Investigating the effectiveness of the Science Seeker learning unit in improving students' ability to read scientific journal articles

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Teaching Philosophy

My overall teaching goals are to foster my students' ability to teach and learn through collaboration while also emphasizing their personal responsibility to learn the techniques and content presented in the class. In a large lecture format, I use think-pair-share activities multiple times per lecture to prompt the students to process the information I've presented and draw connections between different concepts I've discussed. In a smaller lab-discussion format, I have students work on case study worksheets in small groups, applying the information they've learned to a scenario or complex word problem. In both situations, the students are aware that they will be called on to complete similar exercises on in-class quizzes and exams, which discourages them from becoming dependent on their colleagues for answers.

I joined the Teagle Collegium for Inquiry in Action at Indiana University for the 2009-2010 school year to learn different techniques for engaging students and assessing their progress. This group gave me a better understanding of learning theory and the vocabulary used in education literature. It also taught me to use some very useful techniques to improve the effectiveness of my teaching. One of the most useful lessons involved setting semester goals, unit goals, and lesson goals. By writing out these goals before writing my lesson plans, I'm able to both connect the different class sessions to a few overarching goals and assess whether potential activities are the most efficient way to meet the goals. Writing my teaching goals out beforehand also prompts me to make sure all assessments I write reflect those goals.

Abstract

During my previous two semesters teaching L113, I observed that, while the students were expected to be able to read a scientific journal article, understand it, and integrate it into their lab reports, their citations in their lab reports often indicated that they did not understand the article they were citing. I altered one assignment in the class, the library citation exercise, which asks the students to read and summarize a primary literature article. My goal was to introduce the students to the subject material gradually and to show the, how to read the article in a step-by-step fashion. To assess the impact of this altered exercise, I compared the lab reports of my students to those of two other sections in the course who completed the original exercise. All students in the three sections also completed a survey at the beginning of the course and after the completion of the first lab report requiring them to cite a primary literature article (the UV lab report). My results indicate that the altered exercise improves the students' ability to read and understand the

main points of a primary literature article, though it may not improve their ability to integrate the article into their lab reports.

Introduction

Course Overview

Introductory Biology Laboratory (L113) is a stand-alone laboratory course consisting of one 50-minute discussion and one 3-hour lab each week. It is taught in both the fall and spring semesters, with 16-17 sections and approximately 400 students each semester. Each section is taught by a graduate student Associate Instructor (AI), who is responsible for leading discussion, setting up and running the lab, and grading the assignments. The main assignments, such as the library citation exercise, are written by the lecturer (Dr. Hengeveld). These assignments are identical for every section and account for 27% of the class grade. The AI is responsible for writing worksheets and quizzes, which make up 15% of the final grade. The remainder of the class grade consists of lab reports (35%) and the independent project (23%). The class is organized by two professors from the Biology Department, who manage course details and write the lab manual, main assignments, and curriculum. The required textbooks for the course are the lab manual (Bonner et al. 2010) and *A Student Handbook for Writing in Biology* (Knisely 2009).

Course Goals

The stated goals of the course are to teach the students how to:

- do science (e.g., use the scientific method, use sterile technique to apply a bacterial culture to a Petri dish, and use a micropipette); and
- communicate science (e.g., they should be able to read and understand what other scientists have done, and write what they have done in lab using the format and language of the discipline).

Student Demographics

The majority of the students are pre-med or pre-dental and take the course in their freshman or sophomore year. While there are no enforced prerequisites, the students are expected to take the lecture course Biological Mechanisms (L112) prior to or concurrent with L113.

Teaching Challenges

One of the main challenges in teaching this course is the very wide range of backgrounds within one group of students. Some students have already taken a university-level lab course in chemistry or psychology, while other have not. Additionally, many of the students have already taken L111 (Evolution and Ecology) and L112, giving them a solid grounding in L113 course material, while a few students have not taken any biology classes since high school. During a previous semester, to address the issue of teaching a group of students with very different levels of preparation for the course, I utilized the concept of collaborative learning. Instead of giving the students worksheets as homework and then going over the answers at the beginning of class, I had the students complete the worksheets in small groups. This technique caused the students with a better background to teach their group members how to answer the questions. Meanwhile, I was able to walk around the classroom and help groups that had difficulty.

This brought the students with a poor background up to speed with the rest of the class without letting the minority of particularly fast students get bored. I continued to use this technique during the Spring semester of 2010, improving it with the use of case studies.

A second challenge involves teaching the students how to read and write in the language and format of our discipline. This class is generally the first time the students are expected to search for, read, and understand articles from biology journals. Library Day is a discussion period held in the library, during which a librarian teaches the students how to search for journal articles using Web of Science; however, there is no established assignment that teaches the students where to look in an article to obtain the important information. When asked to summarize a journal article, the students commonly base their information on the title and abstract, using phrases from the paper they do not fully understand. The students also have difficulty learning how to write lab reports for this class. While they may have written essays in English class or lab reports in Chemistry class, neither of these disciplines uses the particular format of Biology lab reports, which strongly favors brevity. The students therefore enter the class assuming they know how to write lab reports, only to get frustrated if they fail to read the rubric and textbook carefully.

Library Citation Exercise

Background

The library citation exercise (see Appendix) is an assignment worth 5% of the course grade and is given to all sections of the course after the students have been taught to use the Web of Science search engine. The assignment asks them to find a paper that discusses one of two questions on ultraviolet (UV) light and mutagenesis. Once the students have completed the assignment, they are allowed to leave. The students are then expected to use the techniques developed in this class to find appropriate articles to cite in their UV Mutagenesis Lab Report, Animal Behavior Lab Report, and Independent Project Lab Report.

During the past two semesters that I have taught this course, students have shown a poor understanding of the articles they cite (i.e., poor comprehension) and have not connected the information in the article to the methods and results discussed in their lab report (i.e., poor integration). After considering various possible reasons for this bottleneck, I hypothesized that the poor comprehension and poor integration both resulted from the students' inability to understand the article they were trying to cite. I further hypothesized that this inability to understand was likely due to one of the following two scenarios:

1. The students are not able to understand the article because they had not been given more basic information about the subject before trying to read the primary literature. This hypothesis is based on the Behaviorism theory of learning (Gagne 1985), which argues that learning is hierarchical and that students must be given information in the correct order (from basic to complex) to be able to process the information correctly.
2. The students are not able to understand the article because no lesson or assignment has taught them how to read a primary literature article in biology.

For example, they may not know which pieces of information are the most important (e.g. hypothesis, results, and conclusions) or where in the paper these pieces of information can be found. This hypothesis was based on chapter 2 of *How People Learn* (Bransford et al. 2000), which suggest that novices, unlike experts in the field, must be *shown* how to find the important information or patterns in a larger whole.

Altering the Library Citation Exercise

Since the Library citation exercise is worth the same number of points as the first lab report (each are 5% of the final course grade), I decided to increase the amount of work expected from the students so that the two assignments were more comparable. I expanded the Library citation exercise into three assignments: Website Activity, Encyclopedia Activity, and Primary Literature Activity (see Appendix for examples). For each activity, the students were asked to find a source that answered the question "Does UV light or radiation affect mutagenesis?" The two goals of this change were to:

1. address hypothesis 1 by having the students first read information on UV light and mutations from a web page, which would use a layperson's vocabulary, then an encyclopedia before being asked to read a primary literature article. By introducing them to the subject matter gradually, I hoped they would have a better grasp of the subject matter and find it easier to understand the primary literature article.
2. address hypothesis 2 by changing the assignment associated with the primary literature article. Instead of asking the students to summarize the paper on their own, I wrote a 2-page worksheet that asked them to find each piece of important information in the paper (e.g. the main question, the hypothesis, the results, the conclusions). By showing them which pieces of information were important, I hoped to improve their ability to read primary literature articles on their own. I also wanted to introduce them to the concept of critiquing primary literature by asking them to determine whether the results answered the question the scientists wanted to ask.

To determine whether these changes improved the students' ability to understand primary literature and integrate it into their lab reports, I collected the lab reports from my class and two other sections of the same class. These two control groups used the original Library citation exercise. I then assessed whether each citation was well integrated into the paper and whether the article's contents matched the student's summary of the paper. The integration and comprehension were each scored on a scale from 1 ("poor") to 3 ("good"). Examples of each level of integration are shown in the Appendix.

Additionally, all three classes were given surveys in the first week of class to determine the students' ability to read and understand material from a primary literature article and the students' confidence level in their answers. The same surveys were given a week after the UV lab report was turned in to determine whether the new activities resulted in a more significant change compared to the original Library citation exercise. In the second survey, the experimental group was also asked which of the three assignments they felt helped them the most.

Results

Many of the students in the experimental group misunderstood the Website Activity and found primary literature articles online that they used for the assignment. Therefore, the results are not likely due to the effects of the Website Activity.

As shown in **Figure 1**, the altered Library citation exercise improved the student's comprehension of the articles they cited in their lab report papers. Since several of the students received a "good" score for their comprehension level due to their summary of the article being very vague, it is more accurate to compare the number of students in the different groups with poor comprehension. The percent of students receiving a "poor" rating in the experimental group was 10%, far less than the control groups, indicating that the level of comprehension in the experimental group was higher.

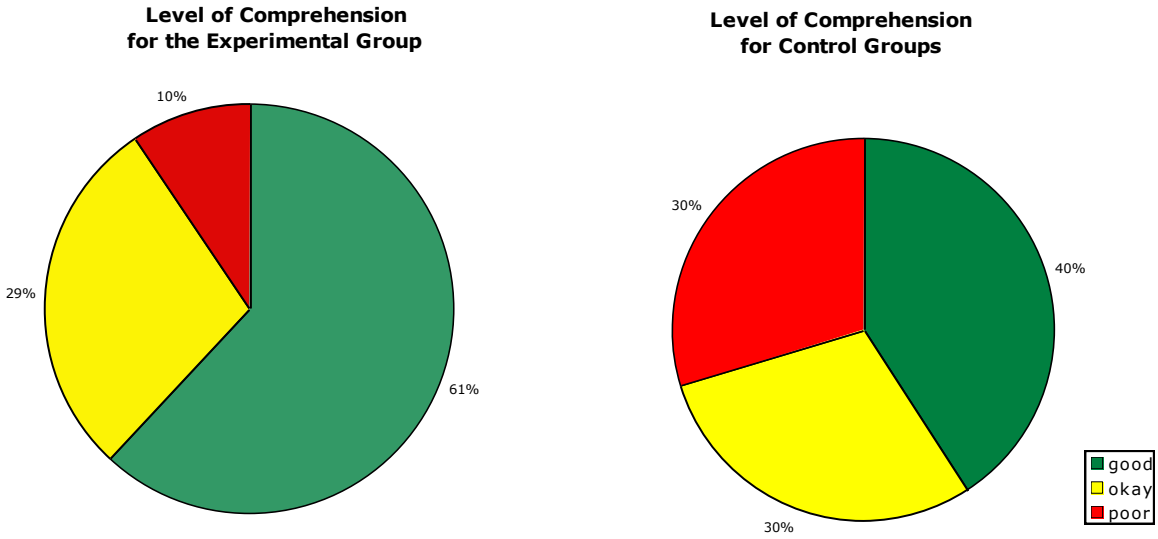

Figure 1. The students in the experimental group summarized their primary literature articles in their lab reports more accurately than the students in the control groups.

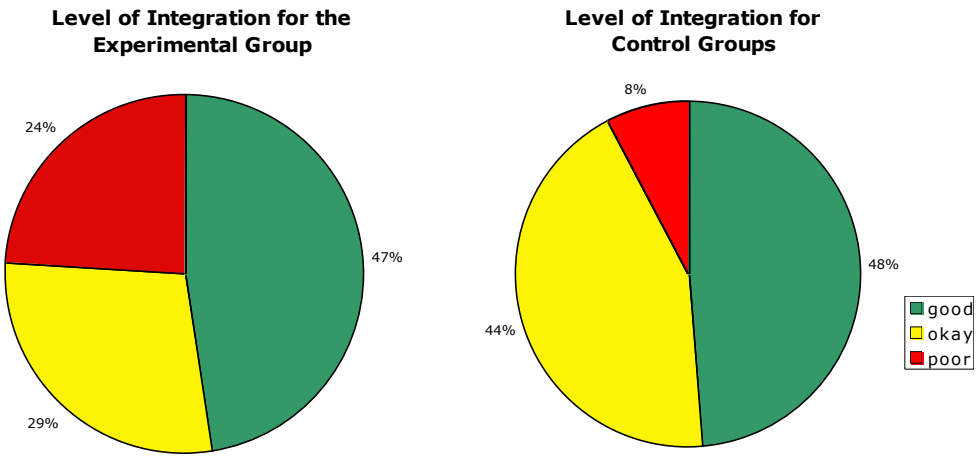

Figure 2. The experimental group did not have better integration than the control groups (experimental n = 22, total control groups n = 26).

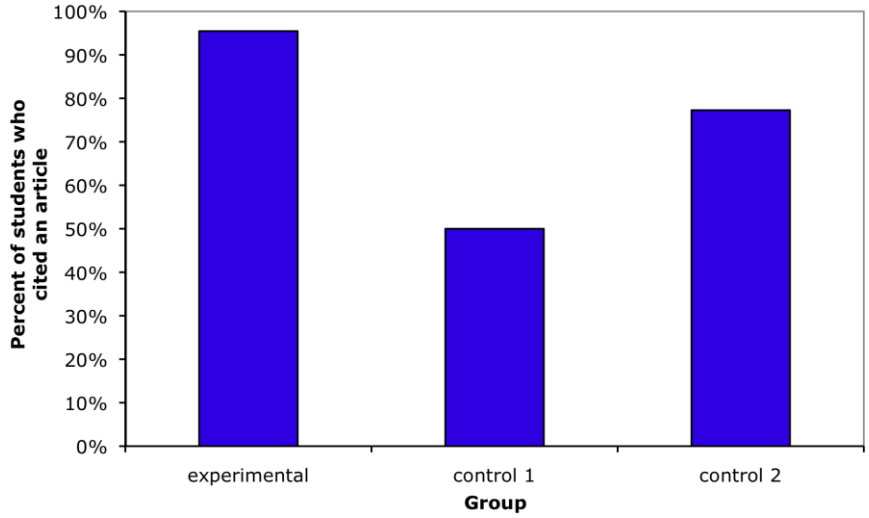

Figure 3. All sections were required to cite a primary literature article for the lab report, but more students in the experimental group cited a primary literature article than in the control groups.

As shown in **Figure 2**, the altered assignment did not appear to improve the students' ability to integrate an article into their lab reports; the surprising number of students in the control groups who failed to cite any article may explain the apparent difference in the quality of integration between the groups. Only 65% of the students in the two control groups actually cited a primary literature article in their lab reports, even though this was a requirement for all sections (**Figure 3**). The difference in sample sizes for **Figures 1** and **2** therefore mask important differences between the groups. The

experimental group should have 22 students and the combined control groups should have 40 students. Instead, the experimental group has 21 students and the control groups have 26 students. If one assumes that the students who failed to cite an article would have done poorly in comprehension and integration, the experimental group's results do not appreciably change (i.e., 14% of students scoring poorly in comprehension and 27% scoring poorly in integration). On the other hand, this adjustment substantially alters the results for the control groups, with 54% of the students scoring poorly in comprehension and 32% scoring poorly in integration.

While these results cannot conclusively show whether the students' inability to integrate the primary literature article was due to their inability to understand the article, it does show that the altered Library citation exercise improved the student's ability to understand a primary literature article.

Survey Results and Student Feedback

I compared the results from question 9 in the pre-survey (**Appendix F**) and question 7 in the post-survey (**Appendix G**), which were identical questions testing whether the students were able to accurately read and interpret a figure from a primary literature article. Preliminary results comparing the experimental group with one of the control groups indicate that the control group's ability to deduce the study's main question, treatments, and results improved. The experimental group scored better on the pre-survey than the control group. The experimental group improved moderately in sub-questions A (**Figure 4**) and B (**Figure 5**), but its score decreased for sub-questions C (**Figure 6**) and D (**Figure 7**).

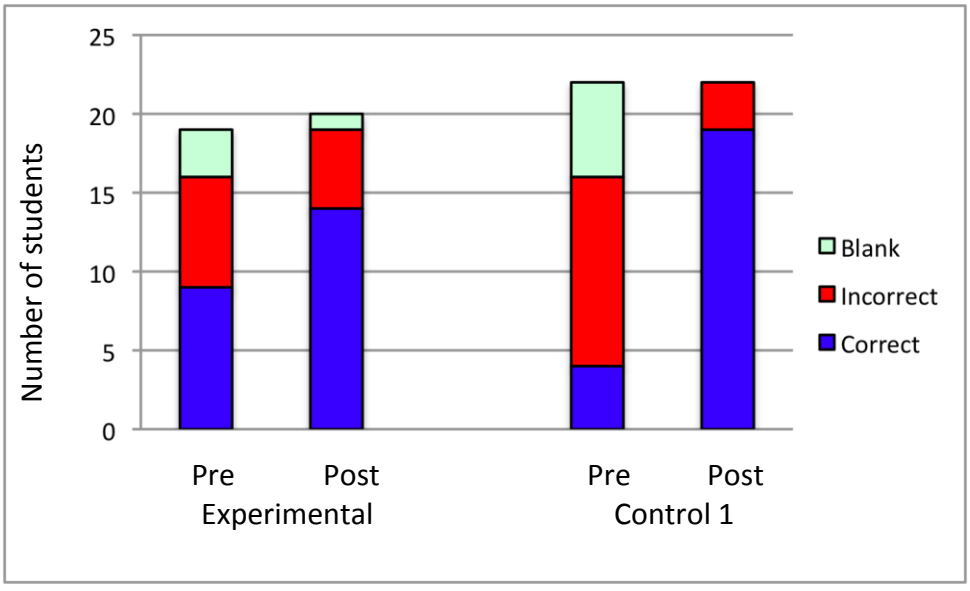

Figure 4. The results of question 9A in the pre-survey and 7A in the post-survey, which asked the students to write the question answered by the figure provided in the survey.

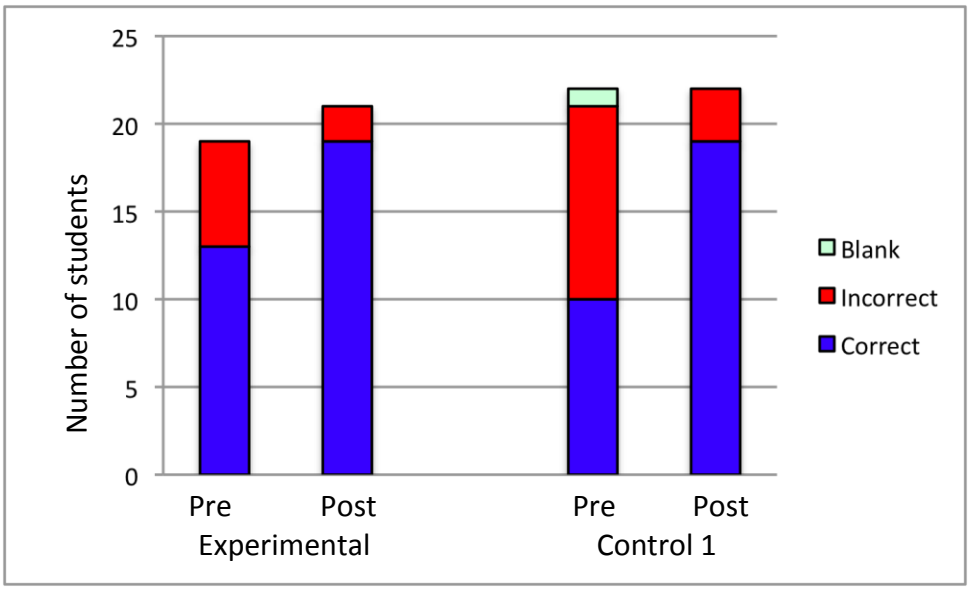

Figure 5. The results of question 9B in the pre-survey and 7B in the post-survey, which asked the students to identify the correct control group from a list of options.

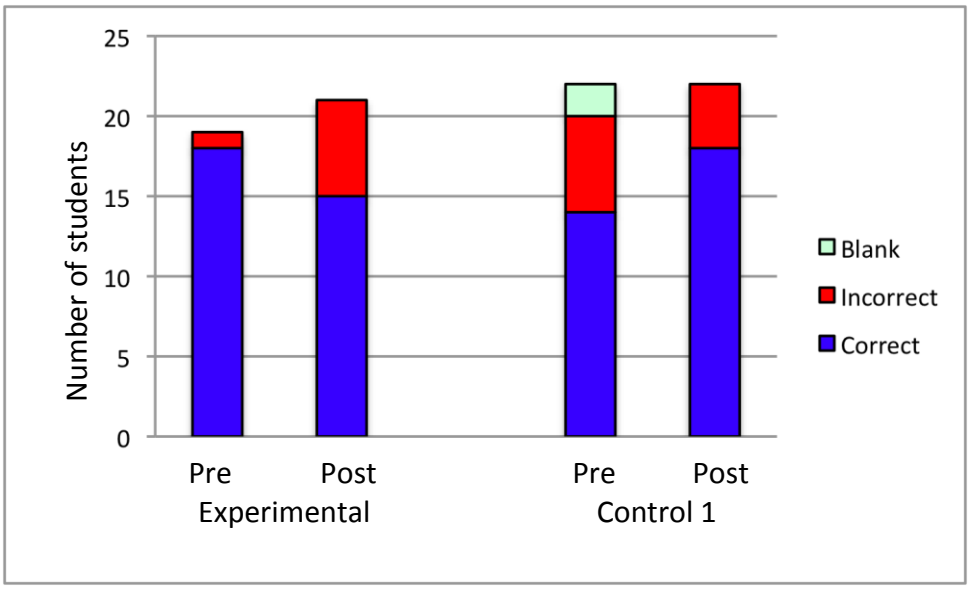

Figure 6. The results of question 9C in the pre-survey and 7C in the post-survey, which asked the students to identify which treatment was used in the experiment.

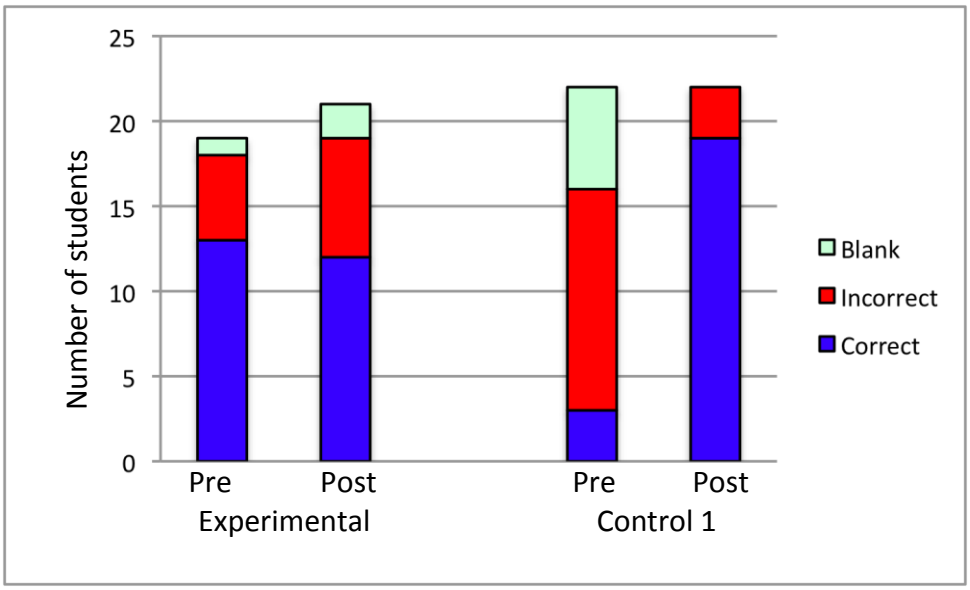

Figure 7. The results of question 9D in the pre-survey and 7D in the post-survey, which asked the students to identify the appropriate conclusion based on the results shown in the figure provided.

Based on these results, it can be concluded that, even though the Primary Literature Worksheet placed more emphasis on learning to interpret figures from primary literature articles than the original Library citation exercise did, the altered assignment did not significantly improve the students' ability to interpret these figures.

The post-survey for the experimental group asked the students to rate how helpful the new Library citation exercise was for writing their UV lab report. As shown in **Figure 8**, most of the students found the exercise moderately helpful (the median rating was 3).

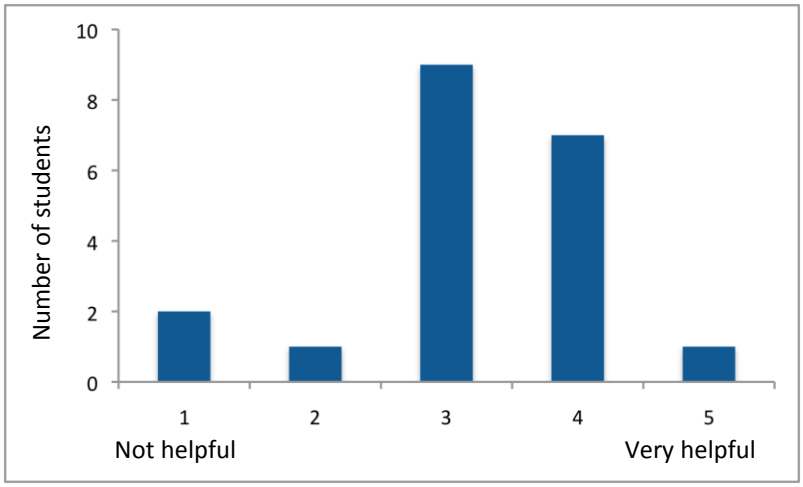

Figure 8. The students rated the altered Library citation exercise on a one-to-five scale. The median of the ratings was 3, indicating that the students found the exercise moderately helpful.

At the end of the survey, the students were asked to indicate what part of the new exercise they found helpful and what changes they would recommend to make the exercise more helpful. Sixteen students wrote aspects of the exercise that were helpful, including:

- "It was very helpful finding a primary article."
- "It helped me narrow down information to find the most accurate information."
- "It was easy to understand."
- "looking for sources"
- "I liked the databases that allowed you to search for more than 1 item."

Three students included suggestions for improving the exercise. Their suggestions focused on including more websites and search engines in the Library Day lecture.

Suggested Changes to L113

Based on the results of this study, I suggest the following changes to the L113 curriculum:

- **Use the Primary Literature Worksheet in place of the Library Citation Exercise.** This worksheet improves the student's ability to understand the article they find during Library Day and increases the probability of their citing it in their lab report. Based on the responses I received during Library Day, when the students were working on the worksheet, and on the answers they provided, I would make some changes in spacing and wording before using the worksheet again.
- **Use a version of the Encyclopedia Activity prior to Library Day to introduce the students to the material before they read a primary literature article.** Since this study used both the Encyclopedia Activity and the Primary Literature Worksheet, it is not possible to determine which of these activities was responsible for the improvement in student comprehension. A future study testing each of these activities separately and together would help determine whether both are needed to achieve the results found in this study. It would also test the relative importance of the Behaviorism and Information Processing learning theories in this unit of the class.
- **Write a tutorial or resource guide describing the various resources the Life Sciences Library website has to offer and the appropriate time to use each resource.** The students indicated a desire to learn more about these resources, but there is not enough time in one class session to cover all of this material. Therefore, it may be most efficient to create an online resource guide or tutorial. The students can be directed there at the end of the Library Day lecture and from the L113 class website.
- **Bring in paper forms of an encyclopedia and a scientific journal for the students to see.** Some of the confusion the students had when trying to distinguish journal articles from encyclopedia articles and websites could have been due to the fact that they are viewing all of these sources on the internet. Using hardcopy forms of the journal and encyclopedia could reinforce the explanation that these sources are more permanent than websites.

Works Cited

Bonner, Hengeveld, Holdeman, Ruf, and Rynkiewicz (2010) Laboratory Manual: Biology L113. Plymouth, MI: Hayden-McNeil LLC

Gagne, RM (1985) The conditions of learning and theory of instruction. New York : Holt, Rinehart and Winston

Knisely (2009) A Student Handbook for Writing in Biology, 3rd ed. New York, NY: W.H. Freeman and Co.

National Research Council. 2000. How people learn: brain, mind, experience and school (expanded ed.). Bransford, J.D., A.L Brown, and A. R. Cocking (Eds.). Washington, DC: National Academy Press.

Appendix A: Original Library Citation Exercies

Assignment: Find one article citation/abstract using Web of Science (WOS) or Biosis Previews that discusses one of the questions and corresponding hypotheses for the Yeast/UV Lab. Then locate the complete article from the citation and hand in a copy of the first page of the article to your AI. In one paragraph, indicate how the article is relevant to the Yeast/UV lab.

Due by the beginning of lab for Week 4 (i.e., Feb 1-4)

A copy of this assignment and tips for searching can be found at
http://www.libraries.iub.edu/index.php?pageId=6488

Description of Yeast/UV lab for WOS/Biosis Previews Search

During weeks 4-6 of L113, you will do an experiment involving the exposure of trp- yeast cells to short-wave ultraviolet (UV) irradiation. These yeast cells cannot grow on a medium lacking tryptophan (i.e. SD medium) due to a mutation at the trp1 allele, but they can grow on a medium that contains tryptophan (i.e. SC medium). After spreading a concentrated yeast solution onto 7 SD plates and a dilute yeast solution onto 7 SC plates, you then expose each set of plates to short-wave UV irradiation for an increasing length of time (0 seconds to 120 seconds). Two questions you should address, along with possible hypotheses, are:

Q1) Does short-wave UV irradiation, in fact, have (either direct or indirect) mutagenic effects?

H1) It seems reasonable to predict that short-wave UV irradiation does have mutagenic effects and that greater exposure will result in more mutations so there should be a pattern of more yeast colonies with greater exposure to short-wave UV irradiation.

Q2) Does short-wave UV irradiation affect more than just the nucleic acids within living cells?

H2) Yes, short-wave UV irradiation causes damage to the proteins in living cells. Increased exposure to short-wave UV irradiation will cause a decrease in survivorship of yeast cells.

Appendix A. This is the original Library Citation Exercise, normally assigned to all sections in L113, which was given to the control groups during this study. This assignment is valued at 20 points, the same number of points given to the first lab report. Previous years have indicated that, while this exercise may help the students learn to use the Web of Science search engine, it does not help them learn how to read the articles. The students then cite articles in their lab reports they don't understand and are unable to correctly summarize. Additionally, many students perceive the exercise as a "scavenger hunt" and spend more time looking for the one "right" paper than reading the papers they find.

Appendix B. Website Activity (example 1)

"Sunbeds, tanning and UV exposure"

Summary:

This article from the World Health Organization expresses the prominent effects from over exposure to ultraviolet radiation. UV radiation can be natural, from the sun, or artificial, from tanning beds. Though it is not a proven fact that an over exposure to tanning bed UV is more or less dangerous than an over exposure to sunlight UV; an increase use of tanning beds has accompanied an increase rate of skin cancer. It is hypothesized that tanning beds cause an increase risk of skin cancer because the UV radiation used in tanning beds cause significant damage to DNA. The damage in DNA then creates a mutation that then can turn into cancer. Different skin types react differently to UV radiation, so it is imperative that skin type is taken into consideration when using a tanning bed or sun bathing in the sun. The lighter the skin is the more likely the person is to burn instead of tan which causes more damage to the skin. Two other risk factors from UV exposure of any type are increased skin aging and permanent eye damage. Though rumored, tanning beds are rarely good for anybody, and is only considered a means of treatment when dealing with serious skin problems. Even then the amount of tanning bed exposure is regulated. Regulations have been proposed to reduce the harmful effects from tanning beds. Though research is still underway, it can easily be deduced that the amount of ultraviolet radiation a person is exposed to can increase the risk of skin cancer and other health factors.

http://www.who.int/mediacentre/factsheets/fs287/en/index.html

Explanation:

I believe this website is a good source for information. I got this website from a suggested website on the Evaluating Sources word document. The website I used was www.who.int. Also the article gives other sources for further information on the topic. At the bottom on the page is contact information to get in touch with the people that wrote the article. The only thing that this article doesn't do is site other sources in the text.

Appendix B. This is one student's Website Activity. This activity gave the students an initial, layperson's understanding of UV light and mutagenesis. It also enabled a discussion on which websites are good sources vs. bad sources and the difference between a journal article and a website.

Appendix C. Website Activity (example 2)

Summary

The particular article I chose describes how ultraviolet (B) light is harmful by causing certain mutations in the cells of carcinomas of the given subject, mice. Researchers working on the experiment discovered that mutations in the p53 gene in the squamous cells of mice occurred when the mice were exposed to high levels of ultraviolet light. One crucial effect of intense UV light included a much higher mutation frequency in the p53 gene among the tumors observed. The scientists working the experiment (including N. Dumaz, AJ Van Kranen, and PW Wester), discovered the exact codons at which the point mutation occurs, and also which codons were transcribed into the wrong corresponding codon. The mutant p53 cells in the mice are parallel to the p53 cells found in humans in that comparison between the two indicated that the mutated cells in human skin carcinomas were very similar to those found in the mice. Therefore, ultraviolet light has a major impact on mutations in skin cells and should be avoided to maintain healthy skin and most importantly avoid skin cancer.

Explanation

I strongly believe that the website I analyzed was a good source to use for several reasons. Foremost, the article is documented as from the Oxford Journals, a respected use for resources. It is also under the institution of the Indiana University library, making it a very credible source. The article also indicates that it is copyrighted and states the names of scientists involved in the experiment at the Laboratory of Molecular Genetics in France. Finally, the article cites references from which information was taken to build on research involved.

http://carcin.oxfordjournals.org/cgi/content/abstract/18/5/897

Appendix C. This is another Website Activity; however, this one cites a primary literature article as its "website." This shows the difficulty students have in separating different types of sources online. The students' confusion about the assignment prompted further discussion in class about the differences between different sources available online.

Appendix D. Encyclopedia Activity

Does UV light/ Radiation Have Mutagenic Effects?

The article starts by describing the effects of radiation on cells. Radiation causes gene mutation and breakage of chromosomes. In gene mutation it can cause a change in the base pair resulting in the actual change in DNA sequence. In cell division, small amounts of radiation delays cell division, if exposed to a large amount, the cell may cease to divide or die. However, if the goal is to kill a large group of cells, higher dose of radiation is required because the cell will not die immediately after being exposed.

The animal tissue that is most likely to affected is the skin, intestine, gonads, and blood forming organs (bone marrow and spleen), because they are the tissues that divide most often. The effects on skin can vary from a slight reddening to the more permanent thinning of skin, scarring of underlying connective tissue, and skin cancer. Radiation of accessory skin structures results in either permanent or temporary hair loss, depending on the amount of radiation injury. In the intestines, radiation causes: ulceration, intractable diarrhea, dehydration, and invasion of the bloodstream by bacteria that normally inhabit the lumen of the bowel. In growing bones, radiation causes problems in skeletal growth, but in mature bones, a large dose results in bone cancer. Radiation of the gonads results in the sperm and egg to be sterile.

Citations:

Arthur C. Upton, "Radiation injury (biology)", in AccessScience@McGraw-Hill, http://www.accessscience.com, DOI 10.1036/1097-8542.566900

Appendix D. This is an example of the Encyclopedia Activity. The students were taught how to use AccessScience and the Encyclopedia of Life Sciences on the Indiana University Library of Life Sciences website. Then they were asked to find an encyclopedia article that answered the question, "Does UV light/radiation have mutagenic effects?" They had to summarize the article, particularly the part that answered the question.

Appendix E: Primary Literature Activity

Name:

Primary Literature worksheet

Directions: Find a peer-reviewed primary literature article (not a review article) that answers the question, "Does UV light/radiation cause DNA mutagenesis?" Read the article and answer the questions below.

Primary paper citation (Name-Year format shown in Knisely pp 78-79):

What is the question that the authors are trying to address?

Describe their hypothesis.

Describe at least one experiment that they do to test this hypothesis. What is the logic of this experiment? (How will the experiment answer their question?)

Describe the type of data they collect. (Is this collected in a lab or in the field? Is it qualitative or quantitative?)

Summarize the conclusions that the authors make. Do you think they are correct?

Appendix E (continued)

Pick one figure you think best summarizes the results.
What are the data plotted in the figure? Describe any different symbols or colors/shading that are used.

What do the two axes of the graph represent?

What is the major relationship or pattern in the plotted data?

What conclusions do the authors make from this figure?

Why is the figure significant to the paper and/or to the question you've been researching ("How does UV light/radiation affect mutagenesis")?

Appendix E. This is the Primary Literature Worksheet (a.k.a. Primary Literature Activity), which was given to the students during Library Day. After a librarian showed the students how to use the Web of Science search engine, the students completed the assignment in class.

Appendix F

Name:_____

Pre-Survey

(for both experimental and control classes)

1) Read the following research question:
Do fruit flies with red eyes have a higher survivorship in the wild than fruit flies with white eyes?
What keywords would you use to search for papers on this topic? Consider synonyms and related terms, and be creative.

2) When performing a broad search for journal articles on a specific topic, what is the most important part of an article to read to quickly determine its relevance to your topic?
   a. abstract
   b. references
   c. introduction
   d. methods
   e. I don't know.

3) In which of the following documents or information sources would you most likely find a detailed explanation of a specific experiment?
   a. primary article
   b. encyclopedia article
   c. review article
   d. index/database
   e. I don't know.

4) In which of the following documents or information sources would you most likely find citations and abstracts for journal articles?
   a. primary article
   b. encyclopedia article
   c. review article
   d. index/database
   e. I don't know.

Appendix F (continued)

5) What is your standing at IU?
   a. freshman
   b. sophomore
   c. junior
   d. senior
   e. other

6) What is your major? _____

7) How would you rank your ability to read and understand scientific journal articles?
   a. excellent
   b. good
   c. average
   d. poor

8) How would you rank your ability to express scientific ideas and questions in writing?
   a. excellent
   b. good
   c. average
   d. poor

please see next page

Appendix F (continued)

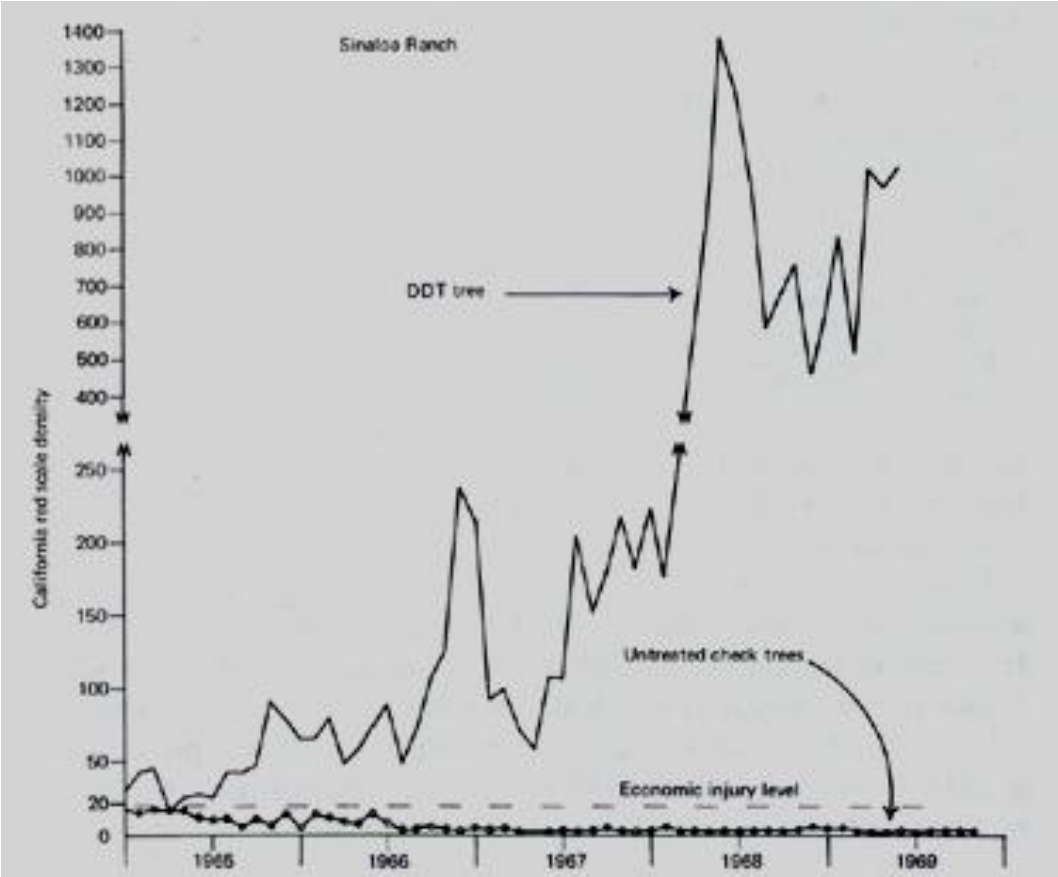

Fig. 2. Increases in California red scale infestation caused by light monthly applications of DDT spray as compared to nearby untreated trees under biological control in the same grove.

9) You are a scientist studying California red scale, a harmful pest that attacks orange trees. Your results are shown in the graph above. (DDT is a pesticide)

a. Write the scientific question you were investigating.

b. What was the control group for this experiment?

A. Trees sprayed with the DDT pesticide
B. Trees that weren't sprayed with DDT
C. Trees that were exposed to the red scale insect
D. Trees that were not exposed to the red scale insect

Appendix F (continued)

c. What was the treatment?
   A. Infecting orange trees with DDT
   B. Infecting orange trees with red scale
   C. Not infecting orange trees with red scale
   D. Spraying DDT on orange trees
   E. Not spraying DDT on orange trees

d. Explain the results portrayed in this graph in lay terms so that a non-scientist would understand.

e. Given the results of your study (see graph above), what would you tell a farmer considering using DDT to control red scale?
   A. Using DDT kills the red scale insect, so he should use DDT on his orange trees.
   B. Using DDT increases the population size of the red scale insect (does not kill the red scale), so he should use DDT.
   C. Using DDT kills the red scale insect but also kills the orange trees, so he should not use DDT.
   D. Using DDT increases the population size of the red scale insect (does not kill the red scale), so he should not use DDT.
   E. Using DDT has no effect on the red scale insect.

10) Which part of your answer to question 9 are you the most confident in?
   a. Scientific question
   b. Control group
   c. Treatment
   d. Results
   e. Conclusions/recommendations

11) Which part are you the least confident in?
   a. Scientific question
   b. Control group
   c. Treatment
   d. Results
   e. Conclusions/recommendations

Appendix F. This survey was given to all three groups during the first week of the semester. An identical survey was then given to the control groups after they had completed the Library Citation Exercise and their UV lab reports (approximately week 7 of the semester).

Appendix G

Name:_____

Post-Survey
(for experimental class)

1) Read the following research question:
Do fruit flies with red eyes have a higher survivorship in the wild than fruit flies with white eyes?
What keywords would you use to search for papers on this topic? Consider synonyms and related terms, and be creative.

2) When performing a broad search for journal articles on a specific topic, what is the most important part of an article to read to quickly determine its relevance to your topic?
   a. abstract
   b. references
   c. introduction
   d. methods
   e. I don't know.

3) In which of the following documents or information sources would you most likely find a detailed explanation of a specific experiment?
   a. primary article
   b. encyclopedia article
   c. review article
   d. index/database
   e. I don't know.

4) In which of the following documents or information sources would you most likely find citations and abstracts for journal articles?
   a. primary article
   b. encyclopedia article
   c. review article
   d. index/database
   e. I don't know.

Appendix G (continued)

5) How would you rank your ability to read and understand scientific journal articles?

   a. excellent
   b. good
   c. average
   d. poor

6) How would you rank your ability to express scientific ideas and questions in writing?

   a. excellent
   b. good
   c. average
   d. poor

please see next page

Appendix G (continued)

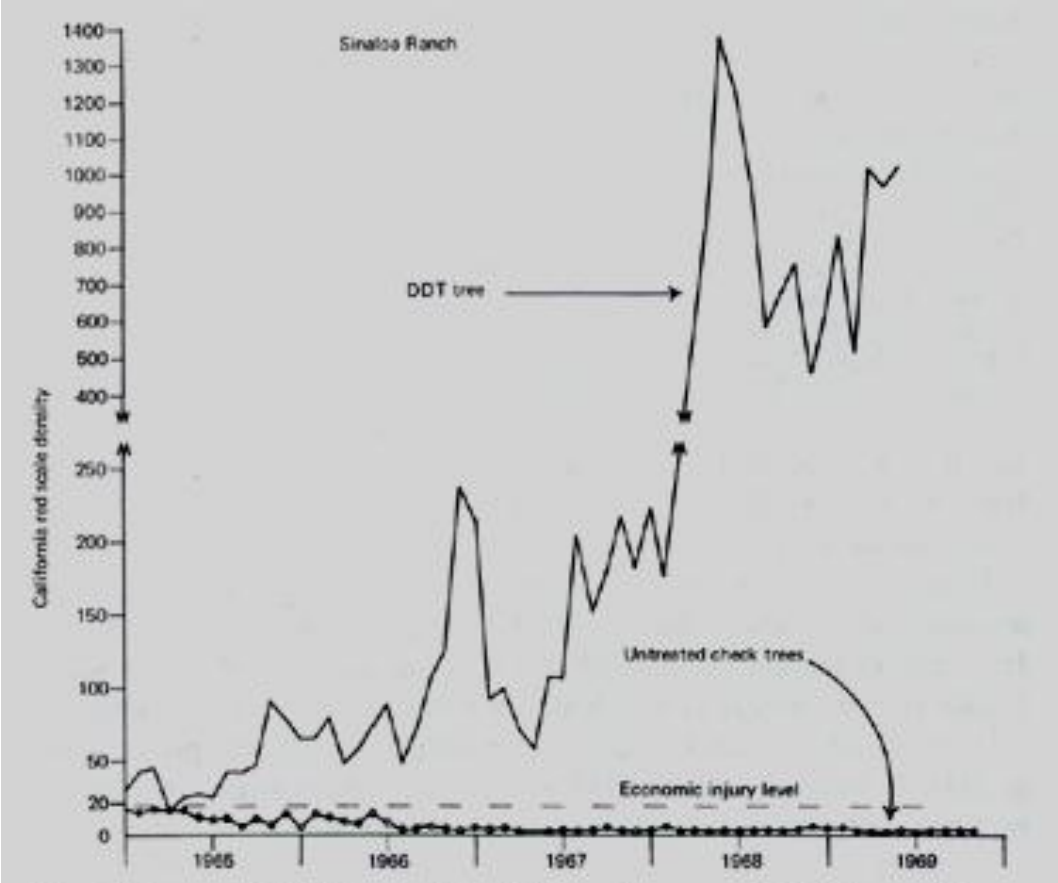

Fig. 2. Increases in California red scale infestation caused by light monthly applications of DDT spray as compared to nearby untreated trees under biological control in the same grove.

7) You are a scientist studying California red scale, a harmful pest that attacks orange trees. Your results are shown in the graph above. (DDT is a pesticide)

a. Write the scientific question you were investigating.

b. What was the control group for this experiment?

A. Trees sprayed with the DDT pesticide
B. Trees that weren't sprayed with DDT
C. Trees that were exposed to the red scale insect
D. Trees that were not exposed to the red scale insect

Appendix G (continued)

c. What was the treatment?
   A. Infecting orange trees with DDT
   B. Infecting orange trees with red scale
   C. Not infecting orange trees with red scale
   D. Spraying DDT on orange trees
   E. Not spraying DDT on orange trees

d. Explain the results portrayed in this graph in lay terms so that a non-scientist would understand.

e. Given the results of your study (see graph above), what would you tell a farmer considering using DDT to control red scale?
   A. Using DDT kills the red scale insect, so he should use DDT on his orange trees.
   B. Using DDT increases the population size of the red scale insect (does not kill the red scale), so he should use DDT.
   C. Using DDT kills the red scale insect but also kills the orange trees, so he should not use DDT.
   D. Using DDT increases the population size of the red scale insect (does not kill the red scale), so he should not use DDT.
   E. Using DDT has no effect on the red scale insect.

8) Which part of your answer to question 7 are you the most confident in?
   a. Scientific question
   b. Control group
   c. Treatment
   d. Results
   e. Conclusions/recommendations

9) Which part are you the least confident in?
   a. Scientific question
   b. Control group
   c. Treatment
   d. Results
   e. Conclusions/recommendations

10) How helpful was the Science Seeker project for writing your UV/mutagenesis lab report?

1	2	3	4	5
(not helpful)				(very helpful)

11) What part of the Science Seeker project did you find the most interesting or useful in helping you identify and interpret scientific literature?

12) What suggestions do you have about the Science Seeker project that would improve your ability to identify and interpret scientific literature?

Appendices H-J

"Many lights used for the beds offer little or no protection from UV rays, creating a risk of excessive exposure to UV radiation for the person who is tanning. This exposure is just as damaging as sun exposure, as found in a recent study (Coelho 2010). This study agrees with our results because we also found UV light to have mostly negative effects. Another article stated that tanning in any form is always dangerous, because the buildup of unrepaired mutations can lead to cancer (NAS 2001). This also agrees with our results, because we observed a lower survival rate as the cells received more exposure."

Appendix H. This is an example of "good" integration in the UV Lab Report. Note how the student connects the results of the articles to his results from the lab experiment.

"Other studies have also shown that UV light causes mutations. According to the article *DNA Damage*, there are more dangerous UV rays breaking through the ozone layer. With more rays breaking through, there is more of a chance for mutations occurring within the DNA structure (Moore, Morris, & Doetsch, 2009)."

Appendix I. This is an example of an "okay" integration into the UV Lab Report. The student makes a superficial connection between the lab experiment and the primary literature article, but she doesn't actually connect the methods or results of the experiment to the methods or results of the article.

"Then in the last primary literature article that I found it talked about how plants use the reversion of the UV light mutations to actually protect and repair themselves. (Liu and others 2000)"

Appendix J. This is an example of a "poor" integration into the UV Lab Report. The student cites an article without connecting it to the results of the lab experiment. A "poor" rating was also given to students citing an article whose topic was significantly different from the subject of the lab.