

# Laboratory Report Writing on Optical Physics Undergraduate Labs – Draft and Feedback Processes to Facilitate Student Learning & Skill Development

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## ABSTRACT

**Writing high quality, formal laboratory reports about optical physics experiments is a key learning outcome for physics and optical technology graduates. Improved learning outcomes are achieved by a process of draft reports which receive feedback. Student engagement is discussed.**

## INTRODUCTION

There is a strong emphasis on developing high level experimental-physics skills and capabilities, including report writing, in bachelor degrees majoring in Physics, Optoelectronics or Optical Technology at Macquarie University. The Department has a tradition of establishing, maintaining and improving sophisticated experiments, using state-of-the-art equipment, for student experience. The length and sophistication of the experiments increases as student progress through the physics units of the degree. By third year students complete three 3 hour sessions in the laboratory for each experiment. They conduct their own background research on the physics of the experiment, away from the laboratory, guided by key reference resources that are provided. This contrasts with a continuation of three hour lab sessions followed by a shorter, results focussed report in optoelectronics or optical technology laboratories, where the emphasis is on providing students with time constrained “experiment and report” experience.

Third year students of Optical Physics undertake experiments selected from Optical Data Processing (Diffraction and Image Formation); Fourier Transform Spectroscopy; Fabry Perot Interferometry; Polarisation & Berry Phase; Holography; Correlation Interferometry & Spatial Coherence; Single Photon Counting and Interferometry; and Photonics Simulation Software for Teaching [1]. Pictures of some of the bench layouts for these experiments are shown in figures 1 and 2. Students write major reports on two of the experiments they complete, following the guideline for report writing developed as a consensus document within the department [2]. These reports and the lab book record of four completed experiments are major assessments that are included in a learning portfolio for the unit which the students have to complete.



Fig. 1 Experimental setup for the Fabry Perot (left) and optical data processing (right) experiments in the undergraduate optical physics laboratory, Department of Physics, Macquarie University. Photos: Dr Gina Dunford.

Assessing one of these optical physics laboratory reports typically takes 40 minutes to one hour to provide comprehensive feedback and correction of any remaining misconceptions or mistakes. It was noted some years ago that, even with quick turnaround of assessment, by the time such feedback is received by the student they have moved on to another experiment and tend to be interested only in the mark for their report. (Focus on assessment rather than learning is a mindset in many of our students that we are constantly challenging.) Thus, most students do not gain much benefit from the thoughtful and comprehensive feedback given – staff time and a learning opportunity are largely wasted. In order to assist the students to learn from the feedback provided, we introduced a process whereby students get feedback before assessment by submitting a draft of their laboratory report. They receive comprehensive feedback on this, and they can act on this feedback for their final laboratory report submission. This mirrors the interaction between research student and supervisor that is the standard approach to writing research papers. Early student responses to this process were largely negative. Students perceived this would increase their workload. Student response to this submission process is now primarily positive, but not always for reasons that are educationally positive. We report and discuss the process and the evolution of student response to this process. As teachers, we have learned that this process gives us useful insight into student learning style, and motivation, on an individual basis. We will discuss the “types and styles” that have been loosely “classified”, and our efforts to engage with each of these for the purposes of assisting students to improve their learning of experimental optical physics and laboratory report writing skills. Primarily, the process supports increased conversation with students about their learning, and, work effort and ethic, in a natural and relaxed way. We identify designing learning tasks to include exchange of feedback and response to feedback; and a “conversation” between the teacher and students, both individually and as a student group; as a preferred model for deep learning.



Fig. 2 Experimental setups for the Correlation interferometry (top), Polarisation and Berry phase (bottom left), and photon counting and interferometry (bottom right) experiments in the undergraduate optical physics laboratory, Department of Physics, Macquarie University. Photos: Dr Gina Dunford.

## THE PROCESS & OUTCOMES

A flow diagram for the staged submission process is shown in figure 3. To mitigate student perception that the requirement of a draft report was an inappropriate increase in workload, it is optional for students to submit a draft report. Students are advised the draft submission process represents an important opportunity to improve their laboratory report writing, and their understanding of the optical physics, by gaining feedback as part of the writing process. This feedback may also address the writing difficulties of English second language students as developed from previous research within the department [3]. The draft reports are not formally assessed. They are returned annotated with suggestions for improvement and a completed evaluation sheet of the form shown in Appendix A. Every year some students ask to receive a grade on the draft report. It is their intention to make a decision on whether or not they will act on the suggestions for improvement on the basis of whether they are satisfied with the grade the draft would gain. The draft submission process is in place solely to facilitate learning and improvement and we explain to the students why no grade is issued at the drafting stage. Recent experience has seen about 90% of students submitting a draft report, with 60-70% of reports submitted being reasonably complete, 20% are incomplete by missing one or two major sections, and 10-20% are less than half complete. For the latter category the students derive minimal benefit from the draft submission. Drafts are guaranteed to be returned to students within one week of being received. The students have a further week to finalise their report for assessment after receiving the annotated draft.

