LabWrite Study

This study was driven by two primary hypotheses, that laboratory students using the instructional materials of LabWrite will: (1) learn the scientific concepts the lab is designed to teach more effectively than students using the traditional instruction in writing lab reports and (2) learn to apply the elements of scientific reasoning more effectively than students using the traditional instruction in writing lab reports. A third hypothesis is that students using LabWrite will develop a more positive attitude toward lab reports than students using the traditional instruction.

## Method

### *Experimental Design*

Participants in the study were North Carolina State University students registered for Biology 183, the second of a two-course introduction to biology for biology and other life science majors. The Biological Sciences program offers both courses every semester; students are not required to take Biology 183 immediately following the first course, Biology 181. Both courses are taught in the typical lecture/laboratory format, one or two large lecture sections with students divided into laboratory sections of about 20 students per section. In the labs, students write traditional lab reports.

The study was quasi-experimental with a posttest-only control-group design (Campbell & Stanley, 1966). The control group was comprised of students registered for Biology 183 in Fall semester, 2000, the treatment group in Spring semester, 2001 (students had no knowledge of the study upon registration). Treatment instruction was made available to all Biology 183 students in the Spring semester; however, in order to limit possible teacher variable, the study focused on approximately 80 students from 4 lab sections in each semester. Control and treatment students were taught by the same professor in the lecture sections and the same 2 instructors in the labs (each instructor having 2 sections), with identical course syllabi, labs, and assigned lab reports.

Lab report instruction for the control group was typical of college lab classes. Students were introduced to writing lab reports on the first day of the lab class with a one-and-a-half-page handout listing the sections of the report and brief descriptions of each section (see Appendix A). Lab instructors reviewed the sections of the lab report with the students and asked them to follow the handout as a guide to writing their reports, referring to the handout during the semester when questions of how to write reports were raised.

The treatment was the LabWrite website, which was integrated into the laboratory activities of the Spring semester course. The nature of the treatment instruction may be understood through descriptions of two of the four components of the website, Pre-Lab and Post-Lab. Giving students a pre-lab test is rather common in college labs, a way of encouraging students to read the description of the lab in the manual before the lab class. Thus, it typically contains questions specific to the lab, such as to identify the solutions that will be used or to describe a certain part of the procedure. In LabWrite, the Pre-Lab questions are designed to enhance the lab as a learning experience and may be used in almost any lab setting. For example, students are asked to identify the scientific concept the lab is about and to write down what they have learned about the concept from the lab manual or the textbook or other sources. Furthermore, students are asked to list the primary variables of the experiment, to hypothesize the relationship among those variables that they expect to find in the experiment, and to explain, referring to what they have said they know about the scientific concept, how they reached the hypothesis (see Appendix B). Thus, students who answer the Pre-Lab

Questionnaire should be well prepared to take advantage of the learning opportunity offered by the lab experience. In Biology 183, students were required to do the Pre-Lab before each major lab.

The Post-Lab guides students through a series of stages for writing the sections of their lab reports. One of the features that distinguishes LabWrite from the usual lab report instruction is that students are given an alternative process for composing the report. In our informal observations of lab students, we found that they would typically begin by writing the title, the abstract, and then the introduction, naturally following the order of the handout. It is, of course, a challenge for students to entitle, abstract, and introduce what they have not yet written and thus do not yet fully understand. LabWrite, then, starts the composing process by guiding students to complete tables and graphs and use these visuals to make sense of the data for themselves. Then they write the Results, making sense of the data for others. After composing the Results, students write Materials and Methods, Introduction, Discussion, Conclusion, Abstract, and Title. In this fashion, students are able to write the sections they have the most information about first, and only after they have a better command of what they found and what they did in the experiment do they proceed to construct the context and interpretation of the experiment.

In addition to offering an alternative order of composing, LabWrite Post-Lab also gives students access to a step-by-step guide for writing each section of the report. The instructional page consists of steps for each section and pertinent links to resources related to those steps (see Appendix C). But the page also provides links that take students to a much more detailed guide for the steps as well as to a sample report they can use as a general model. Our goal was to provide help for students who have different levels of need for that help.

Instruction for treatment students was given only by their biology lab instructors. The instructors themselves received a one-hour workshop on how to use LabWrite and how to introduce students to LabWrite. The introduction was given in the first lab class meeting of the semester, consisting of an overview of the scientific method, a review of the sections of a professional scientific paper, a discussion of the connection between the scientific method and the sections of the scientific paper, a description of the sections required in the lab report, and a tour of the LabWrite website (each lab table provided access to computers). Beyond the introduction, instruction consisted of assigning and grading Pre-Lab questions, reminding students to use the website at appropriate times, and using the LabWrite rubric to grade the reports. Because the LabWrite site provided the primary source of instruction, no special expertise in the genre of the lab report was required of the instructors beyond grading the reports.

Because of the quasi-experimental design with control and treatment groups in different semesters (in order to guarantee an untainted control group, given that students in the same lecture section were likely to discuss different lab pedagogies), both groups were given portions of the "Test of Science-Related Attitudes" (TOSRA) to identify any significant differences in their attitudes toward science that could account for differences in the results of the study. Developed by Fraser (1981), the TOSRA is a 70-item Likert-type test with 7 separate subscales. Scales 3 and 5 (10 items each) were chosen for this survey, measuring attitude toward scientific inquiry and enjoyment of science lessons, respectively. These scales were selected because they seemed to have more relevance to this study and because they measure distinctly different dimensions of science-related attitudes, as shown by previous studies (Schibeci & McGaw, 1981). In addition, students were surveyed for demographic information that might reveal significant pre-existent differences between the groups: academic class, major, number of science courses taken, expected grade in Biology 183, and number of writing courses taken.

No significant differences were found in the scores of the TOSRA (subscale 3, $p=.92$; subscale 5, $p=.41$). The demographic survey revealed 2 significant differences (see Table 1). First, students in the control group were higher in academic class ($p<.0001$). Whereas the majority of students in the control group were sophomores, the majority in the treatment group were freshmen (54% in each academic class; the control group also had higher percentages of juniors and seniors). This difference may be accounted for by differences in the students' curriculum: students in the Fall semester section typically take Biology 181 in the previous Spring semester and are therefore more likely to be sophomores. The second significant difference was that the control group had taken more science courses ($p<.01$), which can also be explained by their higher academic class. Thus, whereas the TOSRA suggests similar attitudes in both groups toward scientific inquiry and enjoyment of science lessons, the demographic survey suggests significant differences that would seem to bias performance in Biology 183 labs in favor of the control group.

*Data Collection and Analysis*

Data for testing hypotheses 1 and 2 consisted of copies of student lab reports collected from the control and treatment groups throughout both semesters. Students turned in two copies of their reports, one for themselves and one for their laboratory instructors to keep for the study. Students' names were blacked out and reports were numbered. Random samples of control and treatment reports were selected for scoring from each group ($n=44$).

Hypothesis 1, related to students' learning the scientific concepts that the experiments were intended to reinforce, was tested by a holistic analysis of the data (White, 1985). Three raters were selected, on a voluntary basis, from a pool of instructors, all of whom had taught introductory biology lab courses and were familiar with the laboratory investigations in this course. The raters evaluated equally sized random samples of reports from two different lab experiments as a way of ensuring that there was no bias toward the scientific concept of either lab. Raters were trained to grade the reports according to the degree to which they indicated that the writers learned the scientific concepts of the labs, using a scale of 1-5 (low to high). Laboratory 1, for example, was focused on the concept of photosynthesis; the raters evaluated those reports by how well the students appeared to have understood photosynthesis. Two raters graded each report, and when graders disagreed, a third rater broke the tie. Before raters began scoring, they calibrated with each other to establish a baseline at each level of the scale (Huot, 1990). A two-way analysis of variance was used to measure any group differences in evaluations.

Hypothesis 2, related to students' ability to apply the elements of scientific reasoning, was tested by a primary-trait analysis of the data. Primary-trait scoring is designed to assess a writer's ability to achieve the purpose of a particular writing task by evaluating the key textual features that are closely tied to that purpose (Lloyd-Jones, 1977; Huot, 1990). In this study, the textual features are those that are identified with effective scientific reasoning (AAAS, 1989; Kirscht, et al., 1994). Nine traits of scientific reasoning were selected and described in the form of a rubric (see Appendix D).

Two raters, both science teachers, were trained to use the rubric in evaluating a random sample of reports (n=40 per group) from laboratory 3, chosen because it was the final single-authored lab report of the semester and would presumably represent the students' best work. The raters graded each trait on a four-point scale: 4=superior, 3=fair, 2=poor, and 1=not applicable (trait was not present in the report). Training consisted of modeling the use of the rubric for the raters and having the raters grade sample reports to attain relative consistency. Raters were calibrated periodically throughout the session to ensure continued consistency. Agreement between evaluators was determined using a basic formula for inter-rater reliability (number of agreements/number of opportunities for agreement) as well as a polychoric correlation coefficient, which accounts for consistency trends in individual raters (Olsson, 1979). One-way analysis of variance was used to determine group differences for each of the primary traits and the composite trait scores.

The third hypothesis, related to overall attitude toward laboratory reports, was tested with a survey. Because there are no instruments that measure college students' attitude toward lab reports, a survey was designed for this study. The instrument, composed of 22 Likert-type items, addressed students' positive or negative impressions of lab reports, confidence and enjoyment in writing them, usefulness of learning to write them, etc. (see Appendix E). Surveys were issued at the end of each semester, and data were obtained from both control and treatment groups (n=60 for each group). Surveys were anonymous. Composite scores (the sum of student ratings for all the items) for both groups were tabulated. A one-way analysis of variance (ANOVA) compared between-group differences. Cronbach's alpha was also calculated to establish reliability for each item of the survey, a way of assessing the validity of the survey.

## Results

All three hypotheses were supported (see Table 1). First, the holistic analysis of lab reports suggests that students using LabWrite learned the science of the labs more effectively than students using normal instructional materials ($p<.003$). As Figure 1 indicates, the difference between groups was essentially the same for both lab reports 1 and 3, suggesting that LabWrite students learned the scientific concepts of the labs independent of what those concepts were.

The treatment group was also judged to be significantly more effective in applying scientific reasoning to the lab experiment ($p<.0001$). Between-group comparisons of mean scores for each of the 9 primary traits that we associated with effective scientific reasoning showed that LabWrite students scored higher in every trait (see Fig. 2). Interrater reliability for the primary-trait analysis was .70, which is acceptable in writing studies (Lauer and Asher, 1988). However, results from the polychoric test established the overall reliability at .93, indicating a very high level of consistency between raters. The polychoric correlation coefficient per item ranged from .74 to .99, for traits 8 and 1 respectively.

For the third hypothesis, students using LabWrite demonstrated a significantly more positive attitude toward lab reports than students in the control group ($p<.01$). Overall internal consistency of items on the attitudes survey created for this study was high, with a Cronbach's coefficient=.91, supporting reliability and content validity of the instrument.

# Appendix A:  Biology 183 Lab Report Handout

## BIO 183 Lab Reports

You will have to write 3 lab reports throughout the semester, each worth 25 points.  The dates due are in your lab manual on the assignment sheet.  Lab reports must be typed, double-spaced, and in the following format.   There is no page limit but aim for approximately 3 pages.

**Title (1 point):** The title should be descriptive and should stand alone as to the contents of the paper.  Often a reader will scan titles and stop to find only those papers that seem relevant or interesting.

**Abstract (5 points):** An abstract is only one paragraph long and serves as a summary of the paper.  This section is also as important as the title for it is read by people to assess if the entire paper should be obtained and read.  An introductory statement as well as your hypothesis or prediction should be included in the abstract.  A one or two sentence description of the methods and the results also is included in this section.  Finally a conclusion as to what the data means should follow.

**Introduction (2 points):** This section needs to provide adequate background information on your topic.  You should assume that the reader will need introduction to all aspects of the topic or experiment.  Often you will see articles that discuss previous research done on a topic to give support to the current investigation.  In other words, you need to address why your research is important or significant.  You also want to include your hypothesis/prediction for the experiment.  This is usually written in the past tense and in the second person.

**Materials and Methods  (4 points):** This should be written in concise paragraphs, past tense, second person.  It should be written in such a way that someone else should be able to read this section and repeat the same experiment.  It should include information on controls, why they are considered controls and any diagrams or figures if it helps describe the experimental design.

**Results (5 points):** This section conveys the results in paragraph form and in charts, graphs, or figures.  These components should supplement one another to give an overall representation of the results.  When using a chart, graph, or figure, a reference in the text needs to be made to direct the reader's attention to the appropriate visual aid.  This is done using parentheses as in (see figure 1).  The figures/graphs will also need a legend or brief description of the figure to help explain what the reader is seeing underneath it.

**Discussion (6 points):** This section should give the researcher's interpretation of the data.  Was your hypothesis supported or refuted?  What do your results mean?  Why are the results significant?  This should be supported by previous research.  There should be a brief (1-2 sentences) conclusion statement describing the final outcome.

**References (2 points):** If you use a reference in the text of the paper or section that you are writing, you need to include the author's last name and year of the publication in parentheses (Smith 1998). If two people are authors, both last names should be included. If three or more people are authors, only the first author's name appears followed by the words "et al." and the year of publication. For these lab reports, there shouldn't have to be any outside research. So the only references that are required are the lab manual and possibly your textbook.

Campbell, N.A., J.B. Reece, and L.G. Mitchell. 1999. Biology, fifth edition. Addison Wesley Longman, Menlo, CA.

## Appendix B: Pre-Lab Questionnaire

Name: ____________________

Date: ______________________

Lab Section: _______________

Lab Title ___________________

**1. Establishing the learning context for the lab.**

a. What is the scientific principle (theory or concept) that you are supposed to be learning about by doing the lab? (You'll probably be able to figure this out by checking the lab manual for the title of the lab and the introduction to the lab.)

b. Write down everything you can find out about this scientific principle. (Look at the lab manual, class notes, textbook, handouts.)

**2. Establishing the goals of the lab.**

a. List the objectives for the lab. (The objectives are the concrete acts you are supposed to perform in the lab, such as to measure something, to analyze something, to determine something, to test something, etc. You'll probably find them presented in the lab manual.)

b. In a sentence or two, give the purpose of the lab. (The purpose tells how achieving the objectives of the lab will help you to learn about the scientific principle the lab is about.)

**3. Establishing your hypothesis for the lab.**

a. List the dependent and independent variables in the experimental procedure. (Dependent variables are the things measure to see what changes take place. Independent variables are the things you manipulate in order to effect changes in the dependent variables.)

b. State your hypothesis for the outcome of the lab procedure, your informed guess as to the relationship between the independent and dependent variables.

c. Explain the reasoning that has led you to your hypothesis. (Your reasoning should be based on what you know about the scientific principle the lab is about.)

**Appendix C: Sample of Post-Lab Instruction**

## Post-Lab: *Writing your lab report in stages*

Follow this Post-Lab guide for writing your lab report. It's best to open a word processing file alongside this page and write the report following the directions step by step. Then when you've finished, you can rearrange your report in the proper order for turning it in. For more detailed help, click on the highlighted title of each stage.

## Stage One/Making Sense of Lab Data for Yourself: *Visualizing the Lab Data*

**Step 1**: For each data set, determine the visual form (table, graph, drawing, etc.) that is most appropriate for representing the data.

Key links:
Tabular Versus Visual Display of Data
Selecting a Graph Type

**Step 2**: For each data set, transform the raw data into the appropriate visual format.

Key links:
Basic Graphing in Excel
Scatter Plots
Line Graphs
Bar Graphs
Histograms

**Step 3**: Describe in words the finding for each visual (table, graph, drawing, etc.) that you are using to represent your data. A finding is a sentence or two that focus on what you think is most important about the data. It typically consists of: (a) either a summary of the data in the visual or a statement of the most interesting points in the data and (b) any additional information (such as statistics) necessary for supporting the summary or interesting points.

**Step 4**: Based on the visual representations of the data and your findings, make a judgment as to whether or not the data you have collected support your hypothesis.

**More Information on Stage One**

## Stage Two/Making Sense of the Lab Data for Others: *Results*

**Step 1**: Write a sentence or two that summarizes all your findings. The Results section should begin with this description of the overall outcomes of your experimental procedures.

**Step 2**: Decide which visuals (tables, graphs, drawings, etc.) you will include in the Results and what order they should be presented in.

**Step 3**: Put the verbal statements of your findings in paragraphs and arrange them in the same order as the visual findings.

**Step 4**: Revise the tables, graphs, and drawings you are using in the Results so that they are correctly formatted.

Key link: Revising your Visuals: Final Presentation

**Step 5**: Revise the written part of the Results so that it properly uses citations to integrate the visuals in the written descriptions and it is readable and grammatically correct.

**Key link**: Example results section

**More Information on Stage Two**

**Tips on writing the Results:**

* In relatively simple labs, the Results may consist of only a few sentences in a single paragraph. Don't feel compelled to add needless detail just to make your Results look impressive.
* The visual and the verbal should be fully integrated in the Results. Do not include any visuals that you have not referred to in words. All graphs, tables, drawings or other visuals you include in the Results must be cited in the text of the report.
* Do not include any interpretations or explanations or draw any large conclusions about the data in the Results. Just report the findings.
* Because you are describing data you have collected in the past, use the past tense.

## Appendix D: Primary-Trait Rubric

Report number __________

### *INTRODUCTION*

**HYPOTHESIS** *The lab report:*

| | |
|---|---|
| **Superior** provides a complete hypothesis that shows that the student has fully thought through the outcome of the experiment; clearly states the hypothesis using proper language (hypothesize, predict, anticipate, etc.) | |
| **Fair** provides a brief, not fully complete hypothesis; may or may not use proper hypothetical language | |
| **Poor** offers what seems to be an attempt at a hypothesis, but it is too vague or confused to be clearly understood; does not use hypothetical language | |
| **Not Applicable** provides no hypothesis | |

**EXPLANATION FOR HYPOTHESIS** *The lab report:*

| | |
|---|---|
| **Superior** effectively explains the reasoning behind the hypothesis: uses a sufficient amount of information from the scientific background of the lab to support an argument; makes a definite link between background and hypothesis, including use of clear explanatory indicators (because, since, due to, as a result, etc.) | |
| **Fair** explains the reasoning behind the hypothesis fairly well: does not use enough information from the scientific background to make a convincing argument AND/OR fails to provide a definite link between background and hypothesis; may or may not use explanatory indicators | |
| **Poor** makes only a vague attempt to explain the hypothesis: does not use enough information from the scientific background to make a convincing argument AND fails to provide a definite link between background and hypothesis | |
| **Not Applicable** provides no rationale for hypothesis | |

### *MATERIALS AND METHODS*

**MATERIALS** *The lab report:*

| | |
|---|---|
| **Superior** provides enough specific detail about the materials used in the experiment and how those materials were used to convince the reader that he/she would be able to repeat the experiment | |
| **Fair** provides a general sense of the materials used in the experiment so that the reader is not fully confident that he/she could repeat the experiment | |
| **Poor** provides so little detail about the materials that the reader would not be able to repeat the experiment | |
| **Not Applicable** provides no reference to materials used in the experiment | |

**ORGANIZATION OF PROCEDURE** ***The lab report:***

| | |
|---|---|
| **Superior** describes the experiment in a clear and well organized manner that can be easily followed step by step; convinces reader that he/she could conduct the experiment; effectively; uses clear time-order indicators (first, second, then, next, after that, etc.) | |
| **Fair** describes the experiment in a way that conveys a general sense of what the steps are; leaves the reader with some uncertainty that he/she could conduct the experiment; uses inadequate time-order indicators | |
| **Poor** describes the experiment in a way that is difficult to follow; makes the reader uncertain that he/she could conduct experiment; uses few if any time-order indicators | |
| **Not Applicable** provides no description of experimental procedure | |

## *RESULTS*

**SUMMARY OF RESULTS** ***The lab report:***

| | |
|---|---|
| **Superior** contains one or two sentences near the beginning of results section that gives a fully sufficient, clearly stated summary of the findings of the experiment | |
| **Fair** contains one or two sentences somewhere in the results section that are recognizable as a summary of the findings but are not fully sufficient and clearly stated | |
| **Poor** contains what may be an attempt at summarizing the findings but is done so in a way that is vague and confusing | |
| **Not Applicable** provides no recognizable summary of findings | |

**INTEGRATION OF VISUAL AND VERBAL FINDINGS** ***The lab report:***

| | |
|---|---|
| **Superior** fully integrates visual and verbal results: written part of results section directly refers to tables and graphs and clearly addresses the data in them | |
| **Fair** fairly integrates visual and verbal results: written part refers to tables and graphs but only as an afterthought AND/OR without clearly addressing the data in them | |
| **Poor** poorly integrates visual and verbal results: written part describes results without any direct references to tables and graphs | |
| **Not Applicable** provides no verbal results AND/OR no visual results | |

## *DISCUSSION*

**RETURN TO HYPOTHESIS** ***The lab report:***

| | |
|---|---|
| **Superior** provides a sentence or two in the discussion that directly restates the hypothesis and indicates whether or not the hypothesis is supported by the experiment | |
| **Fair** provides a sentence or two that only indirectly refers to the hypothesis (without restating it) OR fails to state whether or not the hypothesis has been supported | |

| | |
|---|---|
| **Poor** makes only a vague or passing reference to a hypothesis AND fails to indicate whether or not the hypothesis is supported by the experiment; OR refers to a hypothesis not stated in introduction | |
| **Not Applicable** provides no reference to hypothesis nor to whether or not hypothesis was supported by the experiment | |

**LINKING HYPOTHESIS TO FINDINGS** *The lab report:*

| | |
|---|---|
| **Superior** makes a clear link between hypothesis and findings by using data from the results section as evidence for supporting or rejecting the hypothesis; refers to specific data as evidence | |
| **Fair** makes only a loose link between data from the results and the decision to support or reject hypothesis AND/OR provides only general references to the data | |
| **Poor** fails to make any link between data and hypothesis | |
| **Not Applicable** provides no reference to data from the results | |

**LINKING HYPOTHESIS TO SCIENTIFIC BACKGROUND** *The lab report:*

| | |
|---|---|
| **Superior** makes a convincing argument as to why the hypothesis has been supported or rejected: explicitly uses sufficient scientific background from introduction as a basis for reasoning; makes a clear link between the scientific information and hypothesis; uses clear explanatory indicators (because, since, due to, as a result, etc.) | |
| **Fair** makes a somewhat convincing argument about the hypothesis: provides only general references to scientific background AND/OR provides no clear link between the background and hypothesis; uses few or inadequate explanatory indicators | |
| **Poor** makes a weak argument about the hypothesis: provides no or only vague references to scientific background and no link between the background and hypothesis; uses unhelpful or no explanatory indicators | |
| **Not Applicable** provides no explanation for support or rejection of hypothesis | |

**Appendix E: Lab Report Attitude Survey**

**<u>Directions</u>: Please, respond to what you think about the following statements. There are no right or wrong answers. Put all responses on the "response sheet." Your honest opinion is greatly appreciated.**

A=Strongly agree
B=Agree
C=Neutral
D=Disagree
E=Strongly Disagree

1. I feel that I had enough guidance in this class to help me write good lab reports.
2. I disliked writing lab reports in this class.
3. I felt positive about the quality of the lab reports that I turned in.
4. When writing my lab reports, I often felt unsure about the instructor's expectations.
5. I did well on the lab reports I wrote for this class.
6. I feel that this course is designed to help students write good lab reports.
7. The lab reports in this class were not worth my time.
8. Writing lab reports really helped me to learn about science.
9. Writing lab reports in this class helped me to understand the scientific method.
10. This class helped me understand why we write lab reports in science classes.
11. Writing lab reports in this class was easier than I thought it would be.
12. I expect to do well in writing lab reports in future science classes.
13. This course has increased my confidence in writing lab reports.
14. I feel that this course helped me learn how to create graphs for scientific data.
15. I feel confident that I can write a good discussion section for a lab report.
16. I feel that lab reports have helped me learn biology concepts covered in lab.
17. I don't understand why we have to write lab reports in science labs.
18. I think my lab report writing has improved as a result of this class.
19. I feel that this course gave me all the instruction I needed to write good lab reports.
20. I feel that writing lab reports helped me to understand the data I collected.
22. This class helped me to understand the purpose of each part of a lab report.

Table 1. Summary Statistics for Hypotheses 1-3

| | | N | Mean | S.D. | *F*-Value | *P*-Value |
|---|---|---|---|---|---|---|
| Hypothesis 1 | control | 44 | 1.78 | 1.01 | 4.9 | .003 |
| | experimental | 44 | 2.65 | 1.30 | | |
| Hypothesis 2 | control | 40 | 21.24 | 4.7 | 49.32 | .0001 |
| | experimental | 40 | 29.0 | 4.3 | | |
| Hypothesis 3 | control | 60 | 57.56 | 14.4 | 6.41 | .01 |
| | experimental | 60 | 52.3* | 11.8 | | |

*Note: A lower experimental mean corresponds to higher agreement on the Lab Report Attitude Likert-Scale as compared to the control mean.

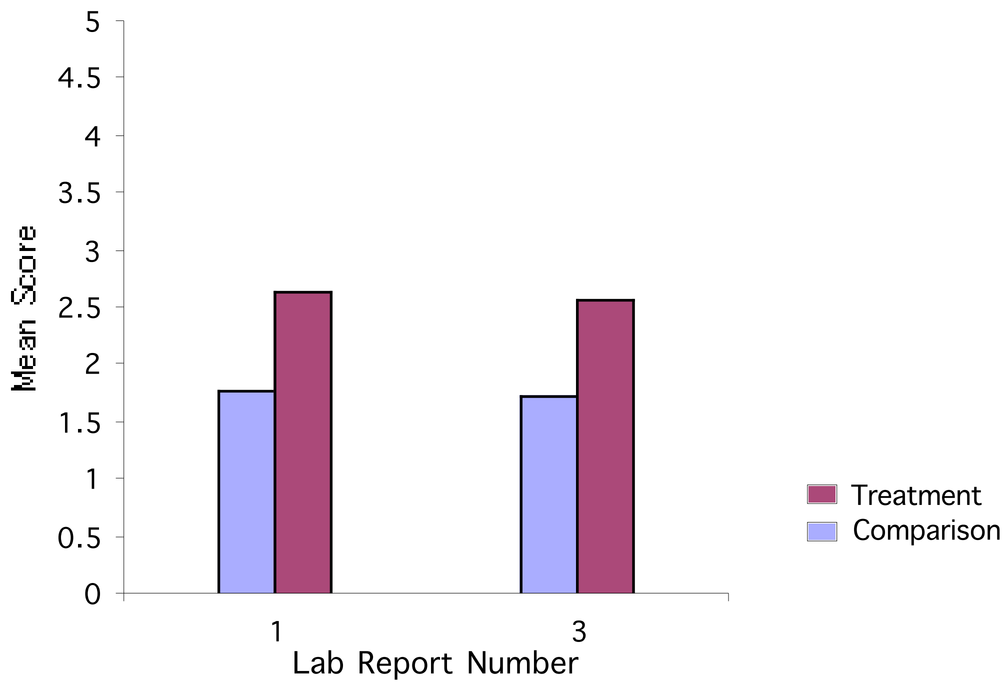


*Figure 1.* Group Comparison of Holistic Lab Report Scores

