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| Curriculum

Peer-reviewed presentation exchange in an undergraduate classroom

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ABSTRACT Reading, presenting, and discussing peer-reviewed scientific reports, case studies, and reviews are essential to modern biology education. These exercises model crucial aspects of students' future professional activities and introduce the students to the current scientific concepts and methodology, data analysis, and presentation. A common format for working with primary literature is a journal club: presenting and discussing research literature in front of peers, which has many merits. However, in large modern classrooms, this format is very time-consuming and stressful, especially since presenting is not a commonly taught skill. We argue that student groups for whom the current educational and professional paradigms present a challenge due to a historical lack of representation or wellness issues are deprived of a key educational opportunity. To solve this problem, we formulated an approach called Peer-Reviewed Presentation Exchange (PRPE), which focuses on collaborative analysis, presentation, and review of research literature that includes (i) voice-narrated research presentations by students, (ii) checklists generated by the instructor to establish expectations for an informative presentation or review, and (iii) presentation assignment and peer review process. We tested this approach in an undergraduate cell biology class over 3 years. Pre- and post-assessments show significant gains in self-efficacy and knowledge not only by students who presented but also by the students who reviewed the presentations; therefore, peer-reviewed presentations are an effective tool for learning. Exit surveys show that the approach is seen as beneficial by most students. Our approach allows every student to speak and ask questions in a low-stress creative environment. It is an excellent customizable, trackable, and scalable low-stakes assessment tool.

KEYWORDS undergraduate, project-based learning, cell biology, primary literature, learning gains

Background and rationale for transformation

Reading primary research literature such as scientific reports, case studies, and reviews published in peer-reviewed journals is an excellent way to bring modern science into the undergraduate classroom. It introduces students to the questions, methodology, and state of scientific discourse in various fields of biology and related disciplines (1–4), leading to specific and quantifiable improvements in knowledge use and integration to levels comparable with those of experts (5). Furthermore, discussing primary research literature in class, especially in the oral form, is an excellent model for disseminating knowledge to experts in the field and the general public. The impact of primary research literature as a learning tool in modern classrooms is evident from the published reports and from the popularity of such tools as figure facts (3, 6, 7). Direct evidence of gains associated with incorporating primary research literature has been shown in many disciplines (1–5, 8, 9).

Reading and comprehending primary research literature are challenging for many undergraduate students. Offering courses on scientific thinking and research, such as

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The authors declare no conflict of interest.

Received 24 April 2023
Accepted 6 December 2023
Published 8 January 2024

C.R.E.A.T.E. (consider, read, elucidate hypothesis, analyze and interpret data, think of the next experiment), which is a teaching strategy involving detailed analysis of primary research literature, may address some of these challenges (10, 11). Such approaches have successfully identified and remedied difficult points related to the use of primary literature by the students (8, 9).

Oral presentations in front of peers are commonly used to share and discuss the material learned from the primary research literature and are an excellent assessment tool and a great way to improve critical thinking, analytical ability, and presentation skills (12–15). Oral presentations have found success as central components of explorative learning of cell biology and microbiology(16), clinical anatomy (17), physiology (12), pathophysiology (14), clinical medicine (18), engineering (19), and other disciplines.

Using peer review to evaluate student presentations provides many benefits, including the self-reported improved perception of the learning process, a better understanding of the material and its relevance, and better classroom integration (14). Furthermore, discussing primary research literature between the students helps establish a learning community. This is reflected in the overwhelmingly positive perception of peer review assessment among students in many disciplines (20).

However, there are several challenges to incorporating these tools into the classes that are not completely and specifically dedicated to analyzing the scientific process. The biggest challenge is the high "time cost" of incorporating the literature into a science class. While it is ideal that each student has a chance to present, it is impossible to accommodate in-class presentations in all but small classes, primarily due to the significant amount of time required for presentations and questions. This likely costs some students learning opportunities from the live presentations and may affect the quality of questions and feedback. The short time for the discussion means that the comments may not be fully understood and recorded. In summary, the current in-class presentation model's specifics may affect the presentation's scope and the quality of the discussion, pushing them toward rhetorical rather than material relevance (18). It is likely that these issues disproportionately affect students who are less prepared for this format and the analysis of research literature in general. Therefore, this is an issue of equity in modern education.

The central goal of the PRPE approach is to establish a framework for an impactful exploration of peer-reviewed primary research literature as an integral part of the education process in an undergraduate cell biology classroom. Our criteria were (i) direct relevance to the material covered in class, (ii) minimal interference with classroom time and schedule, (iii) peer involvement, and (iv) quantifiable outcomes, including the effect on factual knowledge and attitudes toward primary research literature. The approach was deployed in a multiyear study in an undergraduate cell biology class. Gains in self-efficacy and factual knowledge were assessed using pre- and post-assignment surveys to measure their impact alongside participation. The central questions were whether students learn from peers' presentations and whether the student participation in the peer feedback process was associated with gains in formal performance measures.

Intended audience

The PRPE approach applies to a broad range of science courses in which the primary research literature can be a part of the learning process. The approach can help model future professional activities in which presenting and discussing the data or other forms of research findings are practiced.

