

Investigating the Undergraduate Writing of Students Majoring in the Biological Sciences at UC Berkeley: An Analysis of Students' and the Field's Expectations of Writing

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ABSTRACT

Students enrolled in the biological sciences department at UC Berkeley often have the knowledge, laboratory expertise, and research exposure to become efficient practitioners in the field of biology. However, they can be deficient in field specific writing practices, even though they do get some training through their undergraduate writing programs and STEM classes. This study conducted two surveys, one for undergraduate students majoring in biology and the other for faculty members in the biological sciences departments, to assess the comfort level and types of writing experiences of the students and to utilize the hindsight of the faculty members from their journey from neophyte student biologists to practitioners. The results found that the proficiency gap between undergraduate students and practitioners exists and originates from the lack of adequate exposure students receive in the writing conventions of biology and the assumption that graduate school will teach students how to communicate their research effectively. The study found that possible solutions to bridging the proficiency gap would be for UC Berkeley to include undergraduate writing classes, workshops, and scientific discussions specifically around the writing conventions of biology.

Keywords: Writing conventions of biology; Writing expectations of biology; Field-specific writing; UC Berkeley writing; Biology practitioner writing; Biology writing proficiency gap

INTRODUCTION

The intrinsic value of learning the field specific writing conventions of biology is to develop credibility and authority to become a skilled practitioner. Case and Jones emphasize in their article, “How to Write Authoritatively in your Field from the Outset,” that “learning to recognize the writing style used in their discipline from the outset means that students can immediately start trying to incorporate that style in their own writing. This will increase the chances of their work being read—hopefully cited—in their research community” (Case and Jones 2015), but to ensure students write with authority in their work as biologists, they must fully understand the writing conventions of their field to communicate their research effectively. The question that needs to be asked, then, is whether students are aware that their journey from neophyte biologists to expert practitioners includes the ability to both comprehend and incorporate the conventions of biology into their own writing.

Dr. Clark, in the *Harvard Business Review*, explores this kind of unawareness in her article “Simple Ways to Spot Unknown Unknowns” and writes that “the most challenging

circumstances are often completely unexpected, because we never even knew to look for them” (Clark 2017). If, then, biology students are to become successful in their careers ahead, they must be aware of the gap between the expectations of writing and their own writing experiences. In doing so, they will be able to “improve [their] performance and spare [themselves] from the mistakes that—in hindsight—should have been obvious” (Clark 2017).

To help in this process, research is needed to uncover the differences between students’ writing experience and the writing they will be expected to do as practitioners. It would be helpful to understand students’ level of comfort and preparation in field specific writing, and the ways in which UC Berkeley can narrow the gap between students’ and the fields’ expectations of writing in biology. This research aims to utilize the input from current students and the hindsight of faculty members in the various divisions of biology to understand the proficiency gap in the writing of its undergraduate biology students so UC Berkeley can make the process of writing in the biological sciences more efficient and effective.

METHODOLOGY

In order to assess the gap between student writing and expert practitioner writing at UC Berkeley, two different types of online surveys were done to gather statistical data from students and faculty members. The faculty survey also gathered open-ended responses and one faculty member was interviewed. The interview of the faculty member was conducted at UC Berkeley. Both the student survey and faculty survey were administered through the online survey developer SurveyMonkey.

Student Survey

The first online survey was administered to undergraduate freshman, sophomore, and junior students majoring in either Integrative Biology or Molecular Cell Biology. The student survey questionnaire was provided to a biology seminar class of thirty-five students consisting of undergraduate students. Surveys were also distributed to students outside the Valley Life Sciences Building. Ten underclassmen and four upperclassmen completed the survey.

