Investigating the utility of peer-feedback and self-reflection for preparation of Biology Lab Reports

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Course Overview

Biology Laboratory, L113, is a three credit introductory undergraduate laboratory class. The course consists of one three hour laboratory session and one fifty minute discussion section per week. The course is taken by a wide variety of majors at Indiana University, and typically enrolls approximately 400 students in seventeen sections of the course per semester. There are two faculty lead instructors, who manage the course details, write and design the labs and assessment rubrics, and coordinate the labs. Each section of the course is run by a graduate student Associate Instructor who is in charge of running the lab session, designing small stakes assessments or activities (15% of the course points), grading, and one-on-one student interaction.

The major assessments for the course are in the form of written reports, termed minireports. There are four minireports and a final paper distributed throughout the semester. Each minireport increases in points and length. Associate Instructors are free to modify the rubric for any given minireport, but are bound to the number and design of major assessments in the course. Students are assigned a lab manual (Bonner et al. 2009), which has the outlines for experiments, writing and analysis tips, and published rubrics for each new lab. Students are also assigned, A Student Handbook for Writing in Biology, 2nd Ed. (Knisely, 2005) and are required to use it for one worksheet assignment. Associate Instructors are not required to use the text in Discussion section activities or in discussing writing in the course.

Goals and decision-making for my section of L113

In order to define the goals I had for my section of L113, I first considered the signature pedagogies of Biology. Bauer-Dantoin suggests that two of the major signature pedagogies in biology are active learning and inquiry (Bauer-Dantoin, 2008). Because inquiry and active learning are built into the laboratory sessions, I considered how I could incorporate active learning into my Discussion section. The use of active learning also fit with my goal of making the Discussion section a learner-centered environment (National Research Council, 2000). I felt especially strongly about attempting to create a learner-centered environment because much of what students experience in Biology courses at Indiana University are traditional lecture based structures. I wanted students to be responsible for preparing thoughts or written work on a topic prior to coming to Discussion and I wanted the Discussion to be an opportunity for the students to learn from each other, with me guiding the process.
I also considered how to use the Discussion sections to work on writing. The majority of points in the course (58%) are devoted to evaluation of student writing, thus seemed to warrant attention in Discussion. Additionally, through interdisciplinary conversations in the Teagle Collegium, and in background reading, it became clear to me that one skill that is a Signature Pedagogy of every discipline is the effective construction of a logical argument in a clearly written document (Chick et al. 2008). I made this goal explicit to my students and stated that I hoped to demonstrate that improving this type of writing was useful for any student in any major in my section.

Once I had defined a major goal of the course as working on constructing clearly written work with logical arguments, using student collected data as evidence for those arguments; I focused on how I would use the Discussion sections to help students work on their writing in an active learning activity. In an effort to remove myself as the sole source of information on how to write effectively, students were often assigned portions of Knisely (2005) to help them prepare a draft of a portion of the minireport prior to Discussion. In an effort to remove myself as the sole evaluator, I decided to implement peer-feedback. Peer-feedback also seemed to be a way to engage student thinking and learning about writing through critique. I also wanted to make the peer-feedback meaningful, so I implemented activities designed for students to reflect on the peer-feedback and suggest how that feedback would translate into action for their next minireport. This process was based on two elements foundational to Biology. First, as scientists, we are continuously seeking peer-feedback and analysis of our work. Secondly, after receiving peer-feedback, we reflect on it and think about what changes to our own work need to be made; a process requiring metacognition (National Research Council, 2000). I felt that this set of steps would model the scientific process in its entirety, from initiating inquiry in lab to peer-reviewed written work in Discussion.

I chose to use a journal article, de Boer (2004) and the writing principles of Knisely (2005) and Magnusson (1996) to provide students scaffolding for writing. Students’ perception of writing in each discipline is that the expectations vary. Using the term, “lab report”, has a very specific connotation, which is often grounded in Chemistry-style reports (E. Middleton, personal observation). By providing students with other resources beyond my feedback, I was hoping to give students the tools to succeed on their own.

In an effort to be clear about what my expectations were on each minireport, I modified the rubric provided by the course (Bonner et al. 2009). I attempted to retain some of the structure and expectations of the original rubric while highlighting the conceptual points that are required for each section of a report, for example the Methods. I broke each section into a “Structure” and “Writing skills” portion. The “Structure” portion attempted to highlight the most important mechanical aspects expected in a section. For example, in the Methods section, it is important that students cite the lab manual for the source of the protocol (for examples, see Rubrics in Appendix). The “Writing skills” portion attempted to highlight the thought work that had to be done by a student in order for the section to be successful. For example, in the Methods section, it is important that the students make decisions about the appropriate level of detail in describing the protocol; considering their audience (Appendix, p. 22). This task requires that students understand what parts of the protocol are essential
to the replication of the experiment, and which parts another Biologist would be able to complete
without instruction. I also attempted to demonstrate which points of each section are the minimum
requirements for a section, and which points, if included would demonstrate a better grasp of the
material (Appendix, p. 22). I chose to do this, based on suggestions made by Walvoord and Anderson

The following work summarizes my attempts at meeting my goals for the semester: to help students
learn about writing and to put my teaching and learning theoretical background into practice. First, I
summarize who my students were and what preparation they had prior to entering my section in
January 2009. The next three portions of this document summarize the activities and my inquiry
regarding the utility of peer-feedback and self-reflection on the writing process. Then, I summarize
students’ opinions on these activities. Finally, I reflect on what I’ve learned this semester and make
suggestions for modification of L113 course structure.

**Student demographic summary**

I informally polled students at the beginning of the semester in order to get a sense of the distribution
of upperclassmen to lowerclassmen. I also spoke with a majority of students about their majors and
their career goals. I did not take a formal assessment of the demographics of the students until the end
of the semester. The following data are a summary of the end of the semester formal survey of student
demographics.

<table>
<thead>
<tr>
<th>Year</th>
<th>Student number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freshman</td>
<td>2</td>
</tr>
<tr>
<td>Sophomore</td>
<td>5</td>
</tr>
<tr>
<td>Junior</td>
<td>7</td>
</tr>
<tr>
<td>Senior</td>
<td>8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Major</th>
<th>Student number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biology</td>
<td>5</td>
</tr>
<tr>
<td>Biochemistry</td>
<td>2</td>
</tr>
<tr>
<td>Exercise Science</td>
<td>9</td>
</tr>
<tr>
<td>Other</td>
<td>6</td>
</tr>
</tbody>
</table>

Table 1. Summary of student population by year enrolled.

Table 2. Summary of student population by degree major.
Table 3. Summary of student population by career goal.

<table>
<thead>
<tr>
<th>Career goal</th>
<th>Student number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical Therapy</td>
<td>8</td>
</tr>
<tr>
<td>Medical School (medicine, optometry, or dentistry)</td>
<td>7</td>
</tr>
<tr>
<td>Other Medical professional</td>
<td>2</td>
</tr>
<tr>
<td>Undecided</td>
<td>5</td>
</tr>
</tbody>
</table>

Table 4. Summary of student course background for L111 (Evolution and Diversity), a recommended course and L112 (Biological Mechanisms), a required course.

<table>
<thead>
<tr>
<th>Courses taken</th>
<th>total</th>
<th>currently enrolled</th>
<th>last semester</th>
<th>last year</th>
<th>&lt;2 semesters ago</th>
</tr>
</thead>
<tbody>
<tr>
<td>L111</td>
<td>13</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>L112</td>
<td>22</td>
<td>3</td>
<td>7</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>L113</td>
<td>22</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The majority of students in the course (68%) were juniors or seniors. The majority of students in the course (68%) were not Biology majors. The majority of students (77%) had plans to be employed in the health care field upon completion of education. Both L111 and L112 are recommended courses for L113. Sixty percent of students had taken L111 and 100% of students had taken (or are taking) L112. For L111 and L112, over 40% of students had taken either (or both) L111 or L112 more than one semester ago, with 27% of the students taking either (or both) L111 or L112 more than 2 semesters ago.

**Minireport 3**

This minireport asked students to complete the Abstract, Introduction, Methods, and Results section with Figures in standard Biology journal style. Students had not written an Introduction prior to this minireport.

**Activity summary**

In preparation for writing the Introduction section of the minireport, students were asked to come to discussion section having read de Boer (2004). In Discussion, students were randomly assigned groups and given a worksheet that asked each group to intensively read a section of the paper (Appendix, p. 19). I then re-grouped the class and each group shared findings with the class, while I emphasized key points verbally. Below are the questions I designed to highlight qualities of a successful Introduction.

1. What is the function of the first paragraph of the Introduction?
2. What is the function of the third paragraph in the Introduction?
3. What was the purpose of this study?
4. What is the function of the last sentence?

These questions were designed to underscore important characteristics of a well-developed introduction. After the class shared their group findings for each section of the paper, I asked them to reflect on our discussion of the introduction in de Boer (2004) and commit to 3 aspects that they felt would be important to include in the Introduction of the 3rd Minireport. The students turned in their responses on 3 x 5 cards before leaving class. This activity was done 5 days prior to the assignment’s due date.

**Activity Inquiry**

Does analyzing a peer-reviewed science journal article followed by self-reflection help students identify aspects of their Introduction to focus their effort?

Table 5. Summary of the aspects 21 students committed to allocating their writing efforts to. Three responses per student were requested, and 59 responses were usable. **Number of responses** refers to the number of students identifying a particular aspect, while **percent of responders** is defined as the number of students identifying an aspect divided by the total number of responses (=59).

<table>
<thead>
<tr>
<th>Response</th>
<th># responses</th>
<th>% responders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify purpose of study</td>
<td>16</td>
<td>22 %</td>
</tr>
<tr>
<td>Include two citations*</td>
<td>11</td>
<td>19%</td>
</tr>
<tr>
<td>Relate background citations to study</td>
<td>10</td>
<td>17%</td>
</tr>
<tr>
<td>Create motivation for study</td>
<td>8</td>
<td>14%</td>
</tr>
</tbody>
</table>

Students were able to identify aspects, but there was not a consensus on the most important aspects to focus effort on. The two responses with the highest number of responses are more concrete changes to their writing, while the last two responses are more challenging to address and required more integration and application of outside information with their experiment. Because the inclusion of two citations from science journals is a minimum requirement for the submission of the paper, I did not pursue analysis.

**Does students’ focus on the three aspects result in a high quality Introduction?**

I then used the three aspects students committed to including in the Introduction and evaluated which points in the rubric I designed would apply (Appendix, p. 22). The following bullets are elements from the Introduction portion of the rubric that address the top three aspects identified by the students for focus purpose, background, and motivation.

- Does the Introduction introduce the question or problem you wanted to explore?
- Does the **Introduction use a MINIMUM of 2 journal articles?**
- Are any sources clearly integrated into the paper in a way that shows their direct relevance to what YOU did?
- Does the introduction use sources to help summarize what is and isn't known about the topic?

I used the rubric points to evaluate student success on the three aspects identified above. Student papers were accessed via Oncourse, and 16 were available for analysis. I scored the Introduction sections on a 3, 2, 1 scale. A “3” is defined as student exceeded the appropriate criteria according to the rubric, 2 is student met the criteria, and 1 is student failed to meet the criteria.

![Bar graph](image)

**Figure 1.** Number of students achieving a 3, 2, or 1 score for the three aspects students identified as requiring focus in Introduction writing. Purpose refers to, “Identify purpose of study”; background refers to, “relate background citations to study”; motivation refers to, “create motivation for study” (Table 5).

Sixteen students committed to including the purpose of the study in their introduction (Table 5), while fifteen students (94% of available papers) were successful in doing so in their Introductions. Ten students committed to connecting background information to their study (Table 5), while twelve (75% of available papers) were successful in doing so in their Introductions. Eight students committed to creating motivation for their study (Table 5), while nine (56% of available papers) were successful in doing so in their Introduction. An interesting consequence of this activity is that students who didn’t necessarily identify the aspects in the pre-writing activity were able to incorporate the three aspects identified by others into their minireports successfully.

**Activity reflection**

This activity was able to make students aware of characteristics of well-developed introductions, and students were able to apply that understanding to their own work, but the degree of success varied by aspect identified. Students successfully identified and included purpose and background in their minireports. These two tasks are fairly concrete and well-defined by the Introduction rubric. However, a slim majority of students were able to successfully create motivation for their study, which is a more abstract task and is less well-defined by the Introduction rubric. Creating motivation for their study
requires that students first identify the context of their study and the appropriate background articles that address the questions they are investigating. Next, they needed to identify the knowledge gap that their study addresses within the literature. This series of tasks was clearly difficult for nearly half of the student papers surveyed.

**Minireport 4**

This minireport asked students to complete the Abstract, Introduction, Methods, Results and Figures, and Discussion sections in standard Biology journal style.

**Activity Summary**

After completing the experiment in lab, students were given prompt questions highlighting the thought processes required to complete the figures, results, and discussion sections for the next minireport (Appendix, p. 25). Students were then were asked to write up their figures, results, and discussion sections from their experiments in that order. The order of writing the sections is based on the structure suggested in Knisely (2005).

In Discussion, the students then were given a structured peer evaluation worksheet and asked to evaluate another’s work (Appendix, p. 26). Peer-evaluation focused on grading students against the rubric. Finally, student authors were asked to 1) comment on what 3 aspects of the paper that the reviewer identified as needing revision; 2) articulate how the author would go about revising these aspects; and 3) identify which section of the rough draft they felt least equipped to complete. This activity was assigned the discussion prior to spring break, with the paper due the Monday back from spring break (10 days).

**Activity Inquiry**

*Does structured peer-review and author reflection help students identify aspects of their Figures, Results, and Discussion sections to focus their effort?*

The self-reflection worksheet (total responders= 20) had 52 usable responses, 18 students commented on figure modifications, 14 commented on discussion modifications, and 11 commented on results. Because there was a fairly even distribution of comments between the three sections evaluated, I chose to focus my analysis on the aspect of each section most identified.

Table 6. Summary of the aspects 20 students committed allocating their revision efforts to. The top three responses are summarized. **Number of responses** refers to the number of students identifying a particular aspect within a section, while **percent of responders** is defined as the number of students identifying an aspect divided by the total number of responses for a section (=18, 11, 14 for each section listed).

<table>
<thead>
<tr>
<th>Response</th>
<th># responses</th>
<th>% responders</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIGURES: Change figure style (title, axis labels, color, or type)</td>
<td>8</td>
<td>18 %</td>
</tr>
<tr>
<td>RESULTS: Include observational data in results section</td>
<td>4</td>
<td>36%</td>
</tr>
<tr>
<td>DISCUSSION: Explain results in discussion</td>
<td>6</td>
<td>42%</td>
</tr>
</tbody>
</table>
It appears that there was a less clear consensus about what to focus effort on within a section of their rough drafts. The changes that the students focused on in each of the sections are concrete and easily addressed in the preparation of their final draft.

**Does students’ focus on one aspect in each of the three sections result in high quality Figures, Results, and Discussion sections?**

I then used the three aspects students committed to changing and evaluated which points in the rubric I designed would apply (Appendix, p. 29). The following bullets are elements from each section of the rubric that address the top aspect identified by the students for focus in the Figures, Results, and Discussion sections.

1. **Figures:**
   - Are your figures clear and understandable?
   - Are your axes correctly labeled, with units where appropriate?
   - Is the independent variable on the x-axis and the dependent variable on the y-axis?
   - Did the author avoid putting the same data in both a table and a figure?
   - Did the author choose the method of summarizing the data (table or figure) according to the principles outlined in Knisely?

2. **Results:** note: This section does not contain a line that reflects the need for or importance of observational data.
   - Did you describe important trends in the data, and identify key points the reader should note in the graphs?
   - Is your results section FREE of data interpretation, providing an objective description of what happened, without any explanation of WHY it happened that way?
   - Did you make sure that no methods (including calculations) are described or introduced in this section?
   - Are specific raw data presented in graphs, and NOT as lists of numbers in the text of the results section?
   - Does the text of the results section include references to Figures or Tables?
   - Did the author highlight the results that directly respond to the objectives stated in the Introduction?
   - Did the author use the figures/tables as lines of evidence that highlight the trends described?
   - Did the author avoid redundancies when describing the data/key points?

3. **Discussion:**
   - Did you provide a very brief review of the results?
   - Do you tie use results as evidence for your conclusions?
   - Do you connect your results to the existing body of scientific knowledge?

I used the rubric points to evaluate student success on the three aspects identified above. Student papers were accessed via Oncourse, and 21 were available for analysis. I scored each section on a 3, 2, 1 scale. A “3” is defined as student exceeded the appropriate criteria according to the rubric, 2 is student met the criteria, and 1 is student failed to meet the criteria.
Eight responders identified improving their figures as being an important aspect to focus effort on after completing a rough-draft and peer-evaluation and self-reflection exercise (Table 6). Seventeen students (81%) created successful figures in their final draft. Four responders identified the importance of including observational data in their results, while seven students (33%) successfully included observational data in their results sections; a three percent drop from the percent of responders committed to this change in the reflection (Table 6). Six responders identified needing to improve the explanation of results in the discussion in their self-reflection exercise. Sixteen students (76%) of students successfully explained the results of their experiments in their discussion sections.

Students were also asked which section they felt ill-equipped to complete. Sixty percent (12/20) of students felt that there was a section that they were struggling with during the rough draft. The majority (8/12) felt that the discussion was the most difficult for the following reasons: hard to explain the data, did not have connection to prior knowledge (lacked sources), and struggled to make connections between the points the students wanted to make.

**Activity reflection**

This activity was marginally successful in asking students to self-identify what areas of their rough draft required more focus for the final paper. The success was hindered by the open-ended question on the self-reflection sheet (Appendix, p. 28), which left little room for consensus among the majority of students. The top aspect identified for each section (Table 6) is a very concrete change that students could first identify in others’ work and then commit to changing in their own paper. This activity demonstrates the utility of using peer-feedback and self-reflection to identify concrete aspects that would improve written work. Students were also successful at using their self-reflection on peer-feedback to write successful Figures and Discussion sections of their papers. This method was not useful in the identification of the utility of including observational data in the results section, though it should be noted that this was not an explicit expectation on the rubric.

Figure 2. Number of students achieving a 3, 2, or 1 score on the aspect designated for focus in the Figure, Results, and Discussion sections of Minireport 4.

![Bar chart showing the number of students achieving scores of 3, 2, or 1 for Figure style, Observational data, and Explain results sections.](image-url)
I find it interesting that more students did not identify aspects of the Discussion as requiring focus, given that the majority of responders to the question, “which section do you feel most ill-equipped to complete” identified the Discussion. The Discussion was the new portion of the paper that was added to this minireport. The lack of the responses identifies that the peer reviewers were unsure of how to construct Discussion sections themselves, making it difficult to suggest concrete changes to the authors.

**Independent Projects**

Over the course of the semester, students designed and carried out an individual inquiry project on the topic of their choosing. Their final written assignment was to write a full report (all sections included in minireport 4) in Biology journal style.

**Activity summary**

Students were asked to come to class having read the article, “How to write backwards” (Magnusson, 1996) and prepare the following portions of their lab report, following the guidelines presented in the article:

1. Identify the larger biological principle that your experiment is testing? What is the big picture or big question that you are working on contributing to? (A few typed sentences)
2. Prepare submission-quality figures—I want to see how you see your data best.
3. Follow the 5 rules in Magnusson (1996). Each one can be answered in 1-2 short paragraphs.
   a. Make figures first
   b. Write only results that come from figures
   c. Write only the methods that have to do with the data in your results
   d. Write up the conclusions from your results
   e. Write the intro, including only information necessary to understand your results

Students were then put into pairs and given a structured peer-evaluation sheet to go through, evaluating each section based on the recommendations given from the article and from the rubric (Appendix, p. 32). Students were then asked to reflect on the four aspects of the Independent Project paper that they are going to focus on for improving the final draft. This assignment was completed 11 days prior to the final paper being due.

**Activity inquiry**

Does structured peer-review and author reflection help students identify the most important aspects of their reports to focus their effort?

Twenty-two students responded to the four aspects of their papers that required focus. Seventy eight responses were usable. The students commented on all five sections (Introduction, Methods, Results, Figures, and Discussion), as well as Proofreading. The majority of comments were concentrated on the Discussion section (18; 23% of total comments), followed by the Figures (15), and the Introduction (13). Because of the disconnect I identified between students feeling ill-equipped to complete the Discussion, and the Discussion not being identified as the top section requiring focus from last activity, I decided to focus this portion of the analysis on the Discussion section only.
Table 7. Summary of the aspects 22 students committed allocating their revision efforts to. The top three responses from each student are summarized. **Number of responses** refers to the number of students identifying a particular aspect of the Discussion requiring focus, while **percent of responders** is defined as the number of students identifying an aspect divided by the total number of responses for the Discussion (=18).

<table>
<thead>
<tr>
<th>Response</th>
<th># responses</th>
<th>% responders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Explain data in context of big picture</td>
<td>6</td>
<td>33%</td>
</tr>
<tr>
<td>Clear conclusions</td>
<td>5</td>
<td>28%</td>
</tr>
<tr>
<td>Connect the Intro. with the discussion</td>
<td>2</td>
<td>11%</td>
</tr>
<tr>
<td>Connect the data with the literature</td>
<td>2</td>
<td>11%</td>
</tr>
<tr>
<td>Discuss sources of error</td>
<td>1</td>
<td>6%</td>
</tr>
<tr>
<td>Increase relevance</td>
<td>1</td>
<td>6%</td>
</tr>
<tr>
<td>“Elaborate”</td>
<td>1</td>
<td>6%</td>
</tr>
</tbody>
</table>

Sixty one percent of responders committed to the first two aspects, while forty nine percent of students committed to the last five aspects. The top response is more abstract, while the next response is more concrete.

**Does students' focus on creating a connection to the big picture and writing clear conclusions result in high quality Discussion sections?**

Because there was no clear consensus beyond the first two aspects, I selected “explain data in context of big picture” and “clear conclusions” to focus my analysis (Table 7). “Big picture” was defined in the course as being the larger question or perspective that an experiment fits in to. For example, a student interested in eutrophication of water ways constructed a study that contributed to an understanding of predator-prey dynamics in the system. I evaluated which points in the rubric I designed would apply (Appendix, p. 38). The following bullets are elements from the Discussion part of the rubric that address the two aspects identified by the students as requiring focus.

**Discussion:**

- Do you tie use results as evidence for your conclusions?
- Do you connect your results to the existing body of scientific knowledge?
- Does your Discussion section revisit each prediction, compare the data to the predicted result, and provide a thorough discussion of WHY you believe the data came out the way they did?

I used the rubric points to evaluate student success on the two aspects identified above. Student papers were accessed via Oncourse, and 18 were available for analysis. I scored the Discussion section on a 3, 2, 1 scale. A “3” is defined as student exceeded the appropriate criteria according to the rubric, 2 is student met the criteria, and 1 is student failed to meet the criteria.
A slim majority, fifty six percent (10/18), of students were successful in explaining the data in the context of the big picture of their experiments. Conversely, ninety four percent of students (17/18) were successful in clearly stating the conclusions of their experiments.

**Activity reflection**

The degree of success students’ experienced in this analysis is directly related to whether the aspect was abstract or concrete. Defining the big picture for a students’ experiment was challenging for many. I suspect that constructing a big picture was directly related to the amount of time that it had been since students took L111 and L112 (Table 4). This hypothesis cannot be tested, as the surveys I solicited were anonymous, but observationally, the students who were upperclassmen, especially seniors struggled more with connection to Biological context than the freshmen or sophomores in the course.

Evaluation of, “explaining data in the context of the big picture” requires that students are first able to construct the big picture in terms of biology, identify where their particular project fits into that context, and then can successfully apply that context to the interpretation of their data. These steps were not reflected in the rubric expectations (Appendix, p. 38), and I suspect not well modeled in the course.

The more concrete aspect, “clear conclusions” was a well-practiced skill in the course. Students had practice writing conclusions from the beginning of writing minireports in their Abstracts. By the time students reached the Independent Project, they had practiced articulating conclusions four other times, in either the Abstract only or in both the Abstract and Discussion. While the majority of students were successful in writing clear conclusions (Figure 7), the clarity of the experimental results was an obvious confounding factor. If the student had “messy” results, then the ability to articulate a “3” score conclusion was more difficult.

Reflection on this activity again highlights that the specific goals of the two aspects identified by students, which are important aspects of a well-constructed Discussion section, are not clearly articulated in the rubric. Despite the lack of clarity in the rubric, this activity demonstrates that the
majority students are able to identify aspects of as section as requiring focus and use this focus to create high quality Discussion sections. The degree of success in writing high quality Discussion sections is also influenced by whether or not an aspect identified is concrete or abstract.

**End of semester student reflection on writing process**

Along with the standard student feedback sheet for the Department of Biology, I handed out an anonymous survey asking them to evaluate the writing process that we went through in the course. I asked the following questions:

1. In several instances during the semester, we focused our discussions on learning about writing. In general, we used the following process each time:

   - Reading preparation prior to class
   - Instructor-provided rubric
   - Writing a draft
   - Inviting peer feedback
   - Reflection on the feedback
   - Writing a final draft
   - Instructor provided feedback on final draft

   What part of this process was the most valuable?

2. To what extent has your writing changed over the course of the semester?

3. Do you have any suggestions to modify the writing process that we used in the course?

**Response summaries**

Table 8: Response summary to end of semester writing summary, question 1. Twenty one students responded, with 30 usable responses. **Number of responses** refers to the number of students identifying each process part, while **percent of responders** is defined as the number of students identifying each process part divided by the total number of responses for the survey (=30).

<table>
<thead>
<tr>
<th>Process part</th>
<th>Number of responses</th>
<th>Percent of responders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instructor feedback</td>
<td>9</td>
<td>30</td>
</tr>
<tr>
<td>Rubric</td>
<td>7</td>
<td>23</td>
</tr>
<tr>
<td>Peer feedback</td>
<td>7</td>
<td>23</td>
</tr>
<tr>
<td>Rough draft</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>Final draft</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Reading preparation</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Reflection</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>

Instructor feedback after the final draft was the most valuable aspect of the writing process for students, but they equally valued the availability of the rubric and the peer feedback assignments.
Table 9. Response summary to end of semester writing summary, question 2. Twenty one students responded, with 27 usable responses. **Number of responses** refers to the number of students identifying a writing aspect improved, while **percent of responders** is defined as the number of students identifying each aspect improved divided by the total number of responses for the survey (=27).

<table>
<thead>
<tr>
<th>Writing aspect improved</th>
<th>Response number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clarity</td>
<td>6</td>
<td>22</td>
</tr>
<tr>
<td>Succinct writing</td>
<td>4</td>
<td>15</td>
</tr>
<tr>
<td>Comfort writing lab reports</td>
<td>4</td>
<td>15</td>
</tr>
<tr>
<td>Structure</td>
<td>3</td>
<td>11</td>
</tr>
<tr>
<td>Not at all</td>
<td>3</td>
<td>11</td>
</tr>
<tr>
<td>Reasoning</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Other</td>
<td>5</td>
<td>19</td>
</tr>
</tbody>
</table>

Eighty nine percent of the responses indicate that student writing improved in some way. Thirty seven percent of students felt that their general writing quality improved (clarity and succinct writing ability). Fifteen percent of students increased their comfort in writing biology style lab reports. Three students (14% of the class) felt that their writing did not improve over the course of the semester. Examples of responses in the “other” category were: better able to review own work; better connection of ideas to biology; better ability to problem solve; better integration of literature (see sample quotes below).

**Sample student quotes in response to question 2:**
- “My writing is very different. I learned to be more succinct and use words better. Also, I understand how to integrate literature into my writing and problem solve!”
- “Thought about how to connect ideas to biology.”
- “I have become a lot more comfortable and familiar with writing lab reports.”
- “My ability to convey ideas has improved.”
- “It has strengthened. The way I formulate my paper/structure my reasons has improved with better flow.”
- “Barely. I focus more on going exactly by the homework rather than getting my point across.”

Student suggestions for modifications heavily fell on increased discussion of papers and writing in class. One constructive suggestion was to discuss a student paper and edit the paper as a class. This exercise could lead to better communication of what I see in the paper and lead to increased understanding of my expectations. Students asked for more discussion of expectations earlier on just a better explanation of expectations in general.

**Lessons learned from L113 writing activities**

The opportunity to analyze the writing activities I constructed for L113 this semester has been invaluable and I have gained several useful insights that I highlight below.
Content focus versus skills focus
After the interdisciplinary conversations at the Teagle Collegium, I realized that a Signature Pedagogy of every discipline represented was well-constructed logical arguments based on evidence (Chick et al. 2008). Because I had informally surveyed my students and knew that the large majority of them were non-majors, I decided to emphasize critical thinking skills and writing development as a main component of the course. This decision came at a cost to the amount of time I spent addressing the Biological content that supported each lab. As a result, students had more trouble addressing the abstract aspects of their lab reports, such as creating motivation (Figure 1), realizing the utility of observational data (Figure 2), and connecting their experiments to a larger biological context (Figure 3). These abstract aspects are directly related to student command of background knowledge in Biology. Had I explicitly surveyed the students regarding whether they had taken L 111 and L 112 and assessed the amount of time it had been since they had taken those courses (Table 4), I would have made fewer assumptions about the degree of comfort students had with the background material. I will need to apply this survey at the beginning of the course and be sure to temper my writing goals with the student need for reviewing biological concepts.

Alignment of my section with the course structure
I constructed writing preparation assignments in a way that models the suggested writing process in their Knisely (2005) text. Knisely (2005) suggests first writing the Methods, then the Results, Discussion, and Introduction sections to aid students in developing a logical argument in lab reports. The course Laboratory Manual asks students to add on a new section of a minireport each time, starting with Methods and Results, then Introduction, and lastly the Discussion section (Bonner et al. 2009). This disconnect between the assigned text on writing and the requirements of the course might suggest to students that the Discussion section is one of the least important sections of the paper, while Knisely (2005) argues that it is one of the most important. The articulation of conclusions, which students attempt in the Discussion section, is one of the key components of constructing a logical argument. The emphasis on argument construction is echoed in Magnusson (1996), where he also suggests writing the Discussion third, not last. Development of the Introduction as one of the early components of a lab report (minireport 3), emphasizes student mastery of the biological content over the articulation of the conclusions of their work. Misalignment of the text and course structure creates a conflict between the goals of content emphasis and analytical ability in writing a minireport and should be reviewed by the faculty instructors.

Rubric
I modified the course-constructed rubric to model a more holistic rubric approach (Walvoord and Anderson 1998). After students were asked to identify key aspects of different sections to focus effort, and I went back to the rubric to define how I would assign the score of 3, 2, or 1 for this analysis, I saw how the rubric was too long and didn’t hone in on the key aspects that the students identified as being important. Based on comments from the student survey, it is clear that the rubric needs to be restructured because it does not adequately communicate my expectations to students. As the evaluator, I found it more difficult to use because of the many points I had to consider for each section, making it harder to pinpoint the errors in logic; an important problem as I valued logic construction highly in the students’ work. Authentic assessment begins with a rubric aligned with course goals (Wiggins 1998), and my analysis demonstrates that this rubric structure was not.

I do struggle, though, because there are a lot of mechanics of a lab report, such as Figure structure, citation style, and integration of sources that need to be articulated to students. While I cared less about these aspects of a written report, I was responsible for teaching students how to write in the style
of a Biology journal article. I attempted to delineate the importance of the structure of writing a Biology style report and articulate the thinking students needed to demonstrate in each section by making each portion of the rubric two parts, “structure” and “writing skills”. This analysis has demonstrated to me that I have another opportunity for learning about teaching; rubric development!

**Utility of a learner-centered approach to writing**

Using peer feedback and self-reflection as a first evaluation of student writing was useful for concrete aspects of a report, such as defining the purpose of an experiment (Figure 1), modifying figure style and explaining results in the Discussion (Figure 2), and improving the clarity of conclusions in the Discussion (Figure 3). This analysis demonstrates that peer-feedback and self-reflection, in the format I used, is not useful for aiding in development of abstract aspects of report writing, especially connection to biological content. Students did not value these activities to the degree I would have expected. My rubric and comments remained most valuable (Table 8). This result points to the limited success I had at removing myself as the sole-evaluator and source of writing content knowledge; indicating that the goal of making writing learner-centered was not met.

However, eighty nine percent of students did feel that their writing improved (Table 9), indicating that the focus on writing in the course was a beneficial educational experience. I believe that the structured exercises (peer evaluation and self-reflection) did raise student consciousness about particular important aspects of reports. Each time, the number of students successfully achieving a 2 or 3 score on a section was higher than the initial number of responders identifying the aspect. What I cannot test in my analysis is which portion, the peer-feedback, or the students’ self-reflection aided students in their success.

This semester and this analysis have encouraged me to continue to work to understand how I can balance content with skill development, especially writing. I would like to pursue the utility of self-reflection in writing, but the students need to see the value in this exercise for it to meaningfully benefit their writing development.

**Suggested changes to L113 course structure**

- Construct a survey to be passed out to students on the first day of class. This survey would assess the year, major, and the amount of time it has been since in L111 and L112. The survey would be useful for Associate Instructors to understand his/her student population and consider the student background in making decisions about course structure.
- Revise the lab manual progression of sections in minireports to follow the writing process outlined in Knisely (2005). This change will aid students in logic construction in their lab reports and demonstrate the utility of Knisely (2005) as a supplementary text for writing.

**Works cited**


Appendix

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Minireport 3—discussion worksheet, p. 19
Minireport 3—rubric, p. 22
Minireport 4—guiding questions, p.25
Minireport 4—peer evaluation and reflection worksheets, p. 26
Minireport 4—rubric, p.30
Independent project—peer evaluation and reflection, p.32
Independent project—rubric, p.38
Discussion questions for de Boer (2004):

Introduction:
5. What is the function of the first paragraph of the Introduction?
   a. Defining terms
   b. Providing context for the study
6. What is a “diet-induced food preference”? (change in pref. after being exposed to a food for at least 24 hrs-specific for that plant)
7. Why could this be useful for developing larvae? (keep a larvae on a plant, orient them to a food that will aid in development, instinctual-parents always lay on one plant-monarchs)
8. What is the function of the second paragraph of the Introduction?
   a. Highlights a “hole in the research”
   b. Provides motivation for the new study
9. Define phytophagous, polyphagous, and oligophagous
   a. Are phytophagous: feed on plants
   b. Polyphagous: feed on many diff. plants,
   c. Oligophagous: feed on only one plant
10. What is a “sensitive period”? (can only learn something at a specific time-can only change or form food preferences at a certain time of development-there is debate over if or when this is for Manduca)
11. What is the function of the third paragraph in the Introduction?
    a. More specifics about the study system
    b. Introduces the questions in the study.
12. What was the purpose of this study?
    • Study how time and developmental stage affect food preferences—does the amount of exposure to a food or when that exposure took place matter for forming food preferences?
    • How long does it take to induce a preference and how long does it take for that preference to be extinguished
    • Is there a sensitive period for learning food prefs?
13. What is the function of the last sentence? Short preview of the methods.

Methods:
14. How many instars does Manduca have from egg to moth? (Lab Manual).
15. Why did he use tomato and cowpea as the two food choices? How does this relate to tobacco, what Manduca commonly eat in their natural habitat? What was the control choice and why was that chosen as the control?
   • Tomato is in the same family as their natural host plant, tobacco, and cowpea is not
The control was moist filter paper—still edible, but does not have any nutritional value

16. Generally, describe how the study was designed to test the study question. Include what instar of *Manduca* were used in the choice trial, what the different groups were, and what data was collected.
   - Reared on the two different foods, varied which how long and which instars
   - First tests were done on 4th or 5th instar
   - Used 6 disks, half cowpea half paper, measure the amount of each eaten, test done after half of one type was eaten
   - Performed non-parametric stats

17. Provide one example where you feel the author made a “judgment call” about the appropriate amount of detail for the audience?

18. What is the function of the last paragraph of the Methods section?

Results:
19. What is the function of the first sentence?
20. Focusing on the first paragraph, how are the figures used in summarizing the results?
21. Do you agree with the interpretation of the results based on the figures?
22. Summarize the results: Was he able to change food preference? Did there appear to be a “sensitive period” to learning a new food preference? Was the change in food preference permanent? Was there a difference in the results between food types?
   - Individuals reared on tomato for instars 1-4 preferred filter paper to cowpea, and those reared on cowpea preferred that to filter paper
   - Similar results for ind reared 2-4, 3-4, or 4
   - After 36 hrs with cowpea, consumed more cowpea but did not show preference (not stat. sig)
   - Pref could be changed back after 2 or 3 instars experience (2-3 or 4th instar)
   - Sensitive period may be during the 3rd or 4th instar
   - Only one instar of experience on cowpea was enough to change preference to that over filter paper
   - Prefs are not permanent, and can be easily changed

Discussion:
23. What is the function of the first paragraph?
   a. Highlights the main problem
   b. Identifies how the research tried to solve it?
24. Summarize the main points from each subheading. How did the author contrast his results with past work?
   - Past studies had shown a sensitive period during the 1st instar, here it is 3rd or 4th
21. His control was filter paper, not lab diet which the Manduca could prefer over another food.

25. How do you think the results of this study relate to Manduca’s natural behavior or the evolution of feeding behavior? Do you think it would be beneficial for this species to be oligophagous or polyphagous?
   - Oligophagous: maybe tobacco benefits development, and it is important for parents to induce preference for a particular food at hatching
   - Polyphagous: when diet is flexible, you may respond better to environmental changes

26. What suggestions did the author make for future research directions?
   - Learn how little time it takes to change a food preference
   - Look at how total time spent with a food can influence pref.
Minireport 3—Elizabeth Middleton

- Defines a part of the section that is a minimum requirement for a letter grade C.
  - Defines a part of the section, that if you do some but not all of the things listed, you will get a B. If you do all of the things listed, you will get an A.

Title:

- Does it capture the main idea of your project?
- Is it brief but complete?

Summary:

Structure

- Does it introduce the experiment, giving the purpose and scope?
- Does it state your hypothesis(-ses)?
- Does it describe (briefly) the methods used and how the data was collected?
- Does it summarize the results of the experiment?
- Does it summarize your conclusions from the experiment?
  - Is it 250 words or less?
  - Is it free from literature citations?

Writing skills

- Does the summary reflect a logical structure of presenting the information required?
- Does the summary reflect use of judgment on what information is and isn’t necessary in the paragraph?
- Does the summary economize words, where possible?

Introduction:

Structure

- Does it introduce your study organism (genus & species name, italicized, with only the first letter of the genus name capitalized)?
- Does it introduce the question or problem you wanted to explore?
- Does it provide specific PREDICTIONS with a clear and reasonable explanation of the RATIONALE behind each prediction?
- Does the Introduction use a MINIMUM of 2 journal articles?
  - Are any sources clearly integrated into the paper in a way that shows their direct relevance to what YOU did?
  - Are any sources cited using the (name, year) format?

Writing skills

- Does the introduction begin by introducing broad concepts and funnel into the objectives of the experiment?
- Does the introduction use sources to help summarize what is and isn’t known about the topic?
- Are the sources summarized in your own words and not directly quoted from the journal?
- Is the Introduction concise?

Methods:

Structure

- Are the methods written in paragraph format (not like a recipe or a list of instructions)?
Do you omit basic lab technique descriptions and descriptions of conventional lab equipment?

Do your methods include a description of the data collection, calculations, and graphing methods that you used?
  - Have you been careful to keep all events in the correct sequence?
  - Did you cite the lab manual as the main source of the lab protocol?
  - Are any additional sources cited using the (name, year) format?
  - If abbreviations are used, did you define them the first time you used them?

Writing skills

- Do the methods have the appropriate level of detail, given a knowledgeable audience?
- Are the methods clear, concise, and complete?

Results:

Structure

- Did you describe important trends in the data, and identify key points the reader should note in the graphs?
- Is your results section FREE of data interpretation, providing an objective description of what happened, without any explanation of WHY it happened that way?
- Did you make sure that no methods (including calculations) are described or introduced in this section?
- Are specific raw data presented in graphs, and NOT as lists of numbers in the text of the results section?
  - Does the text of the results section include references to Figures or Tables?

Writing skills

- Did the author highlight the results that directly respond to the objectives stated in the Introduction?
- Did the author use the figures/tables as lines of evidence that highlight the trends described?
- Did the author avoid redundancies when describing the data/key points?

Figures:

Structure

- Are your figures clear and understandable?
- Are figure captions complete, providing a thorough and objective description of patterns and key points in the data?
- Did you make sure that your figure captions do NOT include any interpretation of why the data came out as they did?
- Are your axes correctly labeled, with units where appropriate?
  - Is the independent variable on the x-axis and the dependent variable on the y-axis?
  - Are the figures at the end of the document (before Lit Cited) and not embedded into the Results section?

Writing skills

- Did the author avoid putting the same data in both a table and a figure?
- Did the author choose the method of summarizing the data (table or figure) according to the principles outlined in Knisely?
- Do the figure captions help direct the reader to the points highlighted in the results section?

Literature Cited:

- Did you cite the lab manual as the source of the lab procedures you used?
- Did you properly cite the journal article(s) you used?
Overall/General—These are not part of the points earned for the paper. However, they can detract or add to your paper through awarding a + or -. If the errors are particularly bad, your grade can be affected by a letter grade.

- Did you carefully proof-read your paper, in addition to spell-checking and grammar-checking it?
- Did you maintain the use of PAST tense throughout the paper?
- Do the voice and person remain constant throughout the paper (first person, active voice is best)?
- Did you make sure to define all the abbreviations you used, and to explain or describe each new term, procedure, or device when you mentioned it for the first time?
- Is your paper double-spaced?
- Did you provide the names of your lab partners?
Minireport 4 preparation

Lab Prompt Questions

Figures:

1. What type of graphic is most appropriate to summarize these data?
2. Do I know how to make this type of graphic in excel/word?
3. What can I do to improve the clarity of this graphic?
4. What is the take home message of this graphic?

Results:

1. What results are important to summarize with words only?
2. How do I use the figure to help me explain the pattern/trend in my data?
3. Is sharing observation useful here?

Discussion:

1. Have I summarized the main findings from the results? (should also be what your figures summarize)
2. What do I know about the topic I’m testing from the literature?
3. What does the literature imply should have happened, based on similar studies?
4. What am I going to say about the variability/uncertainty in my data?
5. How do my data address the initial hypothesis?
Minireport 4, Peer evaluation and self-reflection forms

RUBRIC EXPECTATION FOR Figures:

Structure

- Are your figures clear and understandable?
- Are figure captions complete, providing a thorough and objective description of patterns and key points in the data?
- Did you make sure that your figure captions do NOT include any interpretation of why the data came out as they did?
- Are your axes correctly labeled, with units where appropriate?
  - Is the independent variable on the x-axis and the dependent variable on the y-axis?
  - Are the figures at the end of the document (before Lit Cited) and not embedded into the Results section?

Writing skills

- Did the author avoid putting the same data in both a table and a figure?
- Did the author choose the method of summarizing the data (table or figure) according to the principles outlined in Knisely?
- Do the figure captions help direct the reader to the points highlighted in the results section?

PEER EVALUATION FOR Figures:

1. What is the main message from each Figure/Table? Write one sentence summarizing each Figure or Table.
2. What makes each Figure or Table successful? Consider how well each Figure/Table addresses the points outlined in the rubric in your response.
3. Is improvement needed on any Figure or Table? What do you suggest? Consider how well each Figure/Table addresses the points outlined in the rubric in your response.

RUBRIC EXPECTATIONS FOR Results:

Structure

- Did you describe important trends in the data, and identify key points the reader should note in the graphs?
- Is your results section FREE of data interpretation, providing an objective description of what happened, without any explanation of WHY it happened that way?
- Did you make sure that no methods (including calculations) are described or introduced in this section?
- Are specific raw data presented in graphs, and NOT as lists of numbers in the text of the results section?
  - Does the text of the results section include references to Figures or Tables?

Writing skills

- Did the author highlight the results that directly respond to the objectives stated in the Introduction?
- Did the author use the figures/tables as lines of evidence that highlight the trends described?
- Did the author avoid redundancies when describing the data/key points?

PEER EVALUATION FOR Results:

1. Comment on the overall flow and structure of this section. What is successful and what about the section needs improvement?
2. Comment on the content and clarity of this section. Is what is reported in this section appropriate? Does this section make sense? What is successful and what about the section needs improvement?
3. Based on the expectations outlined in the rubric, evaluate how well this section meets the objectives. What is successful and what needs to be improved?
4. Are there any technical issues that need to be addressed? This includes: grammar and punctuation, sentence structure, appropriate use of technical language and detail.

RUBRIC EXPECTATIONS FOR Discussion:

Structure

- Did you provide a very brief review of the results?
- Do you tie use results as evidence for your conclusions?
- Do you connect your results to the existing body of scientific knowledge?
  - Are any sources cited using the (name, year) format?

Writing Skills

- Are the results of the different parts of your experiment discussed in separate paragraphs?
- Does your Discussion section revisit each prediction, compare the data to the predicted result, and provide a thorough discussion of WHY you believe the data came out the way they did?
- Are any sources clearly integrated into the paper in a way that shows their direct relevance to what YOU did (not just “stuck in”)?

PEER EVALUATION FOR Discussion:

1. Comment on the overall flow and structure of this section. What is successful and what about the section needs improvement?
2. Comment on the content and clarity of this section. Is what is reported in this section appropriate? Does this section make sense? What is successful and what about the section needs improvement?
3. Based on the expectations outlined in the rubric, evaluate how well this section meets the objectives. What is successful and what needs to be improved?
4. Are there any technical issues that need to be addressed? This includes: grammar and punctuation, sentence structure, appropriate use of technical language and detail, AND USE OF REFERENCES.
After reviewing another person’s interpretation of your paper, please answer the following questions:

1. List three aspects of your paper that your reviewer identified as being successfully completed.
2. List three aspects of your paper that your reviewer identified as needing revision. Also, address how you will go about revising these aspects.
3. Is there any part of writing these sections that you felt ill-equipped to complete? If yes, what did you struggle with?
4. Did you find the prompt questions presented in lab useful or not useful in writing these three sections?
Minireport 4—Elizabeth Middleton

- Defines a part of the section that is a minimum requirement for a letter grade C.
  - Defines a part of the section, that if you do some but not all of the things listed, you will get a B. If you do all of the things listed, you will get an A.

Title:

- Does it capture the main idea of your project?
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Summary:

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- Does it introduce the experiment, giving the purpose and scope?
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Structure

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- Are any additional sources cited using the (name, year) format?
- If abbreviations are used, did you define them the first time you used them?

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- Do the methods have the appropriate level of detail, given a knowledgeable audience?
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Structure
- Did you describe important trends in the data, and identify key points the reader should note in the graphs?
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  - Does the text of the results section include references to Figures or Tables?

Writing skills
- Did the author highlight the results that directly respond to the objectives stated in the Introduction?
- Did the author use the figures/tables as lines of evidence that highlight the trends described?
- Did the author avoid redundancies when describing the data/key points?

Discussion:
Structure
- Did you provide a very brief review of the results?
- Do you tie use results as evidence for your conclusions?
- Do you connect your results to the existing body of scientific knowledge?
  - Are any sources cited using the (name, year) format?

Writing Skills
- Are the results of the different parts of your experiment discussed in separate paragraphs?
- Does your Discussion section revisit each prediction, compare the data to the predicted result, and provide a thorough discussion of WHY you believe the data came out the way they did?
- Are any sources clearly integrated into the paper in a way that shows their direct relevance to what YOU did (not just “stuck in”)?

Figures:
Structure
- Are your figures clear and understandable?
- Are figure captions complete, providing a thorough and objective description of patterns and key points in the data?
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Are your axes correctly labeled, with units where appropriate?
  o Is the independent variable on the x-axis and the dependent variable on the y-axis?
  o Are the figures at the end of the document (before Lit Cited) and not embedded into the Results section?

Writing skills

  • Did the author avoid putting the same data in both a table and a figure?
  • Did the author choose the method of summarizing the data (table or figure) according to the principles outlined in Knisely?
  • Do the figure captions help direct the reader to the points highlighted in the results section?

Literature Cited:

  o Did you cite the lab manual as the source of the lab procedures you used?
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  o Did you maintain the use of PAST tense throughout the paper?
  o Do the voice and person remain constant throughout the paper (first person, active voice is best)?
  o Did you make sure to define all the abbreviations you used, and to explain or describe each new term, procedure, or device when you mentioned it for the first time?
  o Is your paper double-spaced?
  o Did you provide the names of your lab partners?
Independent Project Peer-evaluation: The purpose of this exercise is to have another critical thinker evaluate the structure of your paper. Please be constructive and honest.

Paper author name__________________________________________

Paper reviewer name________________________________________

STEP 1: Figure evaluation

1. What is the main message from each Figure/Table? Write one sentence summarizing each Figure or Table.

From the Rubric

Structure

- Are your figures clear and understandable?
- Are figure captions complete, providing a thorough and objective description of patterns and key points in the data?
- Did you make sure that your figure captions do NOT include any interpretation of why the data came out as they did?
- Are your axes correctly labeled, with units where appropriate?
  - Is the independent variable on the x-axis and the dependent variable on the y-axis?
  - Are the figures at the end of the document (before Lit Cited) and not embedded into the Results section?

Writing skills

- Did the author avoid putting the same data in both a table and a figure?
- Did the author choose the method of summarizing the data (table or figure) according to the principles outlined in Knisely?
- Do the figure captions help direct the reader to the points highlighted in the results section?

2. According to the rubric expectations, what makes these Figures/Tables successful? You may circle which points are best achieved, then write WHY the Figure meets that rubric point below.

3. According to the rubric expectations, is any improvement needed on a Figure or Table? You may star (*) any point that needs to be better addressed on the rubric. Below, give the author two suggestions for improvement.
STEP 2: EVALUATING THE CONCLUSIONS (Rule 1, How to write backwards)

1. For each conclusion the author presented, address its’ clarity. Does each conclusion make sense? Why/Why not?

2. Return to your summary of the figures/tables. Does your summary of the trends seem to fit the author’s conclusions? Why/Why not? Do the author’s conclusions follow logically from the figures he/she presented? Why/Why not?

3. Do you have any suggestions for improvement in this section?
STEP 3: EVALUATING THE RESULTS (Rule 2, H.T.W.B.)

1. Do the results support the conclusions? Evaluate whether the results are logically connected to the conclusions.

FROM THE RUBRIC:

**Structure**
- Did you describe important trends in the data, and identify key points the reader should note in the graphs?
- Is your results section FREE of data interpretation, providing an objective description of what happened, without any explanation of WHY it happened that way?
- Did you make sure that no methods (including calculations) are described or introduced in this section?
- Are specific raw data presented in graphs, and NOT as lists of numbers in the text of the results section?
  o Does the text of the results section include references to Figures or Tables?

**Writing skills**
- Did the author highlight the results that directly respond to the objectives stated in the Introduction?
- Did the author use the figures/tables as lines of evidence that highlight the trends described?
- Did the author avoid redundancies when describing the data/key points?

2. Do the results describe the trends that you identified in the author’s figures?

3. What are two suggestions for improvement for the summary of the results, based on the rubric?
STEP 3: EVALUATING METHODS (RULE 3 H.T.W.B.)

1. Is it clear how the data from the results were collected according to the methods? Why/Why not?

FROM THE RUBRIC:

Methods:

Structure

- Are the methods written in paragraph format (not like a recipe or a list of instructions)?
- Do you omit basic lab technique descriptions and descriptions of conventional lab equipment?
- Do your methods include a description of the data collection, calculations, and graphing methods that you used?
  - Have you been careful to keep all events in the correct sequence?
  - Did you cite the lab manual as the main source of the lab protocol?
  - Are any additional sources cited using the (name, year) format?
  - If abbreviations are used, did you define them the first time you used them?

Writing skills

- Do the methods have the appropriate level of detail, given a knowledgeable audience?
- Are the methods clear, concise, and complete?

2. What are two suggestions for improvement for the Methods section based on the rubric?

STEP 4: EVALUATING THE DISCUSSION (Rule 4 H.T.W.B)

1. What support does the author present that, “modifies, confirms, extends, or contradicts” his or her conclusions?
**STEP 4 (continued)**

2. Does the support make sense? Why/Why not?

3. What two suggestions do you have for the author to improve his/her use of support in the discussion? Consider the use of the literature as support (effective or not) and whether the conclusions need more clarification or elaboration.

**STEP 5: EVALUATING THE INTRO (RULE 5 H.T.W.B)**

1. What are the questions the introduction needs to pose in order for the conclusions to be answers? Write these from your perspective.

2. How do your questions match the questions the author poses in the Introduction?
3. What two suggestions do you have for the author to improve or continue developing his/her introduction?

STEP 5: EVALUATE THE BIOLOGICAL PERSPECTIVE

1. Given the rest of the author’s document, does his/her biological perspective or big question seem to fit with the message of the paper? Why/Why not?

2. What did you see as the appropriate biological perspective/concept/big question that this paper addressed?

TO BE FILLED OUT BY THE AUTHOR:
List four aspects of your paper that you are going to focus on improving for the final draft:
Independent Project Rubric—Elizabeth Middleton

- Defines a part of the section that is a minimum requirement for a letter grade C.
- Defines a part of the section, that if you do some but not all of the things listed, you will get a B. If you do all of the things listed, you will get an A.

NOTE: A minimum of 3 Journal articles are required for this paper. It is up to you to decide how to use and distribute them throughout your paper.

Title:
- Does it capture the main idea of your project?
- Is it brief but complete?

Summary:

Structure
- Does it introduce the experiment, giving the purpose and scope?
- Does it state your hypothesis(-ses)?
- Does it describe (briefly) the methods used and how the data was collected?
- Does it summarize the results of the experiment?
- Does it summarize your conclusions from the experiment?
  - Is it 250 words or less?
  - Is it free from literature citations?

Writing skills
- Does the summary reflect a logical structure of presenting the information required?
- Does the summary reflect use of judgment on what information is and isn’t necessary in the paragraph?
- Does the summary economize words, where possible?

Introduction:

Structure
- Does it introduce your study organism (genus & species name, italicized, with only the first letter of the genus name capitalized)?
- Does it introduce the question or problem you wanted to explore?
- Does it provide specific PREDICTIONS with a clear and reasonable explanation of the RATIONALE behind each prediction?
  - Are any sources clearly integrated into the paper in a way that shows their direct relevance to what YOU did?
  - Are any sources cited using the (name, year) format?

Writing skills
- Does the introduction begin by introducing broad concepts and funnel into the objectives of the experiment?
- Does the introduction use sources to help summarize what is and isn’t known about the topic?
- Are the sources summarized in your own words and not directly quoted from the journal?
- Is the Introduction concise?

Methods:
Structure

- Are the methods written in paragraph format (not like a recipe or a list of instructions)?
- Do you omit basic lab technique descriptions and descriptions of conventional lab equipment?
- Do your methods include a description of the data collection, calculations, and graphing methods that you used?
  - Have you been careful to keep all events in the correct sequence?
  - Did you cite the lab manual as the main source of the lab protocol?
  - Are any additional sources cited using the (name, year) format?
  - If abbreviations are used, did you define them the first time you used them?

Writing skills

- Do the methods have the appropriate level of detail, given a knowledgeable audience?
- Are the methods clear, concise, and complete?

Results:

Structure

- Did you describe important trends in the data, and identify key points the reader should note in the graphs?
- Is your results section FREE of data interpretation, providing an objective description of what happened, without any explanation of WHY it happened that way?
- Did you make sure that no methods (including calculations) are described or introduced in this section?
- Are specific raw data presented in graphs, and NOT as lists of numbers in the text of the results section?
  - Does the text of the results section include references to Figures or Tables?

Writing skills

- Did the author highlight the results that directly respond to the objectives stated in the Introduction?
- Did the author use the figures/tables as lines of evidence that highlight the trends described?
- Did the author avoid redundancies when describing the data/key points?

Discussion:

Structure

- Did you provide a very brief review of the results?
- Do you tie use results as evidence for your conclusions?
- Do you connect your results to the existing body of scientific knowledge?
  - Are any sources cited using the (name, year) format?

Writing Skills

- Are the results of the different parts of your experiment discussed in separate paragraphs?
- Does your Discussion section revisit each prediction, compare the data to the predicted result, and provide a thorough discussion of WHY you believe the data came out the way they did?
- Are any sources clearly integrated into the paper in a way that shows their direct relevance to what YOU did (not just “stuck in”)?

Figures:

Structure

- Are your figures clear and understandable?
➢ Are figure captions complete, providing a thorough and objective description of patterns and key points in the data?
➢ Did you make sure that your figure captions do NOT include any interpretation of why the data came out as they did?
➢ Are your axes correctly labeled, with units where appropriate?
  o Is the independent variable on the x-axis and the dependent variable on the y-axis?
  o Are the figures at the end of the document (before Lit Cited) and not embedded into the Results section?

Writing skills

- Did the author avoid putting the same data in both a table and a figure?
- Did the author choose the method of summarizing the data (table or figure) according to the principles outlined in Knisely?
- Do the figure captions help direct the reader to the points highlighted in the results section?

Literature Cited:

- Did you cite the lab manual as the source of the lab procedures you used?
- Did you properly cite the journal article(s) you used?

Overall/General—These are not part of the points earned for the paper. However, they can detract or add to your paper through awarding a + or -. If the errors are particularly bad, your grade can be affected by a letter grade.

- Did you carefully proof-read your paper, in addition to spell-checking and grammar-checking it?
- Did you maintain the use of PAST tense throughout the paper?
- Do the voice and person remain constant throughout the paper (first person, active voice is best)?
- Did you make sure to define all the abbreviations you used, and to explain or describe each new term, procedure, or device when you mentioned it for the first time?
- Is your paper double-spaced?
- Did you provide the names of your lab partners?