

# USING LEARNING REFLECTION REPORTS TO FOSTER METACOGNITION AND DEEPER LEARNING IN SCIENCE STUDENTS

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## ABSTRACT

In this paper, we describe an introduction of a learning reflection strategy designed to increase students' engagement with their learning process and foster deeper learning in a first year elective astronomy unit. The unit uses the principles of constructive alignment and flipped classroom, and incorporates students' reflection on their learning achievements as a formative assessment at two points during the semester. We present an exploratory analysis of students' responses to these Learning Reflection Reports, which suggest that some students are able to identify where they might be having learning difficulties early in the semester and explain what they need to do in order to achieve the desired level of progress.

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## INTRODUCTION

Learning science can be difficult – students often come with preconceived ideas and misconceptions, which can be hard to shift (e.g., McDermott and Redish 1999). For learning to happen, students need to identify gaps in their understanding of the material taught. This is referred to as metacognition; the ability of a learner to monitor their level of understanding and identify if it is not adequate (NRC report, 1999). In-semester assessment and feedback is meant to provide students with insights into these gaps. Our experience shows that students do not always make use of the feedback comments provided by lecturers or teaching assistants, reducing the effectiveness of formative assessment tasks. Research suggests that students, especially those in the first years of their degree, tend to adopt superficial approaches to learning, focusing on achieving high marks rather than gaining a deep understanding of the course's content (Boud, 1995; Kirby & Downs, 2007).

For this reason, self-assessment tasks are considered an effective method to develop lifelong learning skills in students, who are expected to work autonomously in their graduate life (Tai, Ajjwai, Boud, Dawson, & Panadero 2017). Lifelong learning skills comprise of understanding and incorporating feedback from others, identifying further learning needs in a career, and defining plans to fulfill these needs (Boud, 2000; Cowan, 2010; Fastré, van der Klink, Sluijsmans, & van Merriënboer, 2013). Therefore, in-semester assessment can be used as a powerful formative assessment, where feedback on students' performance is oriented towards improving their performance in subsequent tasks and scaffold their learning (Sadler, 1998).

This context led the first author to consider the implementation of a self-assessment task in their elective astronomy undergraduate unit at Monash University. As described by Lazendic-Galloway, Fitzgerald and McKinnon (2016), *ASP1010 - Earth to Cosmos* is a first-year elective undergraduate unit offered by the School of Physics and Astronomy at Monash University, which has undergone a series of pedagogical transformations since 2014. The unit has around 200 students per semester, mainly first years (around 80%) with STEM majors (around 80%). This unit implements a flipped classroom approach with a mixture of hands-on workshops and independent study, supported by online material such as quizzes, astronomy videos, and interactive exercises. Assessment tasks include team-based practical activities and short tests during the workshops, weekly revision online quizzes and four online assignments, and a paper-based examination at the end of the semester. Feedback on these activities includes formal written comments on weekly in-class tests and online

assignments, as well as discussions in workshops and online forums between students and the teaching staff.

The implementation of a self-assessment task required students to collect and analyse the feedback from their tests and assignments, reflect on their performance and level of understanding of the unit's topics, and identify the relationship between learning activities developed during the workshops and the learning outcomes. In this paper we describe the structure and implementation of self-assessment reports, the Learning Reflection Reports (LRRs), and the responses provided by the students who consented the use of their reports for research purposes.

### **THE PURPOSE OF LEARNING REFLECTION REPORTS (LRRS)**

At the beginning of the semester and closer to the reflection task time, we introduced the idea in the class that students need to be “reflective practitioners” (Schön 1983) of their own work to foster self-regulation and lifelong learning. It was explained to them that LRRs are designed to help them learn these skills, as well as provide timely feedback to the instructors on where the gaps are in students' understanding.

Face-to-face sessions were conducted through two 2-hour hands-on workshops where the instructors can focus on helping students learn the concepts via class activities. Then, when the students come to class next time, they take a short 10 minute test at the start that is based on work done in the previous session. This approach was introduced to minimise receiving “easy” in-semester marks given for the completion of worksheets and to foster retrieval practice (Szpunar, McDermott & Roediger 2008; Bäuml & Kliegl 2013) by asking students to revise what they learned in the workshops before coming to the next session. The students were also expected to complete two LRRs in the unit, one in week 6 and one in week 11 of the semester. The first LRR in week 6 seeks to timely gather information about students' understanding, help them to orientate their efforts for the rest of the semester, and identify possible adjustments to learning approaches. The second LRR in week 11 seeks to help students review their learning towards the final examination.