The survey for undergraduate students consisted of four specific questions. The first question was included for demographic purposes and inquired the class year of the student. The second question asked students to check off all of the writing they had completed at UC Berkeley. The options included essays in humanities courses, STEM courses, and biology courses, research projects with writing components, essays with reading and composition requirement, exams with essay components biology courses, exams with essay components in my STEM courses, lab reports in STEM courses, an option stating that the student has not done any writing as an undergraduate at UC Berkeley, and an “other” option. The third question asked students to rate on a scale from 0-10 (0 being very unprepared and 10 being very prepared) how prepared they felt in their ability to do the writing required of them in the future as biological scientists. The

last question asked students to rate on a scale from 0-10 how much they thought the writing they were doing now in their freshman and sophomore years reflected the writing they would do in their careers pursuing biology (0 being the writing they are doing now does not reflect what they expect to be doing in the future and 10 being that the writing they were doing at present was exactly what they expected to be doing in the future). *See Appendix I*

Faculty Survey

The online faculty survey was administered to ten faculty members in the Molecular and Cell Biology and Integrative Biology departments. Out of the ten faculty members given the survey via email, two members completed the survey. One interview was conducted containing the survey questions with some additional questions. Unlike the undergraduate student survey, the questions included comment boxes for faculty members to write out their open-ended responses.

The survey for faculty members in the biological sciences at UC Berkeley consisted of five different questions. The first question asked faculty members to explain how they learned the writing conventions of biology and also asked if they took any classes geared toward writing in the biological sciences and if they consulted any books about writing in the field. The second question asked if they incorporate essay writing in their class curriculum and if they see common issues with undergraduate students' writing. The third question asked if given unlimited time, money, and resources, did they know specific ways UC Berkeley could make the writing process more efficient and effective for students in the biological sciences. The fourth question asked if there was anything the faculty members wished they had known as an undergraduate student to become better future writer-practitioners in the biological sciences. The last question asked faculty members what kinds of writing they did at present as practitioners in the field. *See Appendix II*

RESULTS

The surveys provided both statistical data of the undergraduate students' survey and open ended responses for the faculty survey. The results of the undergraduate student survey include the raw statistical data of the "check all that apply" and ranking questions alongside calculations of the mean, median, standard deviation, and variance of the sample population. Bar graphs were created using the student survey data to visually compare data among categories. The open ended responses of the faculty were analyzed to determine trends and patterns within the cross sectional data. The faculty members' names were omitted to protect the identities of the participants of the online surveys and interview.

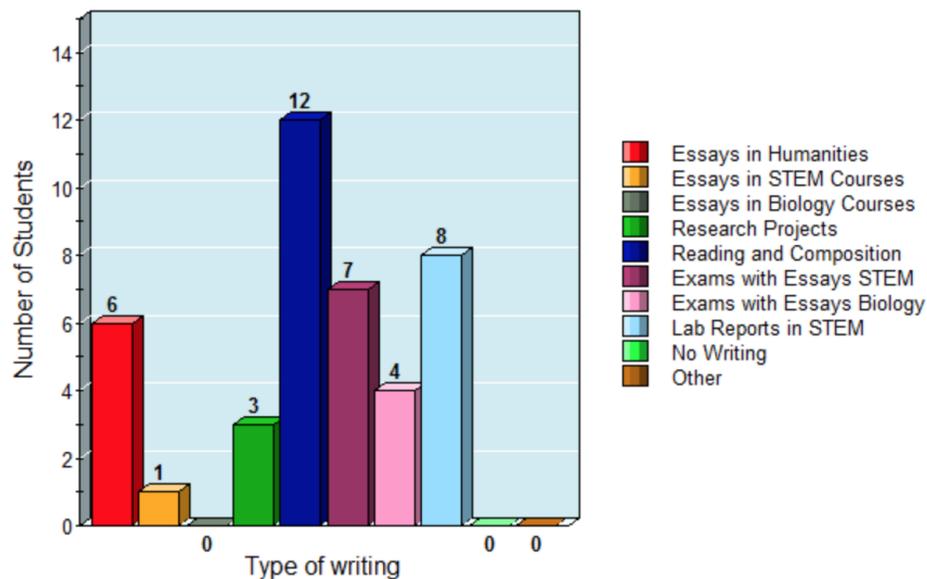
Student Survey

Out of the fourteen students who completed the student survey, six of them were freshman students, five of them were sophomore students, and three of them were junior students.