Learning time

The approach involves one introductory class session (live or recorded) focused on the rationale, benefits, examples and discussion of rubrics, and practical tips, which requires approximately 30 minutes of in-class time. Individual presentation/submission assignments require about 3 hours of out-of-class work. This includes reading the paper

TABLE 1 Learning objectives and assessment tools

Learning objective	Activity	Assessment
Demonstrate new factual knowledge obtained directly from publications or from watching peers' presentations.	Read scientific publications and/or watch peer presentations and identify new information that is relevant to the focus on the class.	Presentations and peer feedback
Demonstrate an understanding of cell biological paradigms and concepts and the role of fundamental cell biology in current biomedical science.	Formulate an explanation and provide examples of how the use of primary literature in the classroom improves the appreciation of cell biological paradigms and concepts and the role of fundamental cell biology in current biomedical science	Exit survey
Demonstrate the ability to bridge the classroom and lecture material and the current advances and paradigms in research.	Use the information learned in class to answer questions based on research literature.	Pre- and post-survey
Demonstrate the ability to summarize and formulate critiques of peer presentations.	Provide detailed and informative feedback on the factual aspects and the stricture of peer presentations.	Peer feedback
Demonstrate proficiency in presenting and discussing primary literature with peers.	Read scientific publications and identify publications dealing with the phenomena and processes that are relevant to the current topic of the class. Identify the key facts and figures illustrating the synergy between classroom material and the research papers. Create presentations using material from the classroom and primary literature; present online or in class.	Pre- and post-survey, presentations, peer feedback

and composing, recording, and uploading the presentation. Reviewing takes about an hour, including watching the presentations and writing and submitting the review.

Prerequisite student knowledge

The approach requires some foundational science knowledge that would be expected of non-expert readers of the journal article (e.g., introductory chemistry and biology for the studied course context). The approach also requires having a basic understanding of the structure of current primary publications, including primary reports and reviews, and familiarity with modern presentation tools, such as MS PowerPoint or Google Slides.

Learning objectives

The students are expected to (i) demonstrate new factual knowledge obtained directly from publications and from watching peers' presentations, (ii) demonstrate an understanding of cell biological paradigms and concepts and the role of fundamental cell biology in current biomedical science, (iii) demonstrate the ability to explain the connections between the classroom/lecture material and current advances in research, (iv) demonstrate the ability to summarize and formulate critiques of peer's presentations, and (v) demonstrate proficiency for presenting and discussing primary literature with peers. The learning objectives and their corresponding learning activities and assessments are summarized in Table 1.

PROCEDURE

Overview

The PRPE approach moves the oral presentations and feedback outside of the classroom, allowing each student to present and critique on their own time and at their own pace. It is a curated exchange of voice-narrated presentations that other students in the class review online. PRPE allows for repeating presentations, multiple critiques of the same presentation, and multi-level feedback. It is trackable (in the sense that presentations and feedback are fully captured), scalable to very large courses, sustainable (i.e., easily implemented in future semesters without additional work), and compatible with many disciplines. Figure 1 shows the structure of this approach.

The introduction session

During the introduction session, the instructor explains the rationale behind the approach and distributes a handout (Fig. SF1). Faculty instructions are presented in Fig. SF2. The students learn about the time they will need to allocate to read the assigned primary research literature, generate presentations, watch their peer presentations, and generate reviews. The instructor explains what constitutes an informative presentation and a review and provides examples of successful presentations and reviews. The students are instructed to focus on the content of their peers' presentations rather than their perceived esthetical value. The timeline of presentation assignments, submissions, and review due dates are established. The students are shown sample presentations (Fig. SF1, Video S1), and the strong points of these examples are discussed.

The checklists

To scaffold the tasks of reading, presenting, and reviewing, the instructor shares the Submission and Review checklists (Fig. 2). The checklists identify specific points to be covered in the presentation and in the review. While the entire class may be given the same checklist by default, as was the case in this class, it is possible to give individualized checklists if some aspects of the presentation or review by some students require individual attention. The submission checklist includes specific and general points for the presentation, such as the main question or hypothesis, a description of the state of

