

Using Peer Review to Improve Lab Report Assignments

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ABSTRACT

Introductory science students participate in peer review as a component of their final lab report assignment. The peer review activity is conducted during lab time at least two weeks before the final report is due. This activity is designed to increase student understanding of science as a process that includes peer review as well as the lab activity, and to provide feedback before the final assignment is submitted for grading. It can be used for any science laboratory course with large lab report assignments.

Key Words: pedagogy; STEM Education; critical thinking; feedback; assessment; term paper.

○ Introduction

Inquiry-based writing has been shown to increase students' scientific knowledge (Walker & Sampson, 2013). One ubiquitous example of inquiry-based writing is the lab report assignment, whose purpose is to learn and practice research article writing and demonstrate that learning to their lab instructors (Parkinson, 2017). The learning goals of lab reports are to encourage deeper understanding of science as a process and to demonstrate how to think in a scientific way, as opposed to considering science as lists of memorized facts and findings (Deiner et al., 2012). Lerner (2007) and Russell (2002) described the original purpose of lab reports as to prepare students to act, think, and write like real scientists. Toward this purpose, lab reports target development of scientific writing skills as well as scientific inquiry (Harris, 2009). Lab reports mimic the process of scientific inquiry and are formatted as scientific publications, though assessment is by instructors rather than peers. In the context of assignments, "peer review is understood to mean the educational arrangement in which students consider or evaluate the value, quality or success of work produced by their fellow students and provide each other with feedback" (Pearce et al., 2009, p. 3). Peer review has an important role in improving writing,

reading, and collaborating. It also helps lower or prevent writing errors, ensure accurate reporting, and improve grades (Colthorpe et al., 2014). In addition to improving individual grades, peer review also contributes to improving critical thinking and self-assessment skills, collaboration and communication skills, as well as increasing motivation, self-confidence, and independence (Table 1).

In 2013, a master's student interviewed environmental science and biology undergraduate students and lab instructors at George Mason University regarding lab report assignments (Kalaskas, 2013). His research identified some concerns:

1. Students may lack the epistemological background to understand lab reports as a process of doing science.
2. Students believe that the lab report is a schooling or academic genre that is assigned exclusively in science lab courses. This is opposed to the view that lab reports are an apprenticeship type assignment designed to teach students how to do science work.
3. Students suggested instructors make too many assumptions about what students know regarding lab report writing and most suggested that instructors intentionally distribute vague instructions.
4. Instructors report a lack of attention to detail is the reason students do poorly, which implies a lack of revision and editing.

In the past we found that few students asked questions during lab or attended faculty office hours. However, our course has participated in a peer mentoring program where undergraduate Learning Assistants (LAs) (see <https://laprogram.colorado.edu>) were available during lab time and held additional study sessions. These peer-led activities had higher participation than other available study aids. Given the LA program's popularity, which employs peer mentoring, and the findings of the 2013 survey, a peer review component was developed to improve student understanding of both the assignment and how peer review is used in the process of doing science. The purpose of

Table 1. Reasons for incorporating peer review for students to write and revise their laboratory report (modified from bulleted list in Pearce et al., 2009, p. 4).