Writing Experiences Question

When asked to check off all of the writing experiences they had at UC Berkeley, twelve students indicated that had done writing in their writing and composition courses, eight students had done writing in their lab reports, and another seven had done writing in essay components in their STEM class exams. Six students had done writing in humanities classes, four students had done writing in essay components in their biology class exams, six students had done writing in humanities courses they had taken, three students had done writing in a research project, one student had done writing in a STEM class, and zero had done writing for a biology classes. None of the students checked off the option of having done no writing at UC Berkeley and none of the students checked off the “other” option.

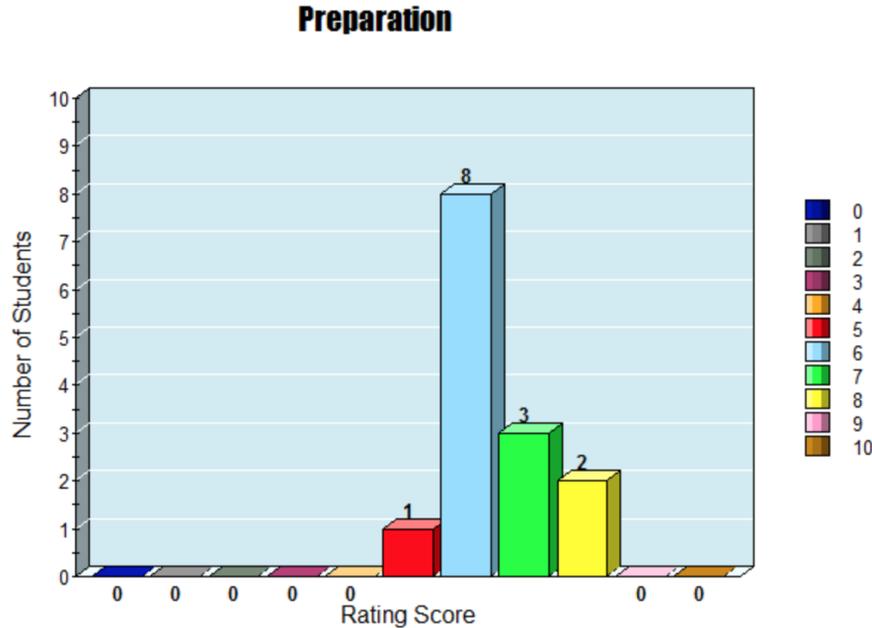
Students' Writing Experiences at UC Berkeley



Preparedness Question

When asked to rate on a scale from 0-10 (0 being very unprepared and 10 being very prepared) how prepared they feel in their ability to do the writing required of them in the future as biological scientists, one student rated 5, eight students rated 6, three students rated 7 and two students rated 8. Using the demographic information, one underclassmen rated 1, five underclassmen and three upperclassmen rated 6, two underclassmen and one underclassmen rated 7, and two underclassmen rated 8.

Regarding the students' preparation ratings, the mean was a rating score of 6.429 and the median was a rating score of 6. The standard deviation was 0.821 using the formula $\sigma = \sqrt{\frac{\sum(x - \bar{x})^2}{n}}$. The variance of the sample population was 0.673 using the formula $\sigma^2 = \frac{\sum(x - \bar{x})^2}{n}$.

