

Supervising Students in Scientific Writing for Peer Review & Possible Publication

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ABSTRACT

Innovation in assessment of STEM (science, technology, engineering, and mathematics) courses in subjects such as biology and biochemistry is a widely discussed topic. We report the use of a novel, research-integrated course assessment designed to increase students' self-motivation and improve their learning outcomes. We encouraged submissions to peer-reviewed journals, supported by stepwise supervision on writing by the instructor, which led to possible publication of some student-written articles. We compared the results from two classes in 2015 and 2016, assessing the quality of the published articles on the basis of journal impact factor, journal Scopus score, and number of citations of each article, using supervised assignments to fulfill this goal. Assessment of research-integrated biology learning via potential publishing may motivate students to actively learn a biochemistry topic and encourage early-career professional development.

Key Words: student motivation; course assessment; biochemistry education; higher education; STEM education.

○ Introduction

In STEM (science, technology, engineering, and mathematics) education, students who work closely and directly with instructors tend to have better learning outcomes. For example, a large proportion of Nobel Prize winners studied in small and elite universities, which provide the greatest opportunities for interacting with professors (Clynes, 2016). In small class environments, which allow for close interactions between instructors and students, the crucial component of biology education is to stimulate student interest in learning the subject. With these facts in mind, course-based undergraduate research experiences are of growing interest in the scientific education community (Bell et al., 2016).

Undergraduate research can take various forms, from writing a review in cooperation with a professor to working in many different laboratory settings. The research goals that a student can achieve depend on the time frame of the work, the student's self-motivation,

and the degree of collaboration with the instructor. The scientific publishing process, when used as a platform and goal for such independent research assignments, can be motivating and exciting for students.

Writing a scientific report and turning it into a manuscript suitable for publishing has always been a challenging yet effective way to assess students' learning (Shah et al., 2009; Bryant et al., 2010; Singh & Mayer, 2014; Mertz & Streu, 2015; Mills, 2015; Gholami & Ilghami, 2016; Zidarić et al., 2016). Article writing, when used as an assessment of learning outcomes, can encourage students to learn course-related topics independently and develop essential scientific communication skills for future professional careers (Bryant et al., 2010). Moreover, the potential to actually publish a writing assignment can provide a significant motivation for students' active learning.

Although publication of student assignments cannot easily be achieved in many native language environments (Zidarić et al., 2016), opportunities for publishing may exist at the international level. Usually, of course, student writing assignments remain within the confines of the educational institution, and as such are not available to a wider audience. However, the instructor-guided assignment described here could serve to effectively motivate student scientific writing by making acceptance for publication by an international journal more likely. Factors that are important to students' success in this regard include (1) whether instructors prioritize and foster students' preparation and submission of material for publication; (2) whether the attempt to publish is an encouraged or voluntary part of the assignment; and (3) selection of journals that are appropriate, in scope and subject matter, for submission of student articles (Shah et al., 2009; Bryant et al., 2010; Singh & Mayer, 2014; Mertz & Streu, 2015; Mills, 2015; Gholami & Ilghami, 2016; Zidarić et al., 2016).

Here, we summarize a two-year investigation in which we explored how biochemistry students in small classes could be motivated, through stepwise instructor supervision, by an assignment to produce a scientific article for submission to an international peer-reviewed journal.

○ Methods

The assignment was designed for Biochemistry I, a pre-med course for upper-level undergraduate students. In the spring semester of 2015, 42 students took the course and wrote topic-based review articles; in the spring of 2016, 62 students took the course and showed interest in writing review articles. In 2015, the assignment was stepwise-supervised, and submission of the resulting paper to a journal was largely encouraged after preliminary selection and multi-round revision; in 2016, it was extra activity and voluntary.

The participants were third- and fourth-year students who had the prerequisite credits in molecular biology, cell biology, and organic chemistry to enroll in Biochemistry I. Thus, these students were already well equipped with fundamental knowledge in biology and chemistry. However, they lacked prior in-depth practice in Biochemistry and scientific writing.

Each year, at the beginning of the course, we introduced the project by providing topics and instructions, followed by individual supervision of writing after students searched the relevant literature. During a time frame of about two months, the drafts were collected and reviewed by the instructor. Next, the revision rounds were performed, including multiple instances of instructor feedback and student revisions. Top-ranked articles were selected and evaluated after grading by the instructor. Potentially publishable articles were further revised by supervising students or by the instructor directly. Finally, all articles considered to be publishable were submitted to academic journals. The entire process is outlined in Figure 1.

The course instructor was the same in both years. Therefore, the supervising and teaching styles, as well as the syllabi, were more or less the same in each class. The instructor, an assistant professor, has more than 20 years of research experience in biology and more than 40 publications in peer-reviewed journals. The instructor has also received training in higher education annually as continuing career development and has reviewed more than 15 manuscripts for various academic journals.

The 42 students who took the course in 2015 were assigned a homework to write a review or commentary article related to a biochemistry topic (either self-defined or provided) and submit it for publication as a part of the total course grade; if the assignment was accepted by the journal for publication, extra rewards were given. For the 62 students who participated in the project in 2016, writing for publication was optional; if published, extra rewards were given. Each student worked individually on a single article in 2015; students worked either in groups or individually in 2016. In each year, high-quality articles were submitted for peer review by academic journals.