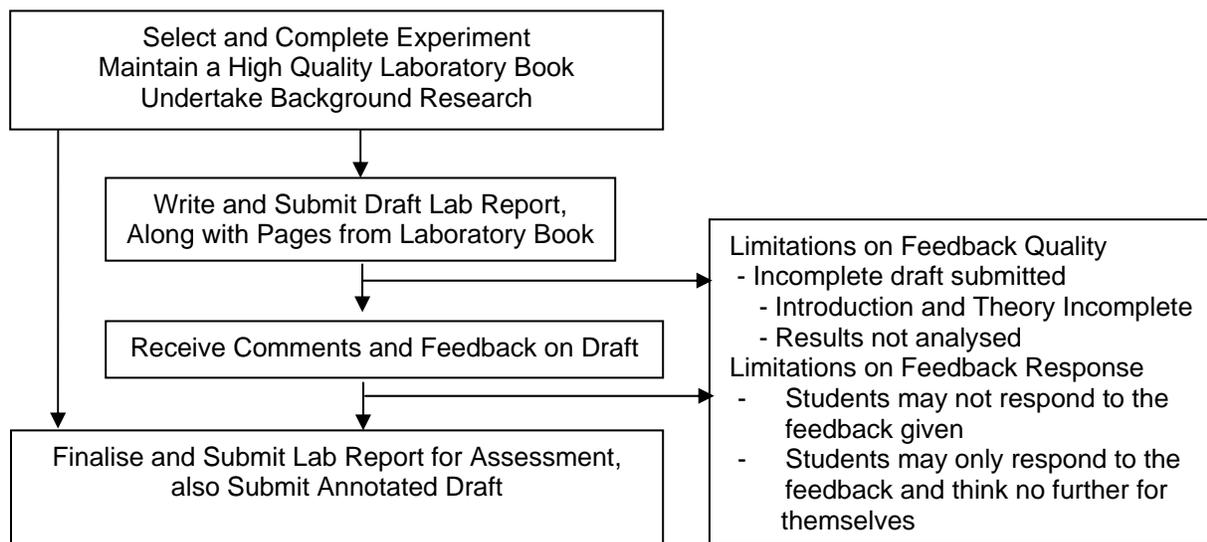


Fig. 3 Flow diagram of the laboratory report writing process.

As the process is currently implemented, there is no formal discussion between student and reviewer on the draft. However, more than 50% of students approach the reviewer to gain further insight into the areas for improvement identified, including discussions of the optical physics. These discussions are highly valued by the students and have the advantage that they are driven by the individual student to support their individual learning. The intensity of engagement by these students at this point in the process is high and is educationally positive. (Experience of students completing a final report for assessment without a draft submission (primarily pre-dating this scheme) would have less than 20% of such students approaching teaching staff to ask questions to facilitate submitting a higher quality laboratory report). The highly motivated and engaged students are to be contrasted with the students in the group with lower levels of self motivation. These latter students span all ability levels and they have identified the draft submission process as a means of reducing their own workload. They see value in the reviewer identifying the shortcomings of a complete or incomplete draft. They then go through their report, implement and tick off a response to every piece of

feedback provided. They do little or no additional thinking about the optical physics and the report as a whole. These were the students who initially responded negatively to a change in process that they perceived would be more work. But, they learned that the additional support of the process could be used to reduce work on their part in favour of work done by the reviewer. This is a strategy which is familiar to anyone with experience of team work dynamics. Some members of the team will use the support of others to reduce their workload in an inequitable manner. Finding the balance between reasonable support from others and reasonable self effort will always be a subject of discussion in teams. The process, as implemented, sees some students reconceptualising the reviewer as part of their “team”. This is not a positive educational outcome. However, it is a predictable outcome when considering the analogous joint writing between research students and their supervisors that generated the idea for the process in the first place. Here, the teacher needs to be mindful that their role is not to become a joint writer.

The educational challenge of designing a learning and assessment process that causes a modification in learning behaviour of students pre-disposed to study-and-work avoidance remains. It is hypothesised that a sequential withdrawal of the feedback process over the course of a year in the laboratories (2 units of study in the Macquarie University context), while raising the expectation of the laboratory report quality that will be required to achieve a specific grade, as experience grows, would be worthy of testing. A judgement of whether a net improvement in learning outcomes could be achieved for a larger percentage of the students by this means could then be made. Other proposals are to incorporate critical evaluation of example laboratory reports by the students against a set of well defined guidelines, and/or to set the task of improving a partially completed report to a well defined guideline and standard. On balance, the positive learning outcomes for those students who fully engage with the learning opportunity involving submission of a draft report, outweigh the negatives of partial learning avoidance by some students. The process involves an increase in time commitment by the teacher/reviewer, and is thus, only suitable for implementation in small class teaching situations. The improvement in learning outcomes that the teacher/reviewer sees directly through the conversations with students makes the time commitment worthwhile.

## APPENDIX A

### Laboratory Report - Draft - Feedback

The key for the descriptors used against the evaluation criteria follows.

**Key:** Ex – Excellent, VG - Very Good, G – Good, A – Acceptable, U – Unacceptable, NA – Not Applicable

Content		Presentation	
Abstract/Introduction		General Structure	
Background Theory		Style/Grammar/Spelling	
Description of Experiment		Correct use of Units/ Presentation of numerical values with Uncertainties	
Comments on Important Observations		Drawing of Graphs	
Results, Calculations and Data Analysis (Including Comparison with Theory and Available Reference Data)		References/ Bibliography	
Logical Conclusions Supported by Experimental Evidence		Layout (Pages, Sections, Figures & Tables)	
Extra Effort			

**General Comments (specific comments are on the report):**

### References

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3. Laboratory report writing skills for undergraduate Physics students, P Roger, T Freeman and D M Kane, pp 252-7, in "Language Analysis, Description and Pedagogy", Eds R Berry, B Asker, K Hyland and M Lam, (The Hong Kong University of Science and Technology, 1999).

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