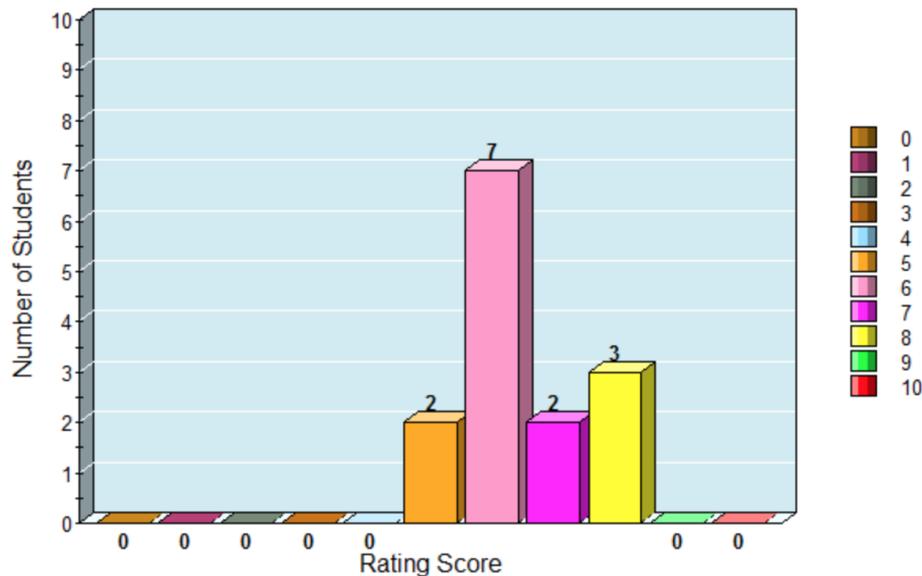


Reflective Writing Question

When asked to rate on a scale from 0-10 how much they thought the writing they were doing now in their freshman and sophomore years would reflect the writing they would do in their careers pursuing biology (0 being the writing they are doing now does not reflect what they expect to be doing in the future and 10 being that the writing they are doing now is exactly what they expect to be doing in the future), two students rated 5, seven students rated 6, two student rated 7, and three students rated 8. Using demographic information, one underclassmen and one upperclassmen rated 2, five underclassmen and two upperclassmen rated 6, one underclassmen and one upperclassmen rated 7, and three underclassmen rated 8.

Regarding the undergraduate students' reflective writing ratings, the mean was a rating score of 6.429 and the median was a rating score of 6. The standard deviation was 1.033 using the formula $\sigma = \sqrt{\frac{\sum(x - \bar{x})^2}{n}}$. The variance of the sample population was 0.595 using the formula $\sigma^2 = \frac{\sum(x - \bar{x})^2}{n}$.

Reflective Writing



Overall, the results of the statistical survey showed that there was a large range of different writing experiences among the undergraduate students, however, the majority of undergraduate students are writing in their laboratory reports and in their Reading and Composition requirement courses. Students also reported that in their STEM courses, most of their writing experiences were from taking examinations. The data from the ranking questions suggest that when undergraduate students are asked how comfortable they felt writing in the biological sciences and how reflective their writing is now compared to what they expect to do in the future, they placed their ranking score at around a 6 on a bell curve with a steep peak at the median. The standard deviation and variance suggest that students clustered their ranking scores with little deviation.

Faculty Surveys (Professor A and Professor B)

Professor A was from the department of Integrative Biology at UC Berkeley. Professor A learned how to write in the biological sciences in graduate school through a trial and error process and did not take a writing class geared toward writing in the biological sciences or consult any books about writing in the biological sciences. This Professor did incorporate writing in the curriculum of the large lecture biology course by assigning a three page essay. The professor did not disclose the details of the assignment, but noted that students often struggle in determining what sources are considered valid for scientific writing, what is peer-reviewed and not, and how to avoid plagiarism. Professor A recommends that the UC Berkeley campus should ensure that courses have enough teaching assistants such as graduate student instructors so biology courses can incorporate more meaningful writing assignments to help students learn how to write in the field.

When asked what they wished they would have known as an undergraduate student to become a better writer/practitioner in the field of biology, Professor A mentioned that students wrote a lot of papers as undergraduates, but needed to learn the specifics of style and tone used in grant proposals and scientific publications versus scientific articles versus broader impacts statements. Professor A said that what really benefited their writing was having someone more experienced in the field take what Professor A had written and make it more appropriate. The Professor stressed the importance of revision and wrote that the most priceless moments were when they could see how their writing had improved with the assistance of those more experienced in the field.