To compare the learning outcomes in the two years, quantitative and qualitative analyses were performed. In the qualitative analysis, indexes including the journal's impact factor, its Scopus score, and the number of citations in Google Scholar from one year after the end of the course were used. To compare the two years of data, a two-tailed *t*-test was performed using the analytical toolbox. Results with $P < 0.05$ were considered significant.

○ Results

Six articles from the 2015 course and three articles from the 2016 course were published in journals. To assess the writing qualitatively, the respective journals' impact factors were analyzed first (Table 1).

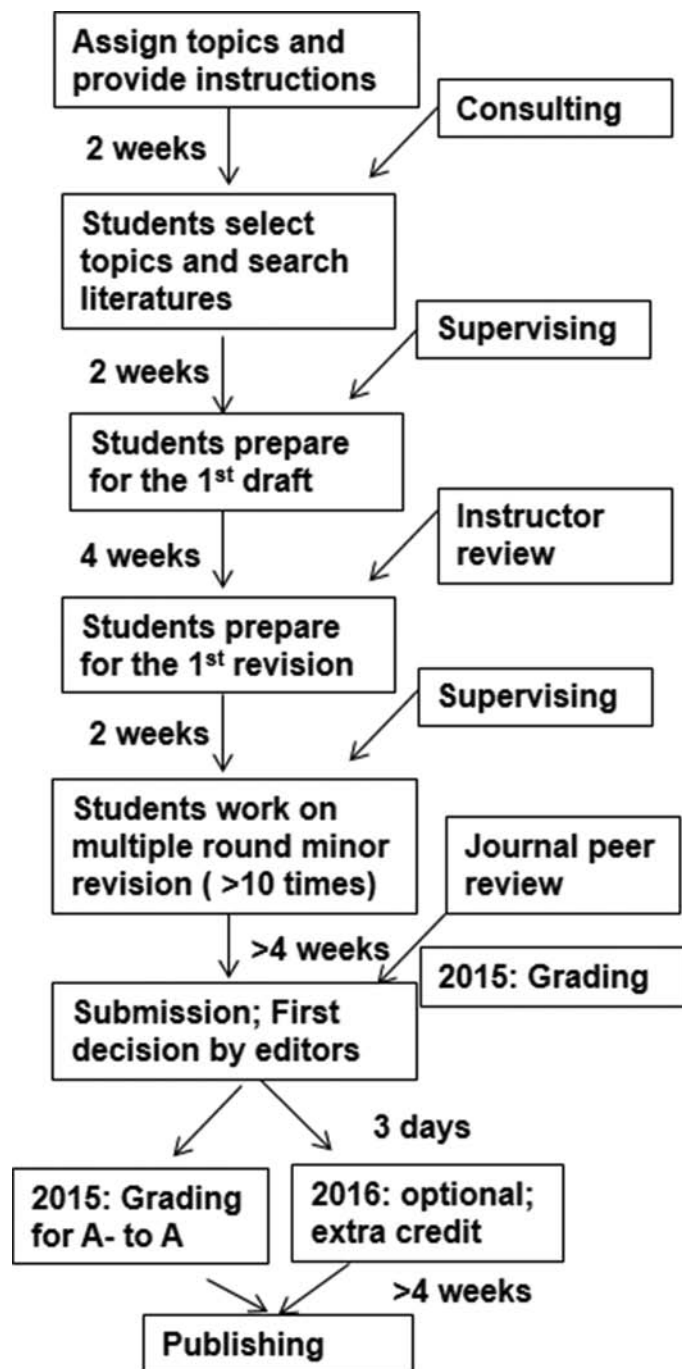


Figure 1. Flowchart of the assignment's progress and supervision by the instructor.

We assumed a relatively constant impact factor for the whole period of the project investigation and consequent data analysis. As shown in Table 2, the mean impact factor value in 2016 is about two times higher than that of 2015, but both have high variances. This result indicates that there is a 56% probability for two randomly chosen published papers to be equal in terms of the journal's impact factor. The test showed that there is no statistically significant evidence to reject the null hypothesis. Given that we could not differentiate the quality of the articles produced in the two years, our data suggest that there was no significant difference in quality of publications in 2015

Table 1. Analysis of the impact factors of the journals in which the students' assignments were published ($n = 6$ articles in 2015; $n = 3$ articles in 2016).

Year	2015	2016
Impact Factor	3.7	4.4
	1.5	1.7*
	1.5	0
	0	
	0	
	0	
Mean	1.12	2.03
SD	1.34	1.81

*Accepted for publication but not published.

Table 2. Analysis of the Scopus scores of the journals in which the students' assignments were published and the number of citations of each article ($n = 6$ articles in 2015; $n = 3$ articles in 2016).

