How to Make Scientific Paper Reading Fun: Journal Club Style Role-Playing to Improve Scientific Literacy and Reading Comprehension Skills in Biology Laboratories

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Many undergraduate students in introductory biochemistry courses find it challenging to understand how Scientific literacy and reading comprehension skills are essential for students participating in inquiry-based laboratories. To many students scientific jargon is a foreign language, and instructors have to help students tackle the challenge of understanding their first scientific papers. The application of simple role-playing can help science paper dissection. Students take on three roles (discussion leader, data master and Devil's advocate) and their performances are assessed in these journal clubs. These paper dissection exercises emphasize teamwork, help students dissect papers in a fun way, and teach them about scientific communication.

Keywords: scientific literacy, journal club, paper discussion, collaborative learning

Introduction

Reading scientific papers improves students' scientific communication skills and their ability to write better lab reports. The major challenge is to have students understand a scientific paper. Many lab courses ask students to present a paper, in a journal club style, but these presentations tend to be dull, and often just repeat the paper word-by-word. Role-playing is a powerful tool in teaching social sciences, and its application is endless in biology teaching. Group paper dissection is based on: a) collaborative learning and b) deep reading.

Collaborative learning has many known benefits (Gillies, 2003), as students not only feel like they are in a secure learning environment, but they also benefit from peer-instruction (Johnson el al 2006, Millis 2010). Deep reading is a process through which students employ various strategies to improve learning comprehension (Parrott and Cherry 2011). The deep reading process was introduced by Roberts and Roberts (2008) as structured reading groups that benefit from various peer-teaching strategies. The major challenge with both collaborative learning and deep reading is that it is difficult to evaluate individual accomplishment.

Two of the five roles described in the Parrott and Cherry (2011) paper were adopted by two courses at

Cornell University in Ithaca, NY in 2012. The *Investigative Biology Course* (400 students) is a large laboratory course designed for biology majors in order to provide lab experience with emphasis on processes of scientific investigation. Students gain expertise in scientific methods and instrumentation, and one of the learning goals of this course is "to teach students how to find relevant scientific information using appropriate library tools and to communicate effectively using both written and oral formats." The *Disturbance Ecology* course is a much smaller course (20 students) designed for students who are interested in ecology, ecosystems, trophic interactions and factors that change them. This seminar course is based on short lectures, paper discussions, and active participation by the students. The two roles these courses utilize, adopted from Parrott and Cherry (2011), are "Discussion leader" and "Devil's advocate". These roles are used to facilitate group discussions and to critique the paper, respectively. A third role: "Data master", was added to focus on methodology and statistics, which are very important both in a hands-on biology laboratory course, and in an ecology course.

This method from Parrott and Cherry (2011) filled a niche in both the *Investigative Biology* and *Disturbance Ecology* courses. For multiple years, students presented papers without role-playing, and usually one person spoke

up while the other two group members were "free-riders". The role-playing paper discussion method was implemented to make sure that all group members participate equally. The grading rubric presented here was developed by the author after two years of experience with the paper dissection groups. It is following the peer-instruction design in which students first need to work individually (finding a paper and answering questions), but ultimately present the paper as a group.

This method ensures the following learning goals: a) students' individual work affects the group grade, and therefore acts as an extrinsic motivation, b) students read papers individually, removing the problem with the "free-riders", c) students learn skills such as how to navigate group dynamics and learn negotiation skills, d) students improve their scientific literacy by learning how to find and successfully present primary literature articles.

These modifications to the Parrott and Cherry (2011) paper added significant components that increased the benefits of this already successful method.