As for the last question of the survey which asked what kind of writing the faculty members do at present, Professor A wrote that their writing focuses on grant proposals, letters of intent to funding agencies, research permit proposals, journal articles, and book chapters. In their service work, their writing focuses on letters of recommendation, peer reviews of grants and research articles, and policy and protocols for professional organizations. In their teaching efforts, their writing focuses on essay topic assignments, quiz and exam questions, study sheets, class announcements, and other biology courses content. In their scientific outreach efforts, faculty members recently wrote (and are now revising) a book proposal.

Professor B was from the department of Molecular and Cell Biology at UC Berkeley. Professor B learned the writing conventions of biology through a trial and error process in graduate school. They emphasized that they attended some general writing workshops as a graduate student, but did not attend any classes specifically geared toward writing in the biological sciences.

Professor B did consult scientific journals to model their scientific writing in their early stages. The Professor did not incorporate essay writing in their curriculum but occasionally gave students examples of biology articles to read and take notes on for their discussion sections. Professor B argues that if given unlimited time, money, and resources, they would like students to attend a class designed for research writing in the biological sciences. They would like to see more interaction between students and faculty members to help students improve their writing. The Professor notes that the internship opportunities and individual research projects that they did in graduate school were the best ways to learn how to communicate effectively in the biological sciences. Professor B currently writes grant proposals and journal articles for publication.

Faculty Interview (Professor C)

Professor C is now a retired Professor from UC Berkeley but agreed to do an interview answering the questions found within the survey and a few open-ended additional questions. Professor C learned how to write through a trial and error process as a graduate student and as a

doctoral candidate, but did not attend a biological sciences writing class. The Professor did not consult any books about writing in the field because they did not exist at the time. They consulted general writing books instead.

Professor C did incorporate writing in his class by adding essay questions to his exams. The Professor said it was interesting to see how students would craft their answers when asked to describe certain biological processes. Professor C added that they grade the writing portion of the exam on two criteria: accuracy and coherency. The Professor noted that students can easily recall the correct information underlined in the textbook but struggle in communicating that information in a way that makes logical sense.

The Professor emphasized that scientific writing is both visual and verbal and students need to practice to master both of these skills. The Professor stressed that the most successful scientific writers have the ability to describe everything that occurs in the lab with precise details. Professor C emphasizes that the best way for students to improve their scientific writing is for them to write as much as they could. Professor C suggests that the UC Berkeley community should incorporate the verbal side of scientific study by encouraging scientific discussion through symposiums and seminars.

The results of the open ended responses from the survey suggest that faculty members learn the writing conventions of biology through a trial and error process in graduate school. Many faculty members have difficulty incorporating writing assignments for their undergraduate students given their amount of time, funding, and resources, but some attempts have been made by incorporating essays and written exam questions in the curriculum of their biology courses. The professors often noted that their best resources were the direct student-practitioner relationships because they gained the expertise and insight from their mentors. All faculty members have numerous written publications in their field.

DISCUSSION

Regarding the proficiency gap between undergraduate student writing and practitioner writing in the field in biology, the research found some dissonance between the two ends of the spectrum. The data provided information about the location and the origins of the dissonance. Although the analysis of the gap is speculative and preliminary, the data aimed to gain insight into how UC Berkeley can make the writing process for biology students more productive.

Location of Dissonance

The student surveys showed that the majority of undergraduate students majoring in biology at UC Berkeley undertook writing in their reading and composition requirements and in both forms of laboratory reports and exam questions in their STEM classes. There is apparent dissonance in that students learn most of their writing skills from their reading and composition requirement

courses which tend to promote the writing conventions found in the Humanities as opposed to the writing conventions of biology publications. Students may be unaware that the writing they are taught in these courses may not be sufficient in becoming a practitioner in the field. Although students do some writing in their STEM courses, the laboratory reports and exam questions which test whether students have mastered the subjects may not directly expose students to the writing conventions of biology which they will need to incorporate in their writing in the years ahead.