The first part of the LRRs consisted of an explanation of why reflection is important for learning and a table for reviewing the results of the tests up to that week. As shown in Figure 1, in this table, students were asked to collect certain information from their previously graded tests (labels 2B, 3A, 3B etc denote the names of the related workshop sessions) and reflect on both their marks and types of mistakes. Based on this, students had to answer the following questions: (1) “Are you satisfied with your progress so far?”, and (2) “Is there anything you think we can do to help you in your learning process?”. The first question seeks to help students identify areas that require improvement while also recognising that they may have different expectations about their performance. The students have different reasons for enrolling into an elective unit such as ASP1010 and obtaining high marks is not the only desired goal. The second question intends to collect timely feedback from students that can be used to provide additional (or improve existing) learning resources during the semester.

**Reflecting on the weekly tests**  
 Use your marked tests to fill out this table. For the tests you missed, for what ever reason, please write "M".  
 For "Type of mistakes" add 1 point for each type of mistake or a written comment we haven given you as a feedback on your test:  
 "x" (cross) means "wrong answer"  
 "?" (question marks) means "not clear enough"  
 "!" (exclamation mark) means "question not read carefully enough"  
 Attach your tests to this report.

Type of questions	2B	3A	3B	4A	5A	Sum
Critical thinking	0	3	2	3	0+1	9
Inquiry	3	2	3	3+3	1	14
Problem solving		2				2
Pre-reading (from the test)	3		3			6
Total sum	6	7	8	9	2	32
Type of mistakes	2B	3A	3B	4A	5A	Sum
Wrong answer	1				1	2
Not clear enough		1+1	1		<del>1</del>	3
Question not read carefully						
Any written feedback?					1+1	2
Total sum	1	2	1	0	3	7
MasteringAstronomy	2A+2B	3A+3B	4A	5A+5B	MA#1	Sum
Quizzes and assignments	✓	✓	✓	m	m	

Marks: 7 / 8

Are you satisfied with your progress so far?  
 Yes, observing my increasing trend of positive performances, however i believe i am not performing well on the mastering Astronomy quizzes.

Is there anything you think we can do to help you in your learning process?  
 A few tips on how to approach critical thinking questions and how to be more precise with answering questions.  
 ie- why ~~questions~~ answers are not clear enough. ok

**Figure 1: An example student entry for the first part of the Learning Reflection Report from week 6. The labels 2B, 3A, 3B etc denote the names of the related workshop sessions. The answers to the two open-ended questions were analysed in this paper.**

The second section of the LRRs (see Fig. 2) was oriented towards reflecting on the concepts learned (i.e. the learning objectives from the workshops). A list of all the specific learning objectives is presented and the students have to answer "A", "B" or "C" depending on how confident they feel they can answer the questions or solve the problems. "A" stands for "feeling confident that they can answer the question adequately", "B" means "somewhat confident", and "C" is that they are "not confident". The main purpose of this section was for students to rate their level of understanding of astronomy concepts learned in the workshops, expressed as exam questions, and take appropriate steps to attend to any gaps in their knowledge.

**Reflecting on the Learning Objectives from the workshops**

Imagine that you are having an exam next week and you need to use your knowledge as it is right now. Depending on how you feel you are prepared right now, enter the following as "Your response":

1. "A" - if you feel confident that you can answer the question adequately
2. "B" - if you think you can answer 50% of the question
3. "C" - if you are not confident that you could adequately answer the question

This is a feedback to you and to us, and you will not be marked on the level of your confidence, so be truthful.

Session	Questions	Your response
1B	Explain what causes the seasons on Earth. Explain what causes phases of the Moon.	A A
2A	Explain how we determine the location of objects on the sk. Explain the difference between Alt-Az and RA-Dec coordinate systems.	B B
2B	Explain how a simple telescope works and what are the main features. Calculate a light-gathering power, magnification and field of view of a telescope with lens diameter $D$ , eye-piece focal length $f_e$ and objective focal length $f_o$ .	B C

**Figure 2: An example student entry for the second part of the Learning Reflection Report from week 6. The intent of this section was for students to identify any gaps in their knowledge.**

The third section of the LRRs focused on the learning outcomes of the unit. Students were asked to identify learning activities done in the workshops that match each one of the "global" unit learning outcomes. This section was intended to assist students in keeping in mind the "big picture" of the unit's learning outcomes and interconnected astronomy concepts, which may be blurred by the incremental nature of weekly topics and learning tasks.

### DATA ANALYSIS AND RESULTS

Out of 217 students, 49 students gave us consent to use their LRR responses for research purposes. We performed exploratory analysis on the two open-ended questions from the first part of LRRs (see Fig. 1) and we summarise emerging themes in Table 1.