Student Outline

The student handout consists of:
a) Paper dissection guidelines describing the different roles they need to use to dissect the paper.
b) Written comments that students need to complete individually prior to their presentations.
c) The rubric the instructor uses to grade their presentation.

a) Paper Dissection Guidelines
Discuss the Paper by Using the Following Roles:
<u>Discussion Leader</u>
Your role is to develop at least two possible discussion questions (specific to the topic of the paper) that will help guide the paper discussion with your lab mates so everyone understands the main points of the assigned reading. Don't worry about the small details. Your task is to help people review the main points of the reading, and to share their reactions to the paper. Be prepared by having brief answers to your questions, but your main task is facilitating discussion in your lab section. You also help everyone make connections among the main findings of the paper to other important concepts, ideas, or issues, whether these connections are related to concepts discussed in class or to other scientific, public health, cultural, social, political, and economic issues. Some of these connections may be articulated in the introduction.
Questions to think about:
- What were the main objectives of this paper?
- Did the authors clearly deliver their ideas?
- Was this paper a good contribution to science?
- Does this research connect to any topics in this class or to current events?

<u>Data Master</u>
Your role is to locate key points of data that are important to the authors' interpretation of their findings. These may represent conflicting data or unconventional interpretations; for example, the data might be controversial or contradictory with concepts we learned in class. You must also share your interpretation of the data and why you are interpreting it the way you have. Discuss whether the tables, figures, etc. meet the requirements for this class.
Questions to think about:
- Are there clear figures/tables in this paper?
- Do they explain the main results?
- Would you have presented the data differently?
- Are they related to the type of graphing we teach in this class?

<u>Devil's Advocate</u>
Your role is to challenge the ideas in the article by developing a list of critical, thoughtful questions and arguments that might be raised by critics of the authors, or by those with different points of view. You will need to come up with at least two challenging questions or arguments (topic specific) including a brief explanation of why you are making this critique. Explain where the authors may have made a mistake and how your research group would do it differently.
Questions to think about:
- Is this a good paper?
- Is the research scientifically sound?
- Did they use proper scientific methods, good number of replicates, and the right kind of statistical analysis?

b) Written Comment Section
Name of the Group Member Providing these Written Comments:
Each member of the group should find a primary literature paper in the assigned module. Each member should individually answer the questions below. As a group, pick the best of the papers and present it to the class, following the paper dissection rubric.
Individually, write three questions about the paper you found. Your three questions can be about objectives, methodology, discussion that you found confusing, or what you would explore further:
Question 1:

Question 2:

Question 3:

Identify the hypothesis/objective of the study. In which section of the paper did the authors' reveal it?

What kind of statistical method did they use (if any) to analyze their data? In which section of the paper did the authors first mention it?

How many replicates did they use?

Was the research hypothesis supported?

Please list the references (in the proper CSE format) for this paper, so the lab instructor can check your answers (i.e. Francisco S. 2014. Mist formation in the Bay Area. J Meteorol. 12:122-123).

Are the references in this paper formatted exactly the same way you need to format the references for your own paper (CSE format)? Name at least two differences.

c) The Grading Rubric

Group members: _____   **Paper title:**_____

Maximum 10 minutes per paper.   **Total points:_____ / 15**

Table 1. Grading rubric.

Requirements	How well was it accomplished?		
	Written comments were complete for all members (6 pts)	**Written comments were more than 75% complete (3 pts)**	**More than half of written comments were missing (0 pts)**
Individual group members provided written comments			
Discussion Leader	**This requirement was fully satisfied (1 point each)**	**It was partially satisfied (0.5 point each)**	**This requirement was not satisfied (0 point)**
Encouraged discussion among lab members			
Identified and discussed main ideas of the paper			
Connected the paper to the course or to current events/issues			
Data Master			
Main results were explained			
Figures/Tables were interpreted and connected to the conclusions of the study			
Data presentation was compared to the analysis and graphing used in the course			
Devil's Advocate			
Criticized the paper			
Explained how his/her group would avoid those mistakes			
Overall			
The paper was a good choice and it was well presented			

Notes for the Instructor

At the beginning of the semester introduce the paper discussion rubric and rules. Create a good learning environment by setting the expectations for the grading of the paper discussion. Have all groups of 3 students sign up for topics of your class. During the journal club, each member of each group will need to assume a role. If you have less than three students in a group, they will have to combine roles. Each role MUST have questions prepared to ask the class in order to stimulate discussion. The groups have to send the papers to the instructors prior to the discussion section.