The statistical data shows that students rated their preparedness to write in the biological sciences around a rating score of six out of ten. The mean and median around six suggest that undergraduate students place themselves on the upper half of the bell curve, but on the lower side of that upper half. The standard deviation and variance show that students are rating very close to the average. This suggests that students may feel that their writing training has made them more proficient in writing in general, but not enough as to feel fully prepared to write in the specific field of biology.

It is important to note that there may be confounding variables at play in that students may be drawing their writing confidence from outside of the writing experiences at UC Berkeley, but the data still implies that there is some underlying uncertainty about students' ability to write in the field. When students were asked how relevant the writing they are doing now is compared to the writing they expect to do in the future, the rating scores centered again around six with little deviation which suggests that students seem to be somewhat aware that the writing they are doing in their classes is not what they expect to be doing in the future as practitioners. Students may be making the assumption that they will gain the field specific writing experience after their undergraduate years. These assumptions could contribute to the inefficiency of the writing process as a whole because students develop uncertainty about the types of writing expected from them later as biologists.

The faculty surveys indicate that faculty members in the biology department recognize that incorporating field specific writing in their curriculum for undergraduate students would be helpful, but they currently do not have the resources for implementation. They understand that students are proficient in writing in a general sense, but oftentimes have difficulty writing appropriately for the biological sciences. Faculty members recognize that students' writing experiences often include memorizing information from their textbooks and notes opposed to writing in defined ways that would mimic the writing they expect to do as practitioners of biology. Undergraduate research exposure is often limited to STEM laboratory reports, so students have difficulty determining appropriate sources of evidence and avoiding plagiarism in their biology research.

Students and faculty seem to agree that a proficiency gap between undergraduate writing and practitioners exists. The dissonance that arises from the gap seems to be in the lack of exposure undergraduate students have to the specific writing conventions of biology. If students gain exposure, they may be better equipped to narrow the proficiency gap between the writing they are currently doing and the writing they will do in the future.

Origins of Dissonance

The open ended responses from the faculty members suggest that biology practitioners usually learn the writing conventions of biology through a trial and error process in graduate school. Many of the faculty members noted that having practitioner advisers in graduate school were the most beneficial resources because they had the ability to pinpoint deficiencies and advise students how they can better their writing to fit the expected standards. Dissonance emerges when undergraduate students assume they will learn the writing conventions of biology after their undergraduate years and when faculty members expect their undergraduate students to learn the specific writing practices the way they did in graduate school.

The data suggests that both undergraduate students and faculty members expected or found graduate school responsible for field specific writing experience. This can lead to misrepresentation of the field of biology for undergraduate students because of their lack of exposure to writing experiences of experienced biology practitioners. Faculty members suggested that the undergraduate school writing process could be made more efficient and effective by incorporating more writing in the undergraduate curriculum, but they lacked the resources needed for implementation.

The dissonance originates from the assumption made that graduate school will make students proficient in field specific writing. However, this assumption raises three major concerns. The first being that undergraduate biology students will go to graduate school to gain writing experience. The second being that students will have mentors who will be dedicated to helping the student improve their writing through the trial and error process. The third is that when students become writer practitioners in the field of biology, they would likely have difficulty in teaching the writing conventions of biology except through the inefficient process of trial and error.

Solutions to Bridging the Gap

In order to narrow the gap between students' performance and expectations, the best resources may be writing workshops or classes specifically catered to writing in the biological sciences. Faculty members noted that having more graduate student instructors would be helpful because grading and providing the necessary help for undergraduate students seems to be difficult without those resources. Encouraging scientific discussion within the classroom may be beneficial as well because it could allow students to gain the experience and exposure of the

writing conventions of the field early so they can later incorporate them into their own writing. Even if it is not possible to encourage students to write more, it may be helpful to hold scientific symposiums and discussions about writing and research publication to mitigate the uncertainty that students experience about the writing expected of them in the future. This may also make the transition from undergraduate to graduate studies more productive because students would gain the exposure of the writing conventions of biology and could ask better questions of their mentors to improve their writing more quickly and effectively.

LIMITATIONS

There were some unavoidable limitations in this survey based study. The sample size of the data was smaller than intended for both the undergraduate student survey and faculty survey due to the availability of the participants and the time constraints of the study. Because of the small sample size, the conclusions of the data are speculative because it was not possible for the research to ensure a representative distribution of both the undergraduate student and faculty population.

It is important to note that because the faculty survey data was self reported and mostly qualitative, so the results of the surveys most likely contain two types of biases. Selective memory bias probably occurred because the surveys often asked participants to remember their writing experiences of the past, however, the participants' memories may not be accurate representations of their actual experiences. The second kind of bias that likely occurred was telescoping bias where participants may have remembered events from a different time than the period of interest. This could affect the conclusions of the data because the questions of the surveys attempted to eliminate the writing experiences students and faculty had outside of UC Berkeley.

These kinds of biases could have been more easily avoided if the student survey consisted of open ended responses. However, adding open ended response questions would have likely affected the number of participants of the survey. The results of rating score questions of the student survey could have also been affected if the range was narrowed from 0-5 versus 0-10. Certain psychological confounding variables such as overconfidence and exaggeration of the sample size could have been avoided. The faculty survey could have also improved if it contained questions asking faculty members to address specific writing experiences they had in the past to receive more quantitative data.

CONCLUSION

Overall, the research discovered that a proficiency gap between undergraduate biology students and writer practitioners exists due to the lack of exposure undergraduate students receive pertaining to the writing conventions of biology. The uncertainty and dissonance seems to stem from the assumption of both undergraduates and faculty members that graduate school's method

of trial and error will teach students how to write in the field of biology. In order to mitigate the anxiety and narrow the proficiency gap, writing workshops, classes, and scientific discussion about writing in the biological sciences could enhance the success of undergraduate biologists of UC Berkeley.

Although a proficiency gap has been established and verified by this study, future studies could possibly find better ways of characterizing the gap by including larger sample sizes, different survey questions, and more statistical data analysis. The results of this study found that graduate school seems to be a major player in the writing process of neophyte biologists so including data about their writing experiences would likely make the data drawn from the surveys more robust. A longitudinal study following neophyte biologists to practitioners would likely be more effective in establishing developmental trends in the research of undergraduate technical writing improvement.

Appendix I Student Survey (SurveyMonkey)

1. I am currently a/an

- Freshman Senior
- Sophomore Other
- Junior

2. As an undergraduate student, my writing experience consisted of (please check all that apply)

- Essays in Humanities Courses
- Essays in STEM Courses
- Essays in Biology Courses
- Research Projects with Writing Components
- Essays in my Reading and Composition Requirement
- Exams with Essay Components in my Biology Courses
- Exams with Essay Components in my STEM Courses
- Lab Reports in my STEM Courses
- I have not done any writing in my undergraduate years
- Other (please specify)

3. On a scale from 0-10 (0 being unprepared and 10 being very prepared), how prepared do you feel in your ability to do the writing required of you in the future?

0 5 10



4. How much do you think the writing you are doing now reflects the writing you will do in your career pursuing biology? (0 being the writing you are doing now does not reflect the writing you expect to do in the future and 10 being the writing you are doing now is exactly what you expect to do in the future)

0 5 10



Appendix II
Faculty Survey (Survey Monkey)

1. How did you learn the writing conventions of biology? Did your writing improve with a trial and error process? Did you take a class geared toward writing in the biological sciences? Did you consult any books about writing in the biological sciences?

2. Do you incorporate essay writing for your biology students? If so, do you see any common issues with the ways in which undergraduate students write in biology courses?

3. Given unlimited money, time, and resources, do you think there are any ways UC Berkeley can make the writing process for efficient and effective for students in the biological sciences?

4. What do you wish you would have known as an undergraduate student to become a better writer-practitioner in the field of biology?

5. What kind of writing and research in the biological sciences do you do now as a writer-practitioner?

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