Year	Article no.	Scopus Score	Google Scholar Citations
2015	1	3.62	3
	2	1.68	9
	3	1.68	28
	4	0.3	0
	5	0.80	23
	6	0.48	12
2016	1	4.66	17
	2	NA	0
	3*	NA	NA

*Accepted for publication but not published; NA = not applicable.

and 2016, as far as journal impact factor is concerned. (The overall academic performance of the students was not accounted for, with the assumption that students' performance in this publishing project was not related to their other grades.)

We further analyzed the quality of the published assignments using the Scopus scores of the journals and the number of citations of each article in Google Scholar (Table 2). Journals without a Scopus score were assigned a score of zero. The journals' Scopus scores did not show a significant difference in quality between the articles produced in the two years (2015, mean = 1.33; 2016, mean = 1.55). Nevertheless, citation statistical analysis using Google Scholar showed a significant advantage in quality for papers submitted in 2015 compared to those from 2016.

Moreover, the ratio of accepted or published assignments to the total number of students who took the course during the two school years shows the quantitative advantage of the first practice

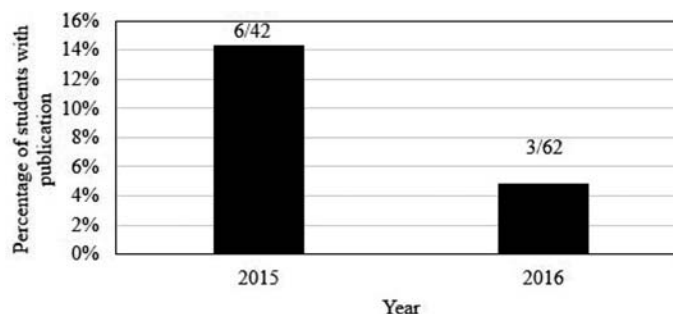


Figure 2. Rates of accepted or published papers from course assignments written by undergraduate students in 2015 and 2016. Each student worked on only one article within the given period.

(Figure 2). The number of accepted or published papers was twice as high in 2015 as in 2016, although there were about 1.5 times fewer students in 2015 than in 2016. This result shows that the highly encouraged approach and the first trying-out showed higher efficiency, which may be due to excitement and interest in this innovative practice. However, it is difficult to estimate whether these numbers represent assessment-encouragement-stimulated results or self-motivated and interest-driven active learning.

Before making a conclusion in terms of the nature of the motivation, we need to account for several points. First, while submission of the article for publication was largely encouraged only in 2015, both classes received rewards. Second, the analysis by the *t*-test showed the same quality of papers in both years. Based on the data analysis, we could derive the conclusion that the first year's innovative practice showed its quantitative advantage without significant quality loss. In the number of citations as well, the first practice showed its superiority. Moreover, the instructor's experience in research and in creatively proposing innovative but applicably small topics – in various fields related to biochemistry, such as cancer, molecular and cellular biology, and biotechnology – may have motivated students to further explore research-integrated active learning through scientific writing.

Discussion

Biochemistry is an interdisciplinary science that tends to challenge learners with a significant amount of information of overlapping but deepened knowledge. It is an important subject for biology majors. The assignment described here was the first experience for most of these students of working closely with a professor, creating their own hypothesis, investigating different phenomena, and analyzing data in order to write a complete scientific paper. Also, it is important to note that some students who were involved in the article writing likely went on to pursue more advanced studies in medical school or in graduate schools in biological sciences. Given that biochemistry is a fundamental course for medicine and biology, it was crucial for students to grasp frontier knowledge through research projects by writing review articles (McDonough, 2012). Applicability of the knowledge obtained in such practice can also motivate students to do wet laboratory research with supervisors (Bryant et al., 2010).

In our method, a supervised research-embedded assignment asked students to learn materials based on teaching content but beyond the basic objectives of the class. This approach focused not only on the quality of the basic class material but also on an in-depth understanding of a specific topic in biochemistry. The method allows students to get some reward from studying cutting-edge knowledge and start their more advanced academic practice earlier than they would otherwise.

Even if the administration of an institution creates a small-class teaching environment to enhance students' learning, motivating, and helping students to publish their own review articles is highly dependent on stepwise supervision. In particular, if the instructor has extensive research experience and actively performs research, the topics of the assignment will be more purposeful and lay the foundation for future research. Although it is challenging for any undergraduate student – even in a small, elite university – to publish project-based articles from an assignment in a biology course, it is more manageable for these students to publish a review or comment article. In the present study, the participants were mostly third- and fourth-year students who had already received ample background knowledge in biology and chemistry and were ready to perform data- and literature-based research through active learning.

Even though supervising and revising students' writing is tedious and time-consuming, it can be quite rewarding. Although the present study provides only a limited analysis, the results suggest that a clear assignment with enough supervision and feedback may result in better student performance. However, we cannot exclude the impact of the rewards offered. Instructors must play a key role in encouraging students to overcome the writing barrier in a stepwise manner by the combination of searching literature, collecting information, and establishing confidence in their scientific writing.

○ Conclusion

We have reported an innovation in course assessment through assigning students to write a research review for international peer review and possible publication. Through writing and publishing the assignment, students actively gained knowledge and enhanced their understanding not only in biochemistry, but also in general biological sciences. More importantly, the students were nurtured in their creativity and critical thinking, paving their path to more advanced study in corresponding areas.

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