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Why Teach Writing When We Are Trying to Teach Science?

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Extended Abstract

The ability to effectively communicate through writing is an essential skill for our profession and a skill that we are challenged to develop in our students. Writing is not only about communication, but also serves as a process to develop and clarify our ideas. Science writing poses its own unique set of hurdles. Writing is expected to be clear and concise, while following a particular format unfamiliar to most undergraduates. While most writing pedagogy has strong foundations in the humanities, some strategies can be adapted for writing assignments in the sciences. Students, using data collected in a laboratory course, are routinely expected to analyze and present their findings in the form of laboratory reports. Such writing assignments can be constructed to incorporate pedagogical elements such as informal writing, drafting, peer review, conferencing, and reflection. Whenever possible, links can be made between pedagogical approaches and real work tasks a professional scientist is expected to perform. Such assignments provide students with the opportunities to improve in their work and thus enable them to gain confidence in their writing skills.

As scientists, we use writing for a variety of purposes to communicate within the discipline and outside the discipline. Informal writing, such as laboratory notebooks or field journals, is used to record data and observations. While the writer may be the only person to use this resource, these notes need to be an accurate record of research to form the basis for later publications. We communicate primary discoveries to the scientific community through scientific papers that have a very particular format. Primary research articles undergo a process of peer review, where other scientists evaluate and write critical reviews of their colleague's work to aid editors in making decisions regarding publication. Grant applications, review articles and reports are other formats through which we communicate to our professional peers. Scientists and science writers communicate to a more general audience through editorials and popular press books to educate the non-scientist on current scientific topics in the public arena. Since these are the ways we as scientists use writing, shouldn't we try to develop assignments for our students that mimic these applications in both topic and process?

While we want our students to be good scientific writers, we acknowledge they may not have the same motivation we do when writing. At any level, writing is work; it is not fun and it is rarely easy. Few people can sit down at a computer and generate a good paper in one sitting. But that is what our students attempt to do. Writing is a skill that needs to be developed with practice and revision. One of our challenges in assignment design is to develop ways to combat student procrastination. By breaking down a large assignment into a series of smaller assignments and monitoring each of those smaller assignments, we provide the student with a guide for how the process of writing should occur. By monitoring steps along the way, we can provide the student with feedback to keep them on the correct path and show them that they can be successful, effective writers if they follow the process.

I have developed a writing assignment that incorporates writing pedagogy in a format that mirrors the process of writing a primary research article for a 300 level genetics course, a course required of our Biology majors (Appendix A). Students, working in teams of four, are assigned an unknown *Drosophila melanogaster* strain containing two mutations. They spend the first half of the semester designing and executing experiments to determine the inheritance patterns of their two genes. The second half the semester focuses on presenting their findings in a scientific paper. Students draft sections of their paper (Introduction, Results and Discussion) and receive feedback on their writing and data analysis from the instructor (Appendix B). In addition, students act as reviewers for the Results and Discussion. Each draft has one internal reviewer (team member familiar with the data) and one exter-

nal reviewer (from another team) who read and comment on the draft. Their reviews are written as a short (two page) paper to be graded as a separate assignment (Appendix C). Students receive feedback from both the instructor and their peers, use that feedback to revise their paper, and submit a final draft of a complete scientific paper. In addition, they write a response letter explaining how they used the feedback to make changes to their paper. The final draft earns a grade for the entire process. While earlier drafts are evaluated, they are not graded. Only those students who fail to complete earlier drafts will be penalized in the final grade.

While students initially struggle with the writing assignments, they are able to see the value of this approach as increased effort on their part translates to better writing and a better grade. Some examples of student comments given at the end of the semester are the following:

> "This lab report has essentially greatened my knowledge on writing lab reports. My first labs in this class were not given such high grades, but over the course of the semester I have learned what is expected in a formal laboratory report and what is essentially necessary"
>
> "Overall I think that this was a beneficial experience that was challenging but attainable. It made us work hard and really put a lot of responsibility in our hands."
>
> "I know that I am not the best writer on the planet and there is still a lot that I need to learn but I think that this is a vast improvement from where I came from in my first drafts and from the beginning of the semester. ….I like that I was able to take a short interlude after the final draft. It allowed me to see more clearly the mistakes that I made. "
>
> "I feel more confident in my abilities to write a scientific paper as well as a better understanding of how to take data recorded in a lab and format it so that others can clearly see what you have done."

With this approach, not only are students writing, but they are also learning a process to become more effective writers. They recognize that writing is something they can do well when they spend the time to draft, solicit feedback, and revise using that feedback. As instructors, we must recognize that this process takes time and factor in that time while designing courses. While students may produce fewer final products, they are producing a better product that they themselves recognize as improved.

Literature Cited

Bean, John C. 2011. *Engaging Ideas: The Professor's Guide to Integrating Writing, Critical Thinking, and Active Learning in the Classroom.* John Wiley & Sons, Inc. New York. 282 pages.

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Link to Supplemental Materials: www.ableweb.org/volumes/vol-34/ramesh/supplement.htm

Appendix A

Fly Laboratory

Biology 315

Overview

This laboratory will be a semester long experiment that you will perform in conjunction with weekly lab exercises. Because you are studying inheritance patterns in living systems, the pace of these types of experiments is dictated by the life cycle of the organism. The length of time required to conduct a real experiment in real time rarely fits neatly into a three hour lab period. You will be expected to put in some time outside of the scheduled lab time, and everyone on the team must share in the responsibility.

This lab will provide you with the opportunity to perform a genetic analysis in real time and become an expert in fly husbandry. In addition to setting up experiments and collecting data, you will be responsible for your supplies and clean-up. When you are working in a laboratory, there are often shared resources and it is important to leave the lab as clean or cleaner than you found it.

Your laboratory team will be assigned a vial of flies with one or two mutation(s). You may assume these flies are homozygous for the trait. You will design crosses between your flies and a wild-type strain and analyze the consequences over the next two generations in order to deduce the number of genes represented by the mutation(s), the inheritance pattern of these gene(s) and the chromosomal location(s) of this/these gene(s). The pool of unknowns contain a variety of mutations. You will need to draw upon the lecture material to help you formulate your conclusions. After a preliminary report is satisfactory drafted, the instructor will provide each group with the name(s) of the gene(s) to enable further research in the scientific literature to aid in the writing of the lab report.

Outcomes

By the end of this laboratory exercise, you should be able:

To culture and cross the genetic model *Drosophila melanogaster*
To construct a hypothesis and determine how it can be tested by experimentation
To set up genetic crosses and collect data from the progeny
To analyze the data using Chi Square analysis and draw conclusions
To present your hypothesis, experimentation, data, analysis and conclusions in a written scientific format
To incorporated peer and instructor feedback to revise your written paper

Observation and Hypothesis

Each lab team will be assigned an unknown. Your first step is to observe your unknown flies and identify the mutation(s) by comparing the unknown to the wild-type flies. Describe the mutant phenotype in as much detail as possible. You may also need to describe the reciprocal wild-type phenotype to use as a reference. Based on your description, speculate whether the mutant phenotype is the result of one or two mutant genes and construct an appropriate hypothesis. This is an opportunity to employ Occam's razor (*Consider all the circumstances and select the simplest explanation.*) Speculate on the function of your gene(s).

Experimental Design

Based on your hypothesis, develop an experimental approach to test your hypothesis. You should think carefully about how to set up the necessary crosses and lay out a time line for what will need to be done when, keeping in mind that you may need to modify this depending on what the flies actually do (rather than what you expect them to do). (FYI: A generation in *Drosophila melanogaster* is about 14 days, depending on a number of environmental conditions and the genetic state of the flies.)

In designing your experiment, you should consider:

a) Replicas: How many should be set up? Why?
b) Order of crosses: female mutant x male wild-type OR male mutant x female wild-type OR both ways? Why?
c) Timing: Do you want all your flies to emerge at the same time or staggered over a longer period? Why?

Finally, work out how your team will record what it has done, who has done it, and what the outcomes were. You may want to consider a group notebook for this lab, as all members of your team need to have access to all of the information. Individual team members keeping track of his/her own actions and data that get pooled at the end is NOT an efficient or acceptable means to this end. Suggestion: you should have an emergency plan in place, in case one of your teammates encounters an unexpected

circumstance that prevents him/her from doing what s/he needs to do. Given that you are working as a team, you have no acceptable excuse for not completing this project on time.

Experimentation

The first half of the semester will be allotted to testing your hypothesis. Your goal is to have collected your F2 data no later than the week after Fall Break (by Friday, October 28). While some of your experimental design can be accomplished in the scheduled lab period (and we have provided time to do so in the schedule), you must spend some time outside of the scheduled class time on this experiment because of the nature of the organism. In order to distribute the work load evenly among team members, there will be a log sheet to keep track of your time spent on this lab outside of the scheduled lab time. You will be required to log in and to explain what work you are performing while in lab. If a member of the team fails to work outside of the scheduled lab time or works significantly fewer hours than others on the team, their final grade for the assignment will be reduced by 15% of the total points eligible.

The laboratory will be available to you at all times except when other courses are being taught. There are two sections of Biol 315 lab, one Tuesday afternoon and one Tuesday evening. Unless given express permission, you may not work on your fly lab while the other 315 lab is meeting. In addition, Dr. Lassiter will be teaching Biol 210 lab in LS410 Wednesday afternoons from 2:20-5:20 pm. Plan accordingly and do not expect to work in the lab during these times.

You are responsible for cleaning up after yourself when you are working in the laboratory. Please realize that Biol 210 students will also be working in the laboratory and coming in outside of class. In order to successfully share this space, we all need to be responsible. In a professional research laboratory, many scientists may need to share the same space and equipment. In order to maintain a safe and functioning laboratory, we need to make sure we are using the resources appropriately, following clean up protocols and notifying the instructors of any problems that arise.

Assignments

The second half of the semester will be allotted to writing and revising your lab report. Guidelines for writing lab reports can be found on Inquire. By the time you work on this report, you will have written several Results and Discussion sections for other lab experiments. This assignment is going to be treated more like a manuscript submission than a class paper. You will be soliciting feedback from your peers and your instructor. You will also demonstrate how you incorporated this feedback into your final version of the complete report.

The grade for this assignment will make up 40% of your grade for lab with the paper accounting for 30% and the review process accounting for 10%.

Drafts are a necessary vehicle to develop and improve one's writing. Consequently, drafts of both the Introduction and the Results and Discussion sections will be required. These drafts will be evaluated to provide feedback, and the quality of these drafts and the subsequent revisions will be incorporated into the final grade on your paper. In addition, the failure to use feedback from earlier drafts to significantly improve the quality of the final paper will negatively impact the grade of the final paper.

The following is a further breakdown of how the 30% will be distributed for the final paper.

Introduction	5%
Title, Methods and Materials	5%
Results	5%
Discussion	5%
References	5%
Quality of drafts and revisions	5%

The review process (the other 10% of the lab grade from the Fly Lab) will consist of submission of peer reviews of two other students' R&D drafts and your response paper explaining your revisions.

While you will be working as a lab group to collect and analyze data, the lab report must be written individually.

Appendix B

Biol 315 Lab

Rubric for Lab Report

Student_____ Grade_____

1. Title (2%)
    a. Informative and accurate

2. Introduction (20%)
    a. States the objective of the experiment incorporating the unknown

    b. Flies as genetic models

    c. Appropriate literature background to explain the phenotype affected
        i. Discuss wild type phenotype

        ii. Discuss process that is affected

    d. Provide a concluding paragraph that states the hypothesis and the approach used the experiment

3. Methods and Material (13%)
    a. Explain culture techniques and materials

    b. Explain cross strategy

    c. Explain the statistical analysis used.

4. Results (25%)
    a. Text (15%)
        i. Results are explained in words
        ii. Appropriate organization of text
        iii. Results refer to the tables appropriately
    b. Tables and Figures (10%)
        i. Table has a title
        ii. Table has subheadings
        iii. Appropriate information

5. Discussion (30%)
    a. Appropriate organization including introductory and concluding paragraphs.
    b. Interpretation of results
    c. Indication of whether original hypotheses were supported or refuted; how does your data support the process you are studying.
    d. How does your work relate to other research

6. References (10%)
    a. Format
        i. Reference list
        ii. Internal citations
    b. Sufficient and appropriate references

Appendix C

Biol 315 Lab

Peer Evaluation Guidelines

You will be assigned two papers from your colleagues in this class. One person will be from your laboratory team (internal review) and one person will be from another lab team (external review). These reviews are not anonymous; please use respectful language and realize that your goal is to help the author improve their work. You will write a review for each paper using the following guideline. These reviews are due on Tuesday Nov. 22 by 1 pm. Please bring two copies of each review. One will be given to the author of the paper, the other will be given to me for a grade.

Your review should consist of the following sections. Address each point in a paragraph.

1. Evaluate the Results text. Comment on the organization and clarity of this section. Is the appropriate material being explained? Are the data in the tables being referenced in an appropriate manner?
2. Evaluate the Tables. Comment on their format, clear representation of data, and if the appropriate data is included. Make suggestions if improvement is required for added clarity.
3. Evaluate the Discussion text. Comment on the organization and clarity of this section. Is the appropriate material being explained? Is the gene mutation and the function of the gene product explained? Is there appropriate primary literature that is connected to the study? Does this section have an appropriate concluding paragraph?
4. Evaluate the references. Remember our final goal is to have at least ten references/five of which are primary literature. Are they making good progress toward that goal? Is the author choosing appropriate references? Is the author using the correct format, according to the assigned guidelines?
5. Write a paragraph, explaining what is positive about the paper and what needs to be improved. Pick at least three points to compliment the author on and three points to suggest improvement. Focus on big picture issues. Try not to replicated information in the other sections. General comments about overall presentation may be made in this section. These can included comments regarding grammar, spelling and sentence structure.
6. You may also write comments directly on the paper and return it to the author. I will not evaluate those comments.
7. On my copy only, provide a recommend grade for the paper.

Mission, Review Process & Disclaimer

The Association for Biology Laboratory Education (ABLE) was founded in 1979 to promote information exchange among university and college educators actively concerned with teaching biology in a laboratory setting. The focus of ABLE is to improve the undergraduate biology laboratory experience by promoting the development and dissemination of interesting, innovative, and reliable laboratory exercises. For more information about ABLE, please visit **http://www.ableweb.org/.**

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