Critical Thinking and Self-Assessment Skills	Motivation, Self-Confidence, and Independence	Collaboration and Communication Skills
<ul style="list-style-type: none"> • Building problem solving skills through identifying areas needing improvement and providing constructive suggestions (Dochy et al., 1999; Somervell, 1993) • Encouraging reflection and thereby promoting skills in self-assessment (Liu & Carless, 2006) • Engaging students actively in critical thinking, in applying criteria, in reflection, and through this, in learning transfer (Nicol et al., 2014) • Providing valuable experience and preparation for the professional workplace (Brindley & Scoffield, 1998; Biggs & Tang, 2007) • Enabling students not only to develop important high-order (generic) skills such as critical evaluation and communication, but also to develop important skills of self-assessment—arguably one of the most important goals of a higher education (Mulder et al., 2014b) • Including the ability to engage with and take ownership of evaluation criteria, to make informed judgements about the quality of the work of others, to formulate and articulate these judgments in written form, and, fundamentally, the ability to evaluate and improve one's own work based on these processes (Nicol et al., 2014) 	<ul style="list-style-type: none"> • Enhancing greater meta-cognitive self-awareness (Topping, 1998; Liu & Carless, 2006) • Increasing student motivation by fostering a sense of responsibility and ownership for their peers' learning (Dochy et al., 1999; Cheng & Warren, 1997) • Increasing interactivity self-confidence (Brindley & Scoffield, 1998) and empathy for others (Topping, 1998) • Engaging in peer review has a positive effect, not only on students' perceptions of peer learning and the value of peer feedback, but also on their academic outcomes (Mulder et al., 2014b) • Making significant improvements in the students' ability to write in science and to evaluate the quality of their peers' writing with a relatively high degree of accuracy (Walker & Sampson, 2013) • Promoting independent learning and reducing dependence on staff as "the experts" (Brindley & Scoffield, 1998; Dochy et al., 1999) 	<ul style="list-style-type: none"> • Sensitizing students to the different ways in which readers might interpret what they have written (Nichol et al., 2014) • Improving social and communication skills such as verbal or written communication, negotiation skills, diplomacy, and giving and accepting criticism (Topping et al., 2000) • Enhancing relationships in the group (Cheng & Warren, 1997) • Developing a collaborative and participatory learning environment (Fallows & Chandramohan, 2001) • Presenting a comparative process wherein students evaluate each peer assignment against an internal representation of their own work, where they use the feedback they generate for others to update their thinking about their own assignment (Nichol et al., 2014) • Alerting students to deficiencies or gaps in their work (Nichol et al., 2014)

peer-review is to provide students with (1) an incentive to scrutinize, evaluate, and understand the grading rubric, (2) an opportunity to learn from seeing examples of different lab reports, and (3) an opportunity for external review and time for revision. In this manuscript, we show our essential evaluation outcomes and process for using peer review in an environmental science course laboratory component. We use this information to provide readers with guidance for incorporating peer review into their laboratory assignments and courses.

○ How to Do It

Peer review is incorporated into an existing lab report assignment. We recommend the review be done in-class to avoid plagiarizing and to ensure the instructor is available for clarification.

○ Format

The day students are introduced to the lab report assignment, they are also introduced to the concept of peer review and provided with grading rubrics. Two weeks after completing the lab activity, students are required to bring two copies of their lab reports for in-class peer review. The instructor collects the lab reports and

gives two different reports to each student to grade using the grading rubric. So each student has received two reviews from different classmates. The rubric is intentionally detailed to help students identify the essential components of an outstanding report, with the idea that the review process builds each student reviewer's own writing ability. After receiving input and grades from their peers, students had one to two weeks to incorporate revisions before turning in a final copy to instructors.

Students had one hour to complete reviews, about 30 minutes per report. The entire assignment lasts about 90 minutes, including instruction, collection, and distribution of reports. This activity is done at the beginning of a lab period that normally does not take the full 2 hours 50 minutes. Assigning this task at the beginning of lab before the regular lab assignments reduces incentive to rush the work and leave early.

○ Instruction and Rubrics

Clear and detailed grading rubrics are necessary to avoid discrepancies between instructors and peer grading. We provide an outline of rubric components (Table 2); a copy of our rubric is available in the Online Supplemental Material_Rubric or can be downloaded

Table 2. Rubric components.

Section	Components / Subsections
Format	Complete, logical, and correct format of sections and labels
Introduction	Concise background, research questions, objectives, hypothesis
Methods	Thorough explanation and justification
Results	Appropriate summary with tables/figures
Discussion	Interprets results in context of hypothesis and background, draws conclusions, addresses uncertainty, and poses new questions

at goo.gl/bMxZf0, though some details are specific to the project in this course and will need to be modified for other lab projects. We strongly suggest that each component be given a description and assigned points based on course learning objectives. For each section and component, we specified the content and format required for assignment of full, partial, or no credit.