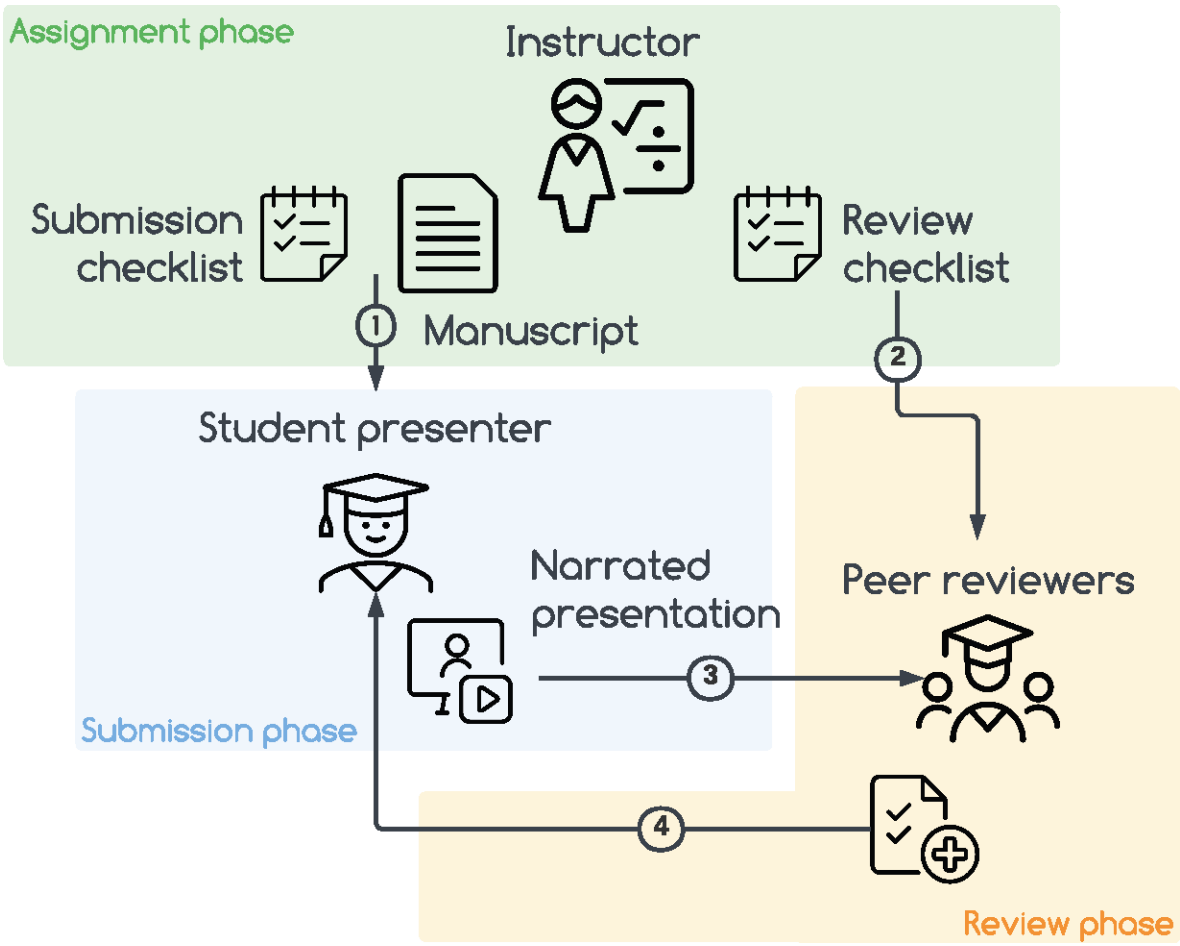

FIG 1 The structure and the workflow of PRPE assignments. The Assignment phase (green panel) involves the instructor assigning manuscripts for review (1) and issuing the submission and the review checklists (2). During the Submission phase (blue panel), the students create narrated presentations, which are assigned to their peers for review (3). During the Review phase (tan box), the students review their peers' presentations and send the feedback.

Presenter's checklist
☐ Significance,
☐ The central problem,
☐ The specific question,
☐ The available approaches,
☐ The main conclusions,
☐ How the data change the field,
☐ The remaining questions.

Reviewer's checklist
☐ Is the central question clear?
☐ Is the central question's importance obvious?
☐ Are the findings supported by data?
☐ Have the remaining questions been identified?
☐ Is the presentation length appropriate?

FIG 2 The presenter and the reviewer checklists.

the field, a critique of methodology, or the conclusions are supported by the findings. The review checklist may include the clarity of presentation, completeness of the report, validity of the conclusions, or other aspects of the review.

Reading assignment

Seven to 10 days before the submission deadline, PDF files of the research publications assigned for reading and presenting are emailed to students or otherwise made available. The assignment can be random, based on the alphabetical order of students' names, or using a volunteering system. Each student is assigned to read one paper per assignment. Three or four assignments took place over the semester. Six papers were assigned each time. In the course with an enrollment between 35 and 85 students, the same paper was read by 5–12 students.

Submission and review assignment procedure

The submissions can be coordinated using web-based peer feedback systems like Peerceptiv [www.peerceptiv.com (21, 22)], Peergrade, FeedbackFruits, or Kritik. Such systems streamline assignments, peer review, and grading using research-validated algorithms. For example, in Peerceptiv, the instructor creates assignments with appropriate deadlines, grace periods, and late penalties. Every aspect of this process occurs completely outside the class.

The instructor issues a submission assignment 1 week before the deadline. After the closure of the submission window, students were automatically assigned three presentations for review (a number that can be adjusted by the instructor). The review deadline was due 1 week after the end of the submissions. The reviewer was asked to evaluate the submission using four rubrics (dimensions in Peerceptiv) described in the Reviewer's checklist (Fig. 3). The answers were in the form of a three- or four-point Likert scale; the reviews were anonymous. In addition to the numerical scores, the three reviewers were asked to submit a brief narrative justifying the scores, which was shared with the submitter after the review deadline.

Suggestions for determining student learning

We tested this approach across 3 years. Each time, we used four submission and review assignments per semester, which took place throughout the semester, usually coinciding with the ending of a course module. Since each submission was matched to three reviewers/each student was given three presentations to review. Therefore, each student was expected to submit four presentations during the semester and was assigned 12 peer presentations to review. Participation in the review and submission process was