**Table 1. A summary of themes identified from student comments in two LRRs.**

Emerging themes	No. of times themes were referred to	
	LRR 1 (week 6)	LRR 2 (week 11)
Not satisfied with their progress	25	11
Would like summary at the end of the workshop*	12	0
Would like more instruction*	7	1
Would like more maths-based examples*	3	1
Would like more exam-like questions*	3	2
Likes workshops	2	7
Likes online activities and resources	4	6
Concepts makes more sense	--	10
Likes more engaging content provided since week 6	--	5
Likes improved pre-workshop material	--	5
Mentioned improved test marks	--	2

\*suggested changes have been implemented from week 6 as a result of this feedback

In the first LRR, from our sample of 49 students, 16 students simply said that they were satisfied with their progress, three were not satisfied, and six gave short responses like "Somewhat satisfied", and "I could do better". However, 21 students provided some detail about why they were not satisfied or what their difficulties were, even when they reported of being satisfied in general. Some of these responses state specific aspects of their experience during the unit, such as concerns about physics concepts, difficulties with online quizzes, or not remembering content or formulas for the tests. Others were able to identify what they might need to do to improve their performance, for example, spending more time reviewing the learning materials, writing more concise notes from pre-readings and workshops, or providing more information to support claims on their tests.

When asked about their satisfaction with their progress in the second LRR, 11 students simply answered “yes”, while five said “no”, “somewhat” or “to some extent”. The remaining students provided more detailed answers about their satisfaction or what they could have done better. Seventeen students reported being more satisfied at the time of the second report, pointing out how their marks or understanding of concepts have improved, how they felt more engaged with the new content, or how their previous LRR helped them to adopt more effective learning practices:

*“After the last reflection report, I have started doing the mastering astronomy self-reviews which have really helped solidify my knowledge. [...] I've also found the reflection reports helpful in my learning too, setting time aside to reflect on what I've learnt assists me in finding out what I need to work on further.”*

Nine students expressed being somewhat satisfied with their performance, while still recognising that they needed to pay attention to certain aspects of the unit. In some of these cases, students reported that their marks have dropped but do not consider it a special concern:

*“With the onset of assignments and other subjects from the second half of semester I haven't studied as much as I would've liked, otherwise I am quite happy.”*

*“Some of the topics have been a bit tough and new, but most of the maths is relatively straightforward and as such I feel like I have a good handle on what's going on. The exam is looking a bit daunting as I haven't done physics since first year (I'm a fourth year) but a lot of practice will help. Other than the exam, I feel like the last 6 weeks have been really interesting and I feel like I have a good handle, especially in relation to stars and star formation.”*

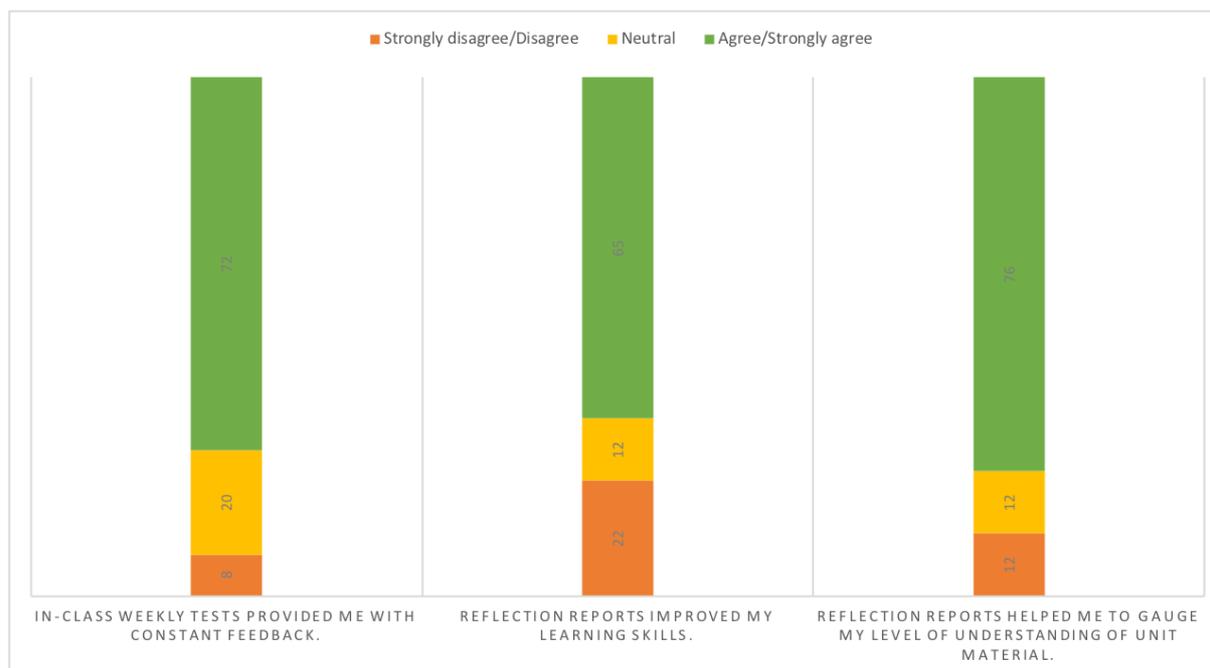
*“I am more satisfied than the weeks previously. However, I am not satisfied with my mastering results or in-class tests for week 6 & 7 and know I need to work hard to re-examine these ideas and concepts.”*

On the other hand, one student who was not satisfied with their performance took responsibility for their perceived low performance:

*“No, procrastination prevails once again. Also keep thinking the questions are harder than it is (putting 2 answers in multiple-choice when it was one), chronic disease of bad handwriting.”*

Ten students expressed that they could make more sense of the later content in the unit, while 12 enjoyed the workshops and found online activities and resources useful for their learning.

We also conducted an observational study at the end of the semester and asked students to fill out a short 3-question survey about how useful they found the weekly tests and LRRs for their learning using a 5-points Likert scale (from “Strongly disagree” to “Strongly agree”). The survey responses, shown in Figure 3, show that the majority of students (72%) agreed that in-class tests provided constant feedback, that the reflection reports improved their learning skills (63%) and helped them gauge their level of understanding of the unit material (76%).



**Figure 3: The end-of-semester observational study conducted using three questions on how useful students found weekly tests and LRRs. The survey responses are given as a percentage out of 49 students agreeing or disagreeing with a statement.**

## CONCLUSION

While further research is needed to measure the impact of the Learning Reflection Reports on students' learning, our analysis suggests that this is a valuable strategy for promoting students' self-regulation and deeper learning. Many students were able to identify some of their difficulties early in the semester and, in some cases, define what they might need to do to improve their performance. Moreover, almost half of the surveyed students reported some improvement in their marks or understanding in the second report. Although we cannot argue that this improvement is solely due to the Learning Reflection Reports, having an explicit opportunity for self-assessment early in the semester may help students take timely actions to identify the gaps in their knowledge and plan for their academic success.

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## REFERENCES

- Bäumli KH, Kliegl O (2013) The critical role of retrieval processes in release from proactive interference. *Journal of Memory and Language* 68(1):39–53.
- Boud, D. (1995). Assessment and Learning: Contradictory or Complementary? In P. Knight (Ed.), *Assessment for Learning in Higher Education* (pp. 35-48): Kogan Page.
- Boud, D. (2000). Sustainable Assessment: Rethinking assessment for the learning society. *Studies in Continuing Education*, 22(2), 151 - 167.
- Cowan, J. (2010). "Developing the ability for making evaluative judgements." *Teaching in Higher Education*, 15(3): 323-334.
- Fastré, G. M. J., van der Klink, M. R., Sluijsmans, D., & van Merriënboer, J. J. G. (2013). Towards an integrated model for developing sustainable assessment skills. *Assessment & Evaluation in Higher Education*, 38(5), 611-630.
- Kirby, N. F., & Downs, C. T. (2007). Self-assessment and the disadvantaged student: potential for encouraging self-regulated learning? *Assessment & Evaluation in Higher Education*, 32(4), 475-494. doi:10.1080/02602930600896464
- Lazendic-Galloway, J., Fitzgerald, M., & McKinnon, D. H. (2016). Implementing a Studio-based Flipped Classroom in a First Year Astronomy Course. *International Journal of Innovation in Science and Mathematics Education*, 24(5), 35-47.
- McDermott, L.C. and Redish, E.F., (1999), Resource letter: PER-1: Physics education research, *American Journal of Physics* 67, 755.
- National Research Council (NRC), *How People Learn: Brain, Mind, Experience, and School* (National Academy Press, Washington, D.C., 1999).
- Sadler, D. R. (1998). Formative assessment: Revisiting the territory. *Assessment in education: principles, policy & practice*, 5(1), 77-84.
- Schön, Donald A. 1983. *The Reflective Practitioner: How Professionals Think in Action*. United States: Harper Collins.

- Szpunar, K. K., McDermott, K. B., & Roediger, H. L. III. (2008). Testing during study insulates against the buildup of proactive interference. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 34(6), 1392-1399.
- Tai, J., Ajjwai, R., Boud, D., Dawson, P., & Panadero, E. (2017). Developing evaluative judgement: enabling students to make decisions about the quality of work. *Higher Education*, 1-15. doi:<https://doi.org/10.1007/s10734-017-0220-3>