○ Grading

Grades received from peers did not count toward the final lab report grade. Peer grades should provide a sense of the final grade assessed with the grading rubric. The graded part of this assignment contributed to participation, based on three components described in the assignment as follows:

Full credit for the peer-review process will be given for a student who (1) is present on the day of peer review, (2) brings two hard copies of their formal lab report, and (3) reviews and grades (using the grading rubric) the formal lab reports of two peers in a thoughtful, thorough, conscientious manner.

Grading the peer reviews requires additional guidelines. Thoughtful, thorough, and conscientious reviews will provide explanation for scores given via the grading rubric. Tools such as Calibrated Peer Review (Robinson, 2001) also exist to assist with honing reviewing skills and establishing expectations for reviewers.

○ Student Responses

Two years after the initial student interviews, peer review was introduced during the Spring 2015 semester into 21 labs taught by eight lab instructors (graduate teaching assistants, GTA) with 337 undergraduate students enrolled. During the last week of the semester, an anonymous link was emailed via SurveyMonkey® to students and instructors, inviting them to complete a questionnaire. The purpose of the questionnaire was to evaluate students' and teachers' opinions regarding peer review. All eight instructors and 298 students (88.4% response rate) participated in the questionnaire (Online Supplemental Material_Questionnaire). Survey responses were anonymized, and students received extra credit points for participating. Most survey questions used 5-point Likert scale with responses ranging from "strongly agree" to "strongly disagree" or provided multiple selections with the option to select more than one response. Open-ended questions were grouped using thematic coding.

The two courses were considered part of a year-long curriculum, though there is no required order, and 64 percent of respondents reported having already taken one of the courses. Of the 298 respondents, 24 percent had previously completed a lab report, and 49 percent had previously participated in peer review as a class assignment. Overall, most students (60%; $n = 226$) rated the peer review process as a helpful aspect of lab report assignments, and 66 percent ($n = 230$) agreed or strongly agreed that the peer review component helped them understand the lab report assignment. Almost all instructors (88%; $n = 7$) agreed or strongly agreed that the peer review component helped improve students' understanding of the lab report assignment. Also, well over half of the instructors (75%; $n = 6$) agreed or strongly agreed that the peer review component helped students earn higher grades on the lab report assignment. Overall, we feel that this activity has improved both student learning experiences and grades. The peer review component will continue to be a part of the lab report in all our undergraduate environmental science courses. Responses varied regarding quality of the revision process, clarity of instructions, and time spent on the peer revision process. The quality of the revision process was a concern for 25 percent of the respondents, who stated the reviewers were inconsistent or did not provide adequate commentary. Approximately 15 percent (45) of the students and two GTAs thought more time should be spent on the peer revision component.

○ Reflection

Based on responses, the two major concerns are allocating sufficient time and the quality of review. Most students believe that their peers did not have enough knowledge to review and revise the lab reports. One way this issue can be resolved is by students practicing review with their instructors. This practice could include demonstration by the instructor and providing students with the same document for review, followed by discussion or presentation of review points by the instructor. This would not only provide the students with more knowledge about the review process, but it will also give them the confidence to correctly revise other's work. Assessing the actual feedback given by reviewers could also be critical for high quality reviewing (Ruegg, 2014), and other studies reveal concerns about review quality and equity in participating in peer review (Mulder et al., 2014a; Cheng et al., 2015). To address both time management and quality of review, we suggest more time for reviewing, explaining, and demonstrating peer review. More time could involve more in-class time or introducing the activity earlier in the semester to give students more time to revise their reports. Using a piecemeal strategy

could also address both time management and instructor involvement. In this strategy, the lab report assignment is split into sections, with each section completed and submitted on different dates. After submitting each section, the instructor returns it to students with comments and feedback. This provides students with input in an iterative process of addressing comments and revising before turning in the final report at the end of the semester. This strategy also makes the learning process less stressful for the students since not everything will be due at one time (Kalaskas, 2013).

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