JMBE Journal of Microbiology & Biology Education

Increasing Undergraduate Student Knowledge about Journal Peer Review Using Outside Reading and In-Class Discussion

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KEYWORDS communications, peer review, publishing, science trust, teaching, undergraduate, writing

INTRODUCTION

Public trust, or the lack thereof, in science and scientists is a recent hot button issue. For example, other work has described breakdowns in public trust and the spread of misconceptions about the 2019 coronavirus disease (COVID-19) pandemic and climate change (1–4). One possible way to influence public trust in science and scientists is by improving scientific literacy, a component of which is understanding the process of doing science and communicating novel findings (4–7).

Scientific literacy is not limited to an individual's scientific content knowledge. Another major aspect of scientific literacy is a working understanding of scientific process and practices (8). Scientific writing and science communication are key concepts commonly taught in undergraduate science coursework and are listed as core competencies in the American Association for the Advancement of Science's *Vision and Change: a Call to Action* (9). Across different fields, the traditional method for practicing scientists to communicate with each other and the public is through publishing articles in journals (10). The peer review step of the publication process is an important quality control measure (7, 11, 12). Though many evidence-based peer review activities for students exist, these often address peer review in the context of student writing only, rather than publications by independent scientists (13–16). This new lesson outlines the publishing and peer review process and prompts students to consider how this process affects trust in science. Through completion of the module, students report and show scientific literacy learning gains related to the publication and peer review process.

Editor Mark A. Sarvary, Cornell University
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The author declares no conflict of interest.
Received: 30 September 2022, Accepted: 27 February 2023, Published: 16 March 2023

PROCEDURE

Safety issues

The module presented requires reading, evaluation of existing data, and group discussion. As a result, no safety issues are anticipated. The only safety concerns would be related to the experimental procedures performed if this module is used as part of a laboratory class. Student data were acquired through voluntary surveys during class. These survey questions were presented via the course learning management system (Canvas). This work was considered Exempted Self-Determination by the University of California, Irvine Institutional Review Board (protocol number 1354) as research conducted in an educational setting involving normal educational practices.

Scientific peer review process module

This module was taught as part of a larger series of scientific writing lessons in an undergraduate biochemistry laboratory course at a large, public university in the United States. The course goal is to provide students with a theoretical background in protein biochemistry techniques and an opportunity to perform these techniques as part of a multiweek enzyme purification and characterization project. The course also requires students to read primary literature and author an independent manuscript in the style of a primary literature article. There were 97 students enrolled in this course. This course typically enrolls fourth- and fifth-year undergraduates majoring in biological sciences or one of its subdisciplines (see Appendix S1 in the supplemental material). Students had two weekly course meetings: one lecture section and one practical laboratory section. Due to the COVID-19 pandemic, the lecture was held in person with the faculty instructor, but a recording was provided for students to watch asynchronously if needed. There were five laboratory section cohorts of approximately 20 students each. Each laboratory section was led by a graduate student teaching assistant and required in-person attendance.

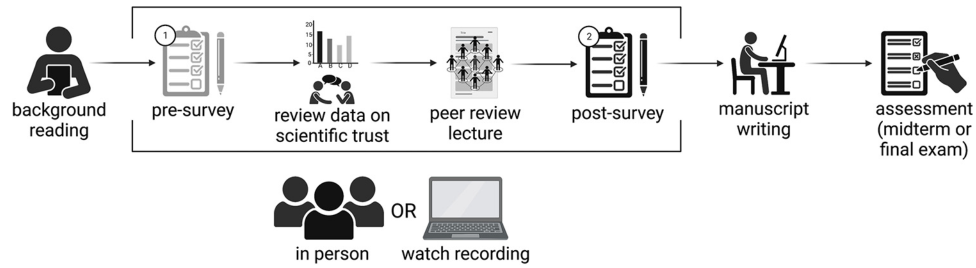

FIG 1. Overview of the peer review module. Created with BioRender.

The scientific writing component of this course requires students to author manuscript-style reports on their multi-week laboratory projects. Two learning objectives were identified for this new publishing and peer review module. These state that students will be able to (i) outline the process of peer review and (ii) explain the purpose of peer review in the process of scientific publishing. These objectives guided the development through backward design (17) of a stand-alone in-lecture module introducing the process of scientific publishing and peer review and relating this process to scientific trust (Fig. 1; Appendix S2). This module was implemented in one lecture session led by the faculty instructor of record. The activity involved the entire class with breakouts into smaller groups to discuss the material. The module was implemented in the lecture session so that all students experienced the same content and activities in the same way. In contrast, laboratory sessions were each led by a different teaching assistant, which could have confounded the evaluation of the module's outcomes. In principle, however, this module could be used in either a lecture or laboratory session with minimal changes.

As preparation for the module, all enrolled students were assigned several blogs and a journal article to read about the publishing and peer review process and its importance (Appendix S2). At the beginning of the class period and before any formal lecture activities, the students were surveyed on topics related to the general public's feelings of scientific trust and their understanding of how scientific publications are evaluated (Appendix S2). Students were also asked about their level of understanding of the evaluation process (Fig. 2, preactivity data). The lesson began with an introduction to survey data collected from several sources. These surveys asked about trust in science and scientists by the public. Students examined these survey data and discussed whether understanding of the publishing and peer review process was related to public trust in science and scientists. This discussion was run as a think-pair-share activity (18). When sharing with the entire class, students predicted that demystifying these processes would be a good strategy for positively impacting trust. Next, the instructor gave a short lecture on the major steps involved in scientific publication, including peer review. Then, the instructor facilitated another think-pair-share activity about scientific publishing norms in the life sciences (Appendix S2). After this part of the lesson, students were surveyed about their understanding of how scientific publications are evaluated (Fig. 2, postactivity data). In later weeks, all students completed a summative assessment in the form of a final exam that included topics from this module.

Assessment

Students were given a brief formative assessment of their understanding of the scientific publishing and the peer review process as part of the in-class module through the Canvas learning management system survey function. In total, 96 of 97 enrolled students participated in the survey. In the lecture, students were given a preactivity survey, then the scientific trust and peer review lesson, and finally a postactivity survey (Fig. 1). In these two surveys, students were given the prompt "I understand how scientific publications are evaluated" and asked to rate their level of agreement on a Likert scale. In the preactivity survey results, most students responded that they "agree somewhat" with this statement (54%) (Fig. 2). Then, students saw data on perceptions of trust in scientists, heard about the publishing and peer review process, and had short paired or small group discussions that were shared with the larger class. After this lesson, most students responded that they "strongly agree" with this statement (59%) (Fig. 2). This suggested that the in-class activities contributed to student understanding of scientific publications.

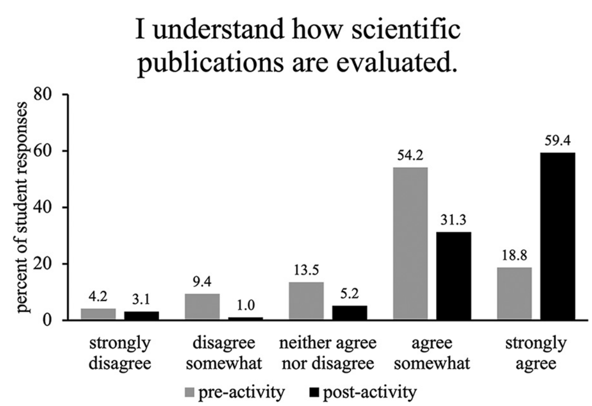

FIG 2. Student responses to the statement "I understand how scientific publications are evaluated." Responses from 96 students were collected electronically via the Canvas learning management system survey function in a biochemistry laboratory course. One enrolled student did not participate in the survey. Preactivity responses (light) were collected during lecture prior to the lecture activity. Postactivity responses (dark) were collected during class after the lecture activity.

TABLE 1
Summary of student responses to final exam question

Topic and question no.	% of students selecting answer:					
	A. Correct	**B. Incorrect**	**C. Incorrect**	**D. Incorrect**	**E. Incorrect**	**F. Incorrect**
Peer review						
Question 1	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Question 2, part 1	92.8%	0.0%	7.2%			
Question 2, part 2	86.6%	13.4%				
Question 2, part 3	99.0%	1.0%				
Question 2, part 4	99.0%	1.0%				
Question 2, avg	94.3%					
General scientific writing (not peer review)						
Question 3	70.1%	1.0%	7.2%	21.6%		

Furthermore, longer-term knowledge of the publication and peer review process was addressed on the course final exam through two different multiple-choice questions (Appendix S3). All 97 enrolled students participated in the final exam. All (100%) students answered the first publication and peer review question correctly, and 86.6% of students answered the second publication and peer review question correctly (Table 1; Appendix S3). For comparison, another final exam question assessed a scientific writing topic unrelated to the scientific peer review process module (Appendix S3). For this question, 70.1% of students answered this non-peer review question correctly (Table 1). Together, these data suggested that this module is an effective tool for building undergraduate students' scientific literacy through their understanding of the publication and peer review process.

CONCLUSION

This lesson is one way to formally introduce students to the publication and peer review process in the biological sciences. In the facilitated discussion, students also considered the link between understanding the publishing process and public trust in science and scientists. The student survey data point toward learning gains related to the publishing and peer review process and thus increased scientific literacy. This lesson is intended to be generalizable to various courses in fields that use similar publication and peer review practices as the life sciences disciplines. It was taught as part of the lecture portion of the class, for which all enrolled students come together with the faculty instructor. However, it could have been implemented in laboratory sections with minimal alteration and proper teaching assistant training. Although this lesson has been paired in this course with a multiweek student writing assignment, it may also serve as a stand-alone lesson in courses that lack such a project. While most students described here were in year four or five of their degree in the biological sciences, I expect that this content could be adapted with minimal changes to an introductory biology or general education course as well. Further work may connect how lessons such as these may also influence students' ability to conduct meaningful peer reviews and even self-review their work.

Learning about publication practices helps provide well-rounded training in scientific communications and develops scientific literacy. This education can increase one's trust in published scientific findings (7). Fostering the growth of new scientists who can take in novel information, analyze it, and then convey that information to others is a common goal for science educators (9). In the life sciences, undergraduate student populations tend to be more diverse than independent scientist populations (19). Therefore, with better education on publication and peer review practices, students may serve as a liaison that communicates the process of science and new scientific discoveries to more diverse communities. Future studies may track whether undergraduate education on publishing and peer review practices correlates with changes in scientific trust by the public.

SUPPLEMENTAL MATERIAL

Supplemental material is available online only.

SUPPLEMENTAL FILE 1, PDF file, 2.1 MB.

ACKNOWLEDGMENTS

Financial support for this work was provided by the Ethics Network for Course-based Opportunities in Undergraduate Research (ENCOUR), an NSF-funded initiative (NSF-DBI 1919312). The views expressed in this article are those of the author and do not necessarily reflect the views, opinions, or beliefs of the National Science Foundation. I also thank the U See I Write Faculty Writing Initiative for writing support and A.W. for a critical reading of the manuscript.

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