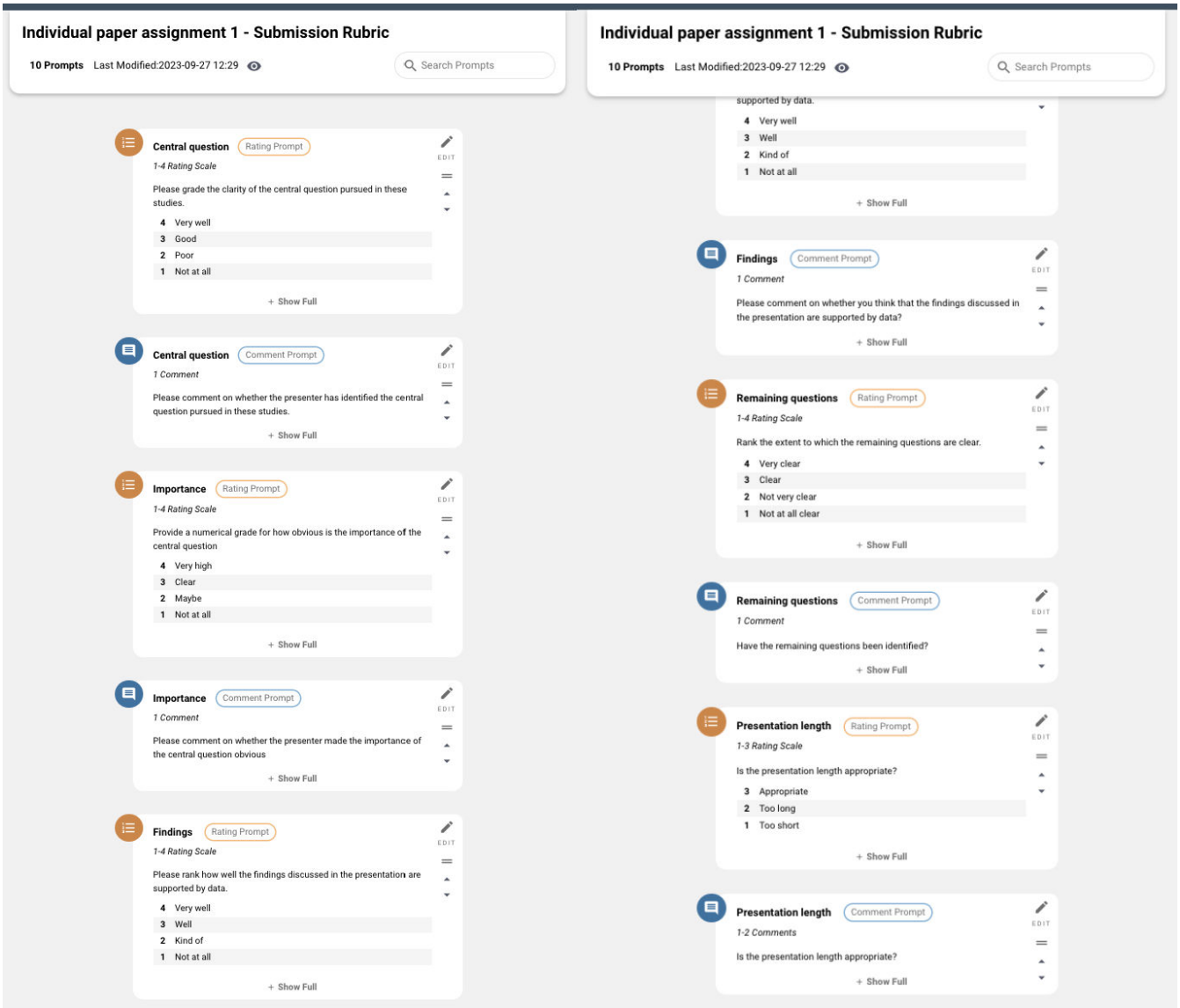

FIG 3 Reviewer's rubric in Peerceptiv.

assessed automatically by Peerceptiv; participation in this approach was a small component of the participation score, which itself was around 10% of the final course grade. Partial grades were awarded to students who did not complete elements of the assignment (e.g., completed submission but not reviews).

Sample data

An example of a voice-narrated presentation authored by a student is provided in (Video S1). Figure 4 shows examples of the reviews and student comments. Clearly, students could create informative presentations and provide constructive reviews (Learning Objectives 4 and 5). There were variations in the depth of presentations and reviews, but the vast majority completed the assignments on time with minimal guidance.

FIG 4 Examples of reviewers' feedback.

DISCUSSION

Field testing

The course context

The studies were performed during a one-semester higher-level three-credit elective undergraduate cell biology lecture class taught in a large R1 public university. Data collection occurred concurrently with the class sections. Enrollment varied between 35 and 85 students across offerings.

Evidence of student learning

This class transformation is based on the idea that reading and presenting primary research literature and reviewing presentations will drive the improvements in student self-efficacy, attitudes toward primary research literature, and factual knowledge. While reading the literature and creating the presentations are enriching, we were specifically interested in measuring direct evidence that students learn by watching peer presentations. Students' attitudes toward the approach, content knowledge, and self-efficacy with the component tasks were surveyed using custom pre- and post-surveys administered four times during the semester. The questions were in the form of a five-point Likert scale focused on students' attitudes and level of comfort toward primary research literature, cell biology, and this course, as well as relevant factual knowledge.

Attitudes

We surmised that working with the primary research literature in a low stake, low-stress environment in a context that is organically connected to the goals of the course should improve students' attitudes toward primary literature. The students were surveyed in this cell biology course for perceived gains in attitude toward the subject and primary research literature. The value of self-reported gains has been debated (23–25), but in the context of this project, it is a useful indicator that directly answers one of the project's goals. Measures of self-reported comfort, satisfaction, and enthusiasm or depression are common in clinical studies and reports (26–31).