Discussion Leader: The primary role of the discussion leader is to talk over the big ideas in the reading and to facilitate discussion by asking questions that encourage their lab mates to share their reactions to the paper. The discussion leader should not be talking about small details but should be concerned that everyone in the class walked away with the big picture of the research. The discussion leader should be using discussion to clarify the paper for the class. A secondary, but still important role, of the discussion leader is to relate the details in the paper to the big picture. Depending on the paper, this can be anything from how the paper ties into the course material to how it ties into current events. The questions the discussion leader should be asking should be about the objectives of the research, whether they were met or not, the contribution of this research to the field, the novelty of the experiment or the results, etc.

Data Master: The role of the data master is to analyze specific information regarding the experiment presented in the paper. The data master should be summarizing the major experimental findings of the paper using the figures/tables and information provided in the methods and results sections. The implications of these findings are left to the discussion master and the critique of the methods should be left to the Devil's advocate. The data master should be the critical eye for the data presented. They should look at the figures and tables and determine if the authors interpreted them correctly. This requires the data master to present their own interpretations of the data and allows them to ask their classmates what they got from the data in the paper. They should be asking the class questions such as: Do the data/figures/tables really support the conclusions that are presented by the authors? Are the figures and tables clear and easy to interpret? Is there another way this data could have been presented that would have been better?

Devil's Advocate: The role of the Devil's advocate is to critique weaknesses in the paper. These can be flaws in the writing, flaws in theory that went into development of the hypothesis, flaws in the research methodology etc. These flaws should then be related to the impact of the research. The Devil's advocate should be asking challenging questions, such as: Do the flaws change the overall interpretation of the data or change how applicable this data is? Do the flaws in the research methodology change how well this experiment addresses the hypothesis? Is there a better way to design the experiment to test the hypothesis presented?

Suggestions to the Instructors

If time permits, multiple groups can be formed, and a jigsaw method can be applied to the different roles: multiple groups can dissect the same paper. The same roles can get together and discuss how they approached their goal as a Discussion leader, Devil's advocate or Data master.

Depending on the course, audience participation may not be the most active. In an elective course (Disturbance Ecology), all students chose to be there, so they read the paper before the class. In the Investigative Biology Lab course (required by the major), many students do not read the paper unless they are presenting. The method presented in this paper fully benefits the presenters but sometimes only partially benefits the audience.

Students are really interested in the differences in the journals. Many of them bring in papers published in *Nature*, which are very different than *PNAS* or *Cell* papers. This is a great method to compare different types of journals and expose students to the peer-review process in scientific publication.

Approving the paper before the presentation by the teaching assistant or the instructor removes the students' ownership of the paper they are presenting. Students learn from their own failures, including trying to present a 16 page long paper in 10 minutes. Instead of a paper approval prior to the role-play, it is suggested that instructors allow students to present any paper the students have chosen. This approach, while riskier, shows the trust of the instructor in the students, which is a strong intrinsic motivator for performing well. Intrinsic motivation may be just as important for a healthy learning environment as motivation by grades, as discussed in details by Ryan and Deci (2000).

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Acknowledgments

About the Author

Mark A. Sarvary received both of his diplomas (in ecology and in marketing) in Hungary. After attending to the University of Minnesota in Saint Paul, MN and conducting research at the University of California in Davis, CA, he received his Ph.D. at Cornell University and continued as a postdoctoral fellow at ETH Zurich in Switzerland. He has been involved in biology education since 2002, teaching at both Cornell University and Ithaca College. Currently he is a lecturer and the director of the Investigative Biology Laboratory at Cornell University, with the responsibilities of teaching, graduate teaching assistant training and course development. He is also actively involved in research and teaching in ecology.

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