Do not be reviewer 2: Using formative feedback as a tool to introduce undergraduate students to scientific peer-review

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Abstract

Formative feedback is an invaluable tool that helps students identify gaps in knowledge, concept formulation, and adaptation of learning strategies to meet the course' goals. As a form of formative feedback, peer-review is one of the cornerstones of scientific publishing and as such, students of scientific degrees should be familiarized with this process. Despite the importance of formative feedback and peer-review, these concepts are not often incorporated into teaching in higher education. In agreement, most of the studies on the impact of formative feedback on educational outcomes are at compulsory school levels and comparatively less information is available to support this practice in higher education (Morris et al., 2021). In this study, I aimed to introduce formative feedback, in the form of scientific peer-review, in a plant molecular biology course. The rationale for this was both to provide the students with the opportunity to experiment with peer-review system and to evaluate the efficacy of formative feedback during the production of an experimental report. Results obtained indicate that students' perception of peer-review was important for the improvement of their lab report, allowing them to identify gaps and convey concepts in a more consistent and clear fashion. This self-reporting is corroborated by my own evaluation of their reports before and after undergoing peer-review, substantial improvements could be seen in each team's reports after peer review. In conclusion, the outcome of peer-review as a form of formative feedback in my course's environment was very favorable and proposes a positive prospect for years to come.

Introduction

Over the last two decades, learning and teaching have put more emphasis on how the student experiences learning; this has resulted in a more "student-centered" learning environment (Noon & Eyre, 2020). Student-centered learning is an umbrella term encompassing students' initiatives that lead to active engagement of the student in their own learning, and teachers creating a framework to promote that goal (Hoidn, 2017). Diverse tools are at the disposal of the teacher to promote student-centered learning, among them activities engaging formative feedback. Formative feedback emphasizes active learning, collaboration, and the development of critical thinking skills (Morris et al., 2021), all of which are fulcra for student-centered learning. Within the different types of formative feedback, peer review places the student in the driving seat of the learning process, as it engages students in their own learning while also encouraging them to take responsibility for their peers' learning. Therefore, it is not surprising that several advantages of peer review for the students' learning process have been widely reported, like enhancing performance and learning, increasing in cognitive and social skills, and enhancing motivation (Cho & MacArthur, 2010; Li et al., 2021; Patchan et al., 2016; K. Topping, 1998; K. J. Topping, 2009; Yu & Schunn, 2023). Given these, peer review appears to be an excellent tool to be incorporated into a teaching framework promoting student-centered education based on a collaborative and reflective learning environment.

Project motivation and context

The intervention reported here was part of the Plant Molecular Biology course for second- and third-year students of the BSc. in Biology. The course has a theoretical component based on the analysis and discussion of primary literature and a practical component where the students are introduced to molecular biology methods contextualized in ongoing research in my lab. As the framing of the course is heavily inspired by scientific precepts and research-based teaching, I realized that the practical part of the course could be further developed into a scenario where the students could experience science as closely as possible as it is

done in our lab: Start with an hypothesis-driven research question, execute experiments to test the hypothesis and write a short article reporting their findings. These changes were introduced last year with excellent results. This year, and influenced by introspection fueled by UP course, I realized that the lab work could be further expanded to integrate peer-review and editorial handling, providing the students with a more complete overview of the entire scientific publishing process. Thus, the goals of the intervention were to introduce the students to the process of scientific writing and peer review. Simultaneously, I wanted to provide the students with an opportunity to use formative feedback to stimulate critical thinking, self-assessment, and collaboration. In sum, with this intervention I wanted to provide a more well-rounded learning environment for scientific publishing, in a didactic manner.

Pedagogically, peer-feedback has four essential pillars: 1) Framework and context, 2) purpose, 3) criteria and 4) Support and embedding (Ellegaard et al., 2022). Given the novelty of integration of peer review in academic teaching for the students and me, it was evident I needed to focus on all 4 pillars to make the intervention succeed, and these are described in the section below.

Description of the intervention

To provide a framework to implement this type of formative feedback, the lab exercise module had to be modified from previous years. The assignment was structured as follows: The students would be divided into 8 groups of 2-3 students and execute two experiments to answer a biological question regarding the putative role of cellular recycling mechanisms during stem cell formation. These experiments and the biological question would be the basis of their report. The report would be drafted as a Brief Report (3 Pages, approx. 1600 words), in the style of the journal Proceedings of the National Academy of Sciences (PNAS). After producing the reports, their colleagues would get one week to perform peer reviews on each other's work. Then, the groups would receive their own report back and get another week to take the reviews of their report into consideration for modification/improvements. Additionally, the students could get supplemental comments from the

editor (me) if any glaring mistakes/weaknesses were not detected by their peers. Finally, their reports would be graded by me, taking into consideration the development of the lab report between the first and second versions of the report.

The students were introduced to the lab exercise during the first lecture and were also given supporting literature for the assignment (Pillar 1 & 4). These were reintroduced again in the lab exercises where data were gathered for the lab report. In this way, I incentivized the student to critically think about the way and type of data they needed to collect to produce a high-quality report.

Given the heavy reliance on discussion and presentations of primary literature in the lectures, the students rapidly understood the importance of peer-review to scientific publishing and the relevance of learning this process (Pillar 2). I also informed the students about the experimental nature of this task, how it was integrated into my UP-course project and that their participation and feedback were important to improve the course. The students were highly motivated and engaged in this conceptual experiment, indicating that the first two pillars were successfully established.

The week before the beginning of their assignment, the students were given instructions on the criteria for peer review, i.e. how to give peer feedback and what aspects to focus on (PLOS instructions https://plos.org/resource/how-to-write-a-peer-review/). In addition, we also analyzed examples of real peer review from selected articles previously presented during the course, showing both good and bad instances of peer review. This was aimed at providing a template to guide the students in their first incursion into peer review (Pillar 3 & 4).

To evaluate the outcome of the intervention, the students were subjected to a questionnaire composed of 10 questions gauging distinct aspects of the peer-review process and the student's perception of the impact of peer review in drafting their own report.

Outcome of the intervention and discussion

Lecturer's perspective

When the intervention was first introduced in class, the students were apprehensive, and this state of mind was clearly connected to the novelty of the task. With the start of the article presentation and discussion sessions, the students got to experience how data is acquired, presented, and discussed and how scientific peer review functions. Consequently, it became easier for them to assimilate the task at hand and understand what was expected regarding the written report and the peer-review process.

After the students submitted their first written draft and performed peer reviews on their colleagues' work, I made personal notes/evaluations about each report to be able to register any improvements from the first to final draft. Given the students' limited experience with peer-review, the quality of their assessments was more than acceptable. In general, the students' peer-review comments tackled various aspects such as the content of the introduction, data presentation and interpretation, and conclusions. Upon reading the reports for a second time it was evident that peer-review had functioned in two ways: a) The students were able to incorporate changes suggested by their "reviewers"; b) they also took ideas from the reports they had themselves evaluated. The overall quality of the reports after the peer-review process led to a more "polished product"; in some cases, the students got a higher grade with their peer-reviewed report than they would have gotten without peer-review.

Students' perspective

Given the data gathered from the questionnaire (n= 17 students) , it seems evident that the students perceived the peer-review experience as favorable. All the students reported that the peer-review process encouraged them to critically evaluate their own reports, that they were able to identify weaknesses/areas of improvement they had missed initially, and it also helped them provide constructive and respectful feedback (not shown). As seen in Fig 1, all the students were able to implement feedback received from their peers in their own reports and

70% of the responses indicate that by reviewing other reports, they were able to recognize pitfalls on their own reports. Specifically, 70% of the students indicated a heavy contribution (level 4 and 5) of reviewing their colleagues' reports as a source of novel ideas on their own reports. Likewise, 90% of the students reported that receiving feedback had a strong influence (level 4 and 5) in helping them to better understand the strengths and weaknesses of their own reports. The high value of performing peer-review to improve their own reports agrees with findings indicating that reviewing others' works promotes higher gains than receiving feedback (Lundstrom & Baker, 2009; Yu & Schunn, 2023).

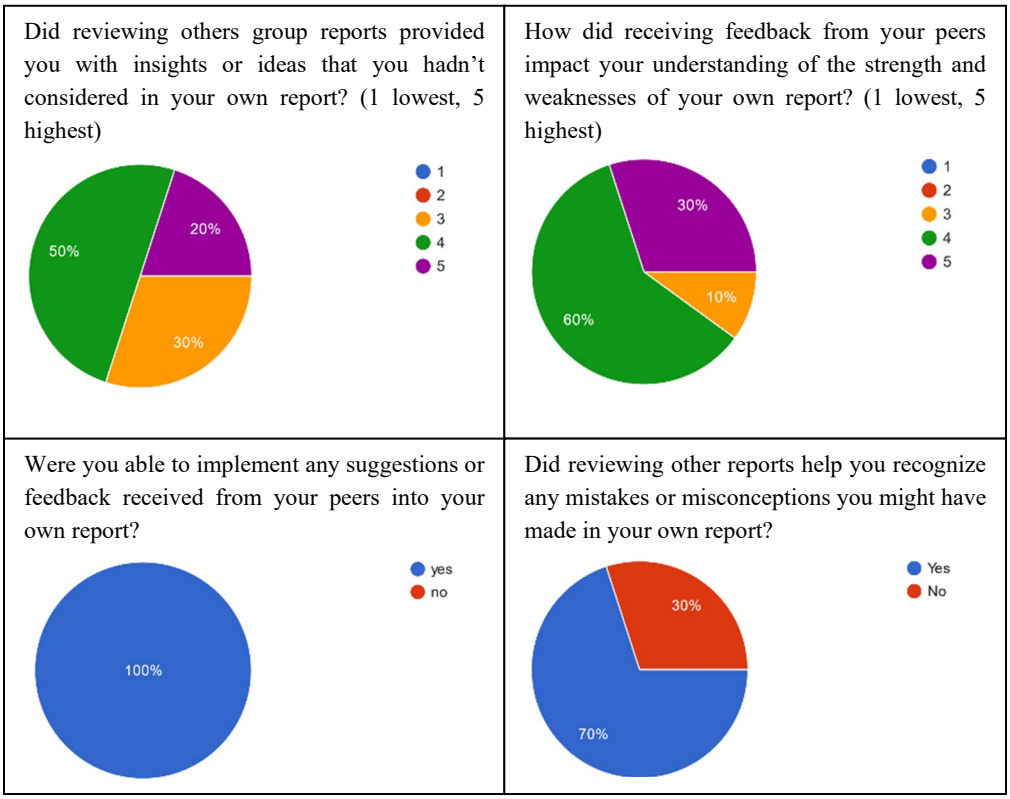

Fig 1. Results of the student's evaluation of the Peer-review system.

When asked to specifically indicate how discussing their reports and peer review contributed to their learning outcomes, most of the students replied favorably. Here, the students were allowed to answer freely, with the following sentences illustrating how this task promoted the students' self-reflection about their lab reports:

> *"It helped with identifying good parts and things that could be improved. I got some new points from the peers that I have not thought about before"*

> *"we discussed different aspects on how to look at a report and I reflected more about my writing style and especially what I can improve"*

Additionally, the students were asked to provide an appraisal of the whole experience of peer review and how this impacted the quality of their own report. Again, all answers were favorable and selected answers illustrate why the students had this perception:

> *"it gave us an opportunity to interpret the results better and have a better structure for the report itself"*

> *"I think being able to review someone else's worth and critique it not only improves our skills when it comes to criticism but also what to look out for in our own essays"*

One particularly interesting comment was

> *"Besides getting feedback to improve on missing, erroneous, etc. parts, it also lifts some of the pressure by acting as a safety net, making sure the report, probably, isn't completely s***, at the very least after implementing the reviewers' suggestions"*

I did not anticipate that by providing peer review, the students would feel less pressure due to the added layer of proofing the report. I also found it a bit surprising that the students would have such high acceptance of their peer's input; from other tasks like article presentations, it is very common that the students complain about the lack of quality of the presentations by their peers and that they would rather have the expert (lecturer) presenting the articles instead. In line with this, several articles in the literature support the view that students prefer feedback from the lecturer and that colleagues feedback is less insightful (reviewed in Misiejuk et al., 2021). Still, in the small-scale intervention reported here, all the students indicated that the peer-review system allowed them to improve

their own report. This is consistent with observations indicating that feedback can have a substantial impact on students' learning when the system is geared to increase their perception of how to improve (Black & Wiliam, 2009; Wheatley et al., 2015). Precisely as discussed by Wheatley and colleagues (2015), feedback can be highly advantageous when used as feedforward, i.e. allowing the students to experiment and fail and learn from those mistakes through feedback, before they receive summative feedback, which agrees with the improvements seen in the students reports and on the comment about the "safety net" and concomitant reduced pressure enabled by the peer review process.

Conclusion

In sum, based on the appreciation from the students and me, the process of introducing formative feedback in the form of peer-review during the preparation of a lab report was a success. The objectives of the intervention were fully met, with the students' reporting signs of active learning and enhanced critical thinking, which resulted in visible improvements in their ability to produce a lab report. This success also reinforces the achievement of high tier ILOs which are part of the course description and opens the way for further experimentation and better integration of the course content, learning objectives and students' educative needs. In comparison to previous iterations of the course, the students' reports were more well-rounded because of peer review and the hypothesis-driven questions were also the target of praise during the course evaluation. It was also interesting to see the acceptance of peer-review in contrast to student's article presentations where their yearly complaints about preferring the lecturer's presentations to that of their peers are noted. My impression is that several items are at play for this difference: a) better scaffolding of the peer-review vs presentations, b) production of written peer-review document vs presentation slides, c) peer-review is a direct part of the evaluation process while student presentations are not. Given the positive outcome of this intervention, the relevance of giving good feedback, and the lack of examples of peer-review style feedback in classes at universities, this report opens good prospects for broad implementation of this tool in other classes.

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