Student self-efficacy and factual knowledge

We propose that low-stake activities focused on reading, presenting, and reviewing should increase students' self-efficacy for understanding, using, and applying primary research literature in and outside the classroom. Furthermore, we think this activity should improve knowledge among the students who read and presented the papers and in the students who watched the presentations (i.e., engaged in knowledge transfer between students). Both assumptions were tested using pre- and post-surveys administered during each assignment. We did not find existing self-efficacy or factual knowledge rubrics in this space and created new surveys targeting student confidence and factual knowledge regarding the general and specific content of each paper. Students were asked the same set of questions regardless of whether they had read (Presenter), reviewed (Reviewer), or did neither (Naive) with the given paper. Sample questions are presented in Fig. SF4. Therefore, because assignment to condition was random rather than self-selected, our data include intrinsic controls for general knowledge (performance of the Naive group) and knowledge transfer (performance of the Reviewer group). Each survey included 10–20 questions prepared by the instructor and pre-set answers, including "I Do Not Know." The proportion of "I Do Not Know" responses was used to measure self-efficacy in this context, whereas the proportion of correctly answering the item was a measure of content knowledge.

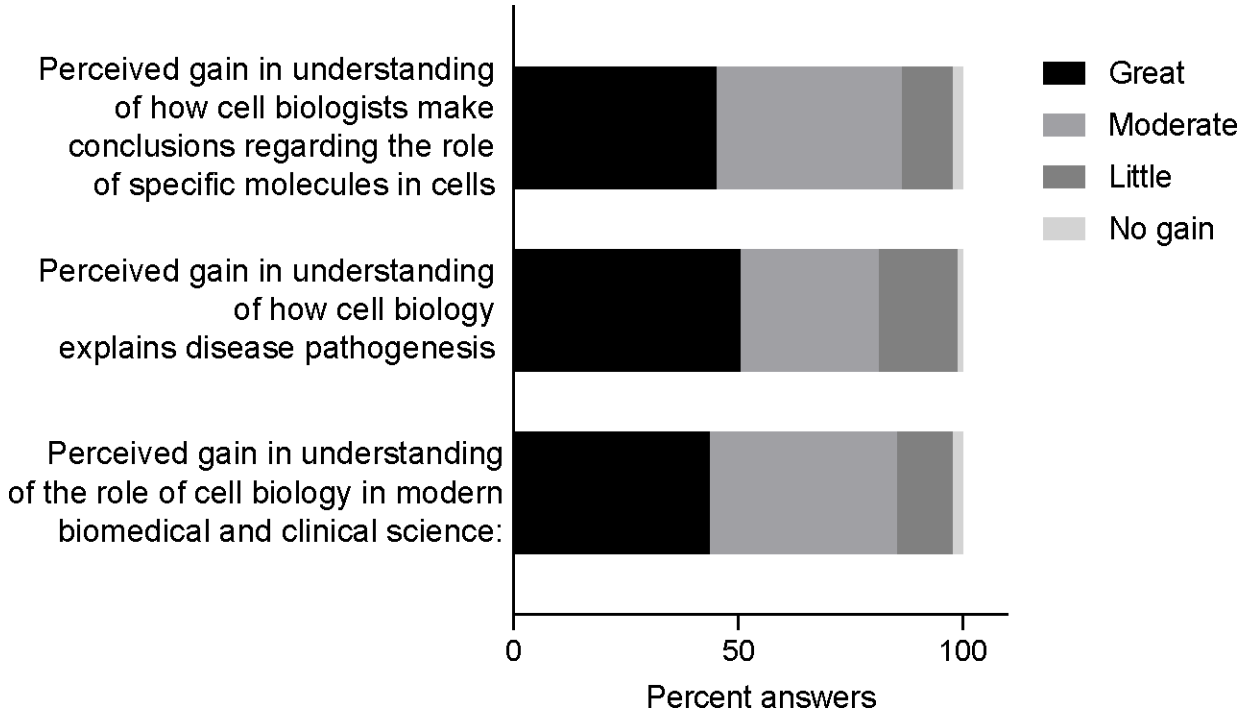

FIG 5 Perceived gains. Data are from 2 years, *n* = 23 and 44.

Data collection

The student self-efficacy and content knowledge surveys were administered 2–4 days before and after each assignment, three times during the semester. The students were asked to identify themselves so that the paper on which they were presenting and reviewing and, therefore, their status relative to the paper (Presenter, Reviewer, or Naive) could be identified.

Simple paired *t*-tests on mean pre- and post-scores within each survey assessed overall pre-post gains in self-efficacy and content knowledge; Cohen's *d* was used to measure effect sizes. A repeated-measures analysis of variance (ANOVA) was conducted

