation of the results. It is possible that they did already have the skills to present and interpret data, but that the particular structure of a formal prac report meant that they did not apply these skills. Even if this is the case, this assessment has caused them to focus on, and improve, these skills.

IV. Conclusion

In conclusion, practical reports can be reduced to only a results section and still retain the essential components of results interpretation and presentation. Analysis questions need to be used to ask students to more deeply consider the meaning of the experiment, and how it fits with the literature. This reduced practical report allows for quicker marking, providing a fast feedback cycle. It is also economical in terms of student writing time and marker time, the latter providing a cost saving for the Department.

Acknowledgements

This project was carried out with the approval of the Monash University Human Ethics Committee – Project CF12/1824 – 2012001009. This project was supported by an Education grant from the Faculty of Science, Monash University. I would like to thank Christa Meek for technical support in collating marks for this unit/class. I would like to thank the other lecturers in this unit/class, Professor John Bowman and Associate Professor Coral Warr, for allowing my changes to their practical assessments.

Appendix. Marking guide for results figures

INSTRUCTIONS FOR WRITING PRAC REPORTS IN GEN3030

Reports for Topics 2,3,4,and 5

Each of these practical reports will consist of two parts.

Part 1: Answers to the Analysis Questions, which are numbered in the prac. The marks allocated to each question are indicated. Part 1 accounts for 75% of the marks for the prac.
Part 2: A Results Figure. For this section, you will submit a journal article-style figure reporting one of the results from the prac. The specific experimental results to be reported are indicated in the relevant prac. Part 2 accounts for 25% of the marks for the prac. Part 2 from one of these four pracs will also be used in and contribute toward your Major Prac Report (see below).
The Results Figure should contain:

- Panels with drawings, pictures taken in the prac, or graphs of numerical data.
    - If there are multiple panels, they should be labeled with A, B, etc.
    - You may need to use arrows or other indicators in the figure to demonstrate the result.
- A comprehensive figure legend that includes sufficient information to completely understand the results shown in the figure.
- A written results paragraph that explains the experiment and the result, as would appear in a journal article.

Use the figures and text from primary journal articles in the field of Developmental Genetics as your guide.

Assessment Criteria for Results Figure	
The figure panels present the data clearly and understandablly	40%
The figure legend is comprehensive and understandable	30%
The results paragraph contains a correct explanation and interpretation of the results	15%
The results paragraph is appropriate for a results section, and does not contain significant amounts of discussion.	15%

References

Adams, D. J. (2009). Current trends in laboratory class teaching in university bioscience programmes. *Bioscience Education, 13*. doi: 10.3108/beej.13.3

Cohen, J. W. (1988). *Statistical power analysis for the behavioural sciences* (2 ed.). Hillsdale, NJ: Lawrence Erlbaum Associates.

Collis, M., Gibson, A., Hughes, I., Sayers, G., & Todd, M. (2008). The student view of 1st year laboratory work in the biosciences — Score gamma? *Bioscience Education, 11*. doi: 10.3108/beej.11.2

Corradi, H. R. (2012). A sample practical report to facilitate writing in the scientific style. *Biochemistry and Molecular Biology Education, 40*(1), 65-67. doi: 10.1002/bmb.20571

Deiner, L. J., Newsome, D., & Samaroo, D. (2012). Directed self-inquiry: A scaffold for teaching laboratory report writing. *Journal of Chemical Education, 89*(12), 1511-1514. doi: 10.1021/ed300169g

Gratz, R. K. (1990). Improving lab report quality by model analysis, peer review, and revision. *Journal of College Science Teaching, 19*(5), 292-295.
Greenbowe, T. J., Rudd, J. A., & Hand, B. M. (2007). Using the science writing heuristic to improve students' understanding of general equilibrium. *Journal of Chemical Education, 84*(12), 2007. doi: 10.1021/ed084p2007

Hofstein, A., & Lunetta, V. N. (2004). The laboratory in science education: Foundations for the twenty-first century. *Science Education, 88*(1), 28-54. doi: 10.1002/sce.10106

Hughes, I. (2004). Coping strategies for staff involved in assessment of laboratory write-ups. *Bioscience Education, 3.* doi: 10.3108/beej.2004.03000005

Jones, H. (2009). Teaching undergraduates to write practical reports. *Centre for Bioscience Bulletin* 26. Retrieved from http://www.bioscience.heacademy.ac.uk/ftp/newsletters/bulletin26.pdf

Kirschner, P. A., & Meester, M. A. M. (1988). The laboratory in higher science education: Problems, premises and objectives. *Higher Education, 17*(1), 81-98. doI: 10.1007/BF00130901

Lerner, N. (2007). Laboratory lessons for writing and science. *Written Communication, 24*(3), 191-222. doi: 10.1177/0741088307302765

Nicol, D. J., & Macfarlane-Dick, D. (2006). Formative assessment and self-regulated learning: A model and seven principles of good feedback practice. *Studies in Higher Education, 31*(2), 199-218. doi: 10.1080/03075070600572090

Parry, D., Larsen, C., & Walsh, C. (2008). Summative assessment with formative feedback: An intervention in a small bioscience cohort. *Bioscience Education, 11*. doi: 10.3108/beej.11.c2

Race, P. (2005). Learning through feedback. *Making learning happen*. London: Sage.

Tilstra, L. (2001). Using journal articles to teach writing skills for laboratory reports in general chemistry. *Journal of Chemical Education, 78*(6), 762. doi: 10.1021/ed078p762

Walsh, C., Parry, D., & Larsen, C. (2010). Blending learning: a novel assessment strategy enhancing student learning from practical work in the laboratory. *Bioscience Education, 15*. doi: 10.3108/beej.15.c2

Watson, D., & Knight, G. L. (2012). Continuous formative assessment and feedback in an enquiry-based laboratory course. *Bioscience Education, 20*, 101-105. doi: 10.11120/beej.2012.20000101

Whelan, R. J., & Zare, R. N. (2003). Teaching effective communication in a writing-intensive analytical chemistry course. *Journal of Chemical Education, 80*(8), 904. doi: 10.1021/ed080p904

Wilson, J., Adams, D., Arkle, S., Bevan, R., Boachie-Ansah, G., Bradshaw, T. . . Wilson, J. (2008). Report: 1st year practicals: Their role in developing future bioscientists. Retrieved from www.bioscience.heacademy.ac.uk/ftp/reports/pracworkshopreport.pdf