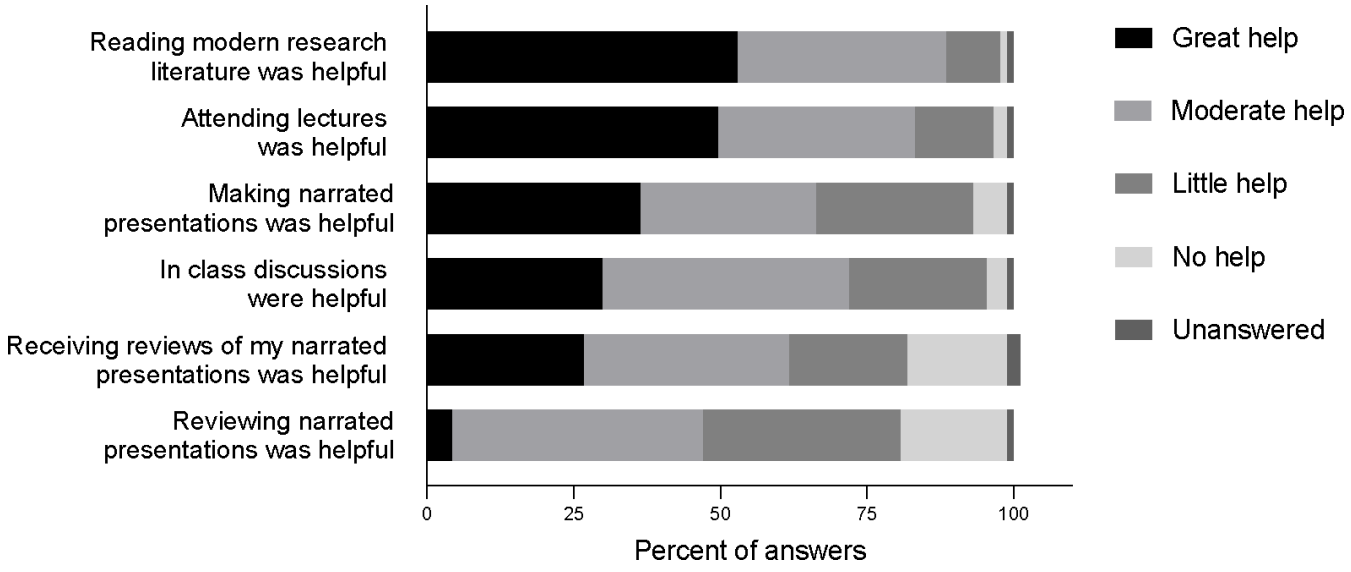

FIG 6 Perceived usefulness of specific components of the approach. Data are from 2 years, *n* = 23 and 44.

to assess the consistency of the gains across years and assignments. Pre- and post-assignments were the within-subjects factors, and the year of course offering was the between-subjects factor. To further assess the consistency of the pre-post changes by a specific knowledge area, means for each given self-efficacy topic or knowledge question were calculated across all students at pre- and then again for all students at post-changes.

Improved attitudes toward primary research literature

The student opinion surveys, which were administered in two of the examined years, showed improvements in the key aspects of the class without measurable negative developments: we detect improvements in attitude toward cell biology, experimental science, and primary research literature; understanding of the process of research and each other's learning process; and understanding how the scientists make conclusions and how the discoveries are transformed into practice. Over 90% of the students report great or moderate gains in understanding the role of cell biology in modern biomedical and clinical science, with zero students reporting no gain (Learning Objective 2; Fig. 5). Nearly 90% of the students report great or moderate perceived gains in understanding how cell biology explains disease pathogenesis and in understanding how cell biologists make conclusions regarding the role of specific molecules in cells, with only 1%–2% reporting no perceived gains.

Nearly 100% of the students reports that reading modern research literature was greatly or moderately useful, and over 60% reports that making or reviewing narrated presentations was greatly or moderately useful (Learning Objective 3; Fig. 6). The student comments mention qualitative changes in understanding cell biology and the scientific process.

Improved content self-efficacy and knowledge

Figure 7 shows pre-post gains in self-efficacy, represented by the decreasing fraction of "I Do Not Know" responses post-assignment at the level of the entire class. On average, during the second session, we detected a 59% ± 3% (SEM) drop in the number of "I Do Not Know" responses [significant at $P < 0.005$ (**) and $P < 0.0001$(****) levels].

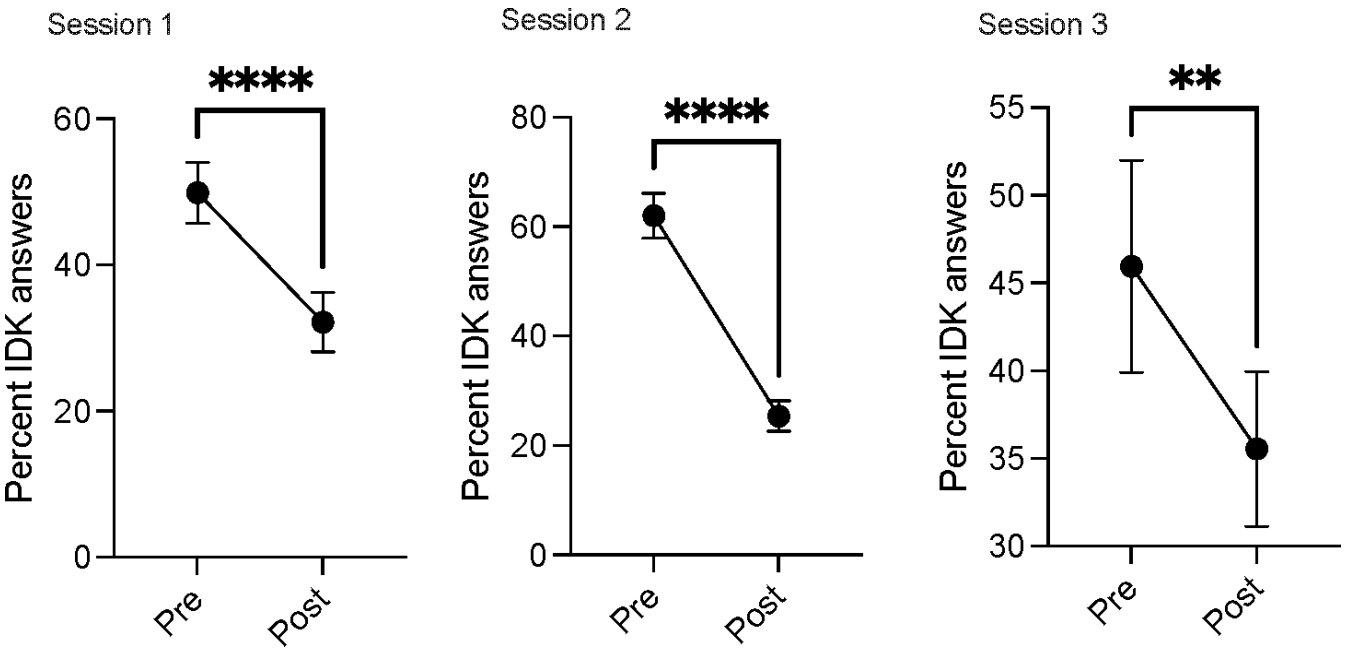

FIG 7 Gains in self-efficacy reported after PRPE assignments. Error bars are SEM, data average from 3 years. Points average 13 questions. Data were analyzed using paired two-tailed *t*-tests. ** represents $P < 0.005$ and **** represents $P < 0.0001$.

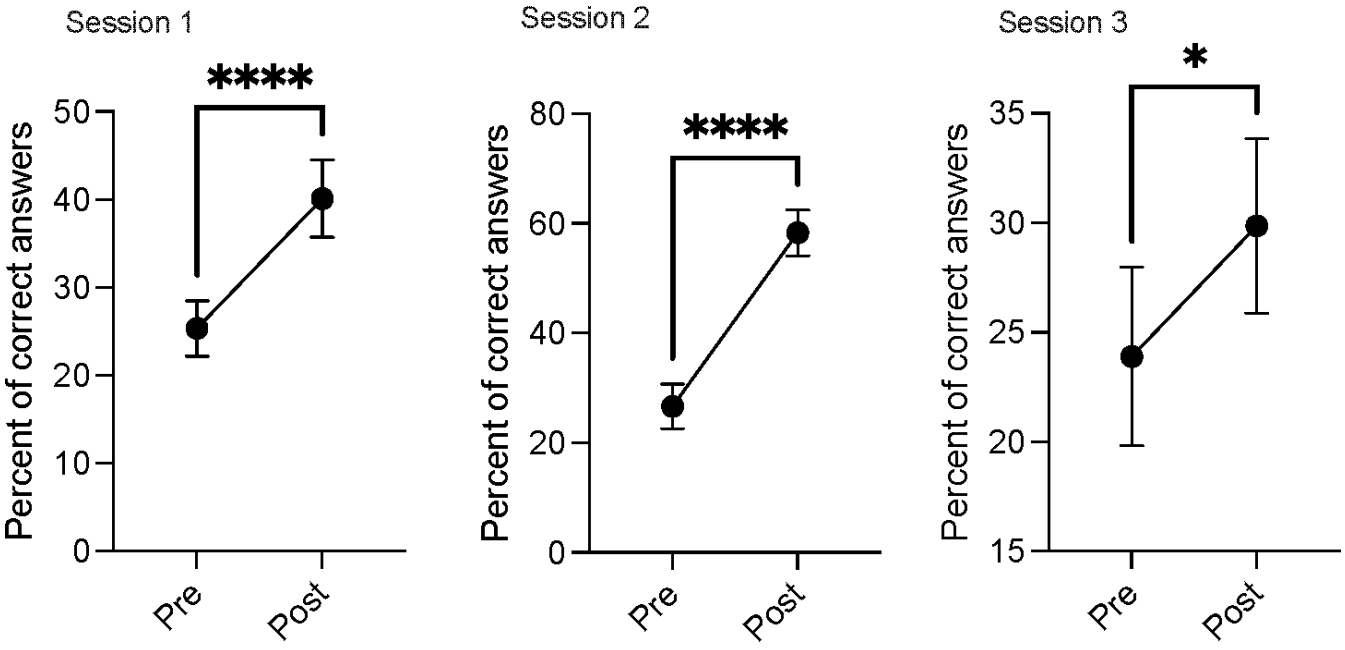

FIG 8 Gains in correctness reported after PRPE assignments. Data representation as in Fig. 7. * represents $P < 0.05$.

We interpret the increase in self-efficacy as evidence of proficiency in presenting and discussing primary literature (Learning Objective 5)

We detect a significant increase in response accuracy post-intervention, reflected in the decreasing fraction of incorrect responses associated with the assignments (Learning Objective 1; Fig. 8). On average, during the second session, we detected 175% ± 24% increase in the number of correct responses [significant at $P < 0.05$ (*) and $P < 0.0001$(****) levels].

A detailed analysis of student groups reporting "I Do Not Know" shows a significantly lower fraction of these responses in the Presenter and Reviewer groups relative to

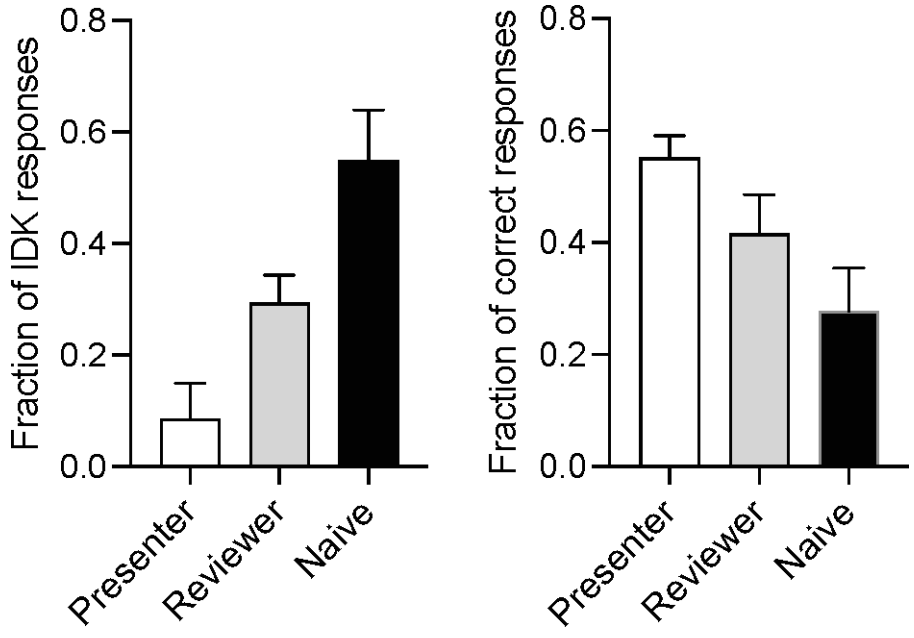

FIG 9 Pre- and post-gains in self-efficacy (left) and correctness (right) in specific student groups. A cumulative of five questions, one session. Error bars are SEM.

Naive (sample data in Fig. 9, left). The latter fact shows that the enriching effects of this approach are not limited to reading and presenting but also include reviewing the presentations. As above, a detailed group analysis shows a decreasing probability of incorrect responses in the Presenter and Reviewer groups, following each assignment relative to Naive (Fig. 9, right). Again, the enriching effects of this approach extend to reviewing the presentations.

CONCLUSIONS

This approach extends the benefits of presenting and discussing primary research literature to students in moderate to large classes.

One of the goals of our studies was to answer whether exposure to primary research literature improves students' attitudes toward research literature. The student surveys show gains in several areas, including subjective improvement in understanding the role of cell biology and research literature in modern biomedical science and how scientists make conclusions from the research. The students report a better understanding of each other's thought processes, a better understanding of the material, and transformative experiences (Learning Objectives 1–5; Fig. 10). Therefore, the use of PRPE is associated with an improved attitude toward primary research literature.

The PRPE approach potentially impacts teaching in several ways. Specific to its original goal of facilitating the use of primary research literature in the classroom, it allows every student to speak and ask questions in a low-stress creative environment. Because of this, PRPE stimulates student involvement and improves the attitude toward primary research literature. It is an excellent tool for formative assessment and intervention in education. PRPE is a low-stakes assessment tool that is customizable to the individual student's needs and traceable so that student progress can be easily extracted and documented. It allows the students and the instructors to revisit previous presentations to review and study the progress or review the presentations from the new points of view afforded by the new knowledge.

Using checklists allows the instructor a high level of control over the review process and the presentation so that specific focus on different aspects of these processes can be achieved. The lists can be customized to each student's needs, contributing to a focused and dynamic learning environment. The format allows exploring the dynamics of the peer review process in a group or individual context. It is scalable and not limited to a specific discipline.

Possible modifications

Several aspects of the PRPE approach impact remain unclear, such as (i) whether there is a quantifiable improvement of learning outcomes due to the use of Presentation Exchange and which one of its components delivers the most gains, (ii) is there a student group that statistically benefits or reports gain to a lesser or higher degree that an average student, and (iii) how the presentation exchange workload compares with other assignments. These may be addressed using large and detailed studies focused on knowledge gains. Depending on the level of student preparation, other areas of

- I am now knowledgeable about how scientists test their hypotheses and explain its overall, central importance to the scientific world.
- I never knew how research worked in detail so **reading modern literature really opened my eyes** to how experiments are conducted, what each experiment's role is, how mechanisms are proved or disproved, and how these findings are used in the clinical setting. These concepts can be universalized throughout all science classes.
- I better understand cell biologists thought process when trying to understand processes within a cell.

FIG 10 Representative free-form feedback from exit surveys pertaining to student opinion of specific components of the class.

modification may include an in-class discussion of the papers before the assignment or group assignments. These may help students who are not used to working with the primary literature.

We did not evaluate the esthetical quality of student presentations but focused on the knowledge transfer between the students. The decision to ignore the esthetical quality of presentations was because this course is not tech presentations, and thus, the potential assessment of the esthetical value of the presentations relied on factors that are outside the given classroom.

In summary, the Perspex approach effectively introduces primary research literature in the class while giving every student an opportunity to speak and receive feedback requiring no classroom time. There was a high enthusiasm among students for this approach. This scalable and sustainable approach is an excellent means of formative assessment and a window into the peer review process. While the peer review process is increasingly common in the classroom, this is, to our knowledge, a unique application of narrated presentations in this context.

ACKNOWLEDGMENTS

This work was supported by a course transformation award from the University's Discipline-Based Science Education Research Center to Kirill Kiselyov.

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ADDITIONAL FILES

The following material is available online.

Supplemental Material

Supplemental file SF1 (jmbe00067-23-S0001.pdf). Sample handout for students.
Supplemental file SF2 (jmbe00067-23-S0002.pdf). Sample handout for faculty.
Supplemental file SF4 (jmbe00067-23-S0003.pdf). Sample assessment.
Video S1 (jmbe00067-23-S0004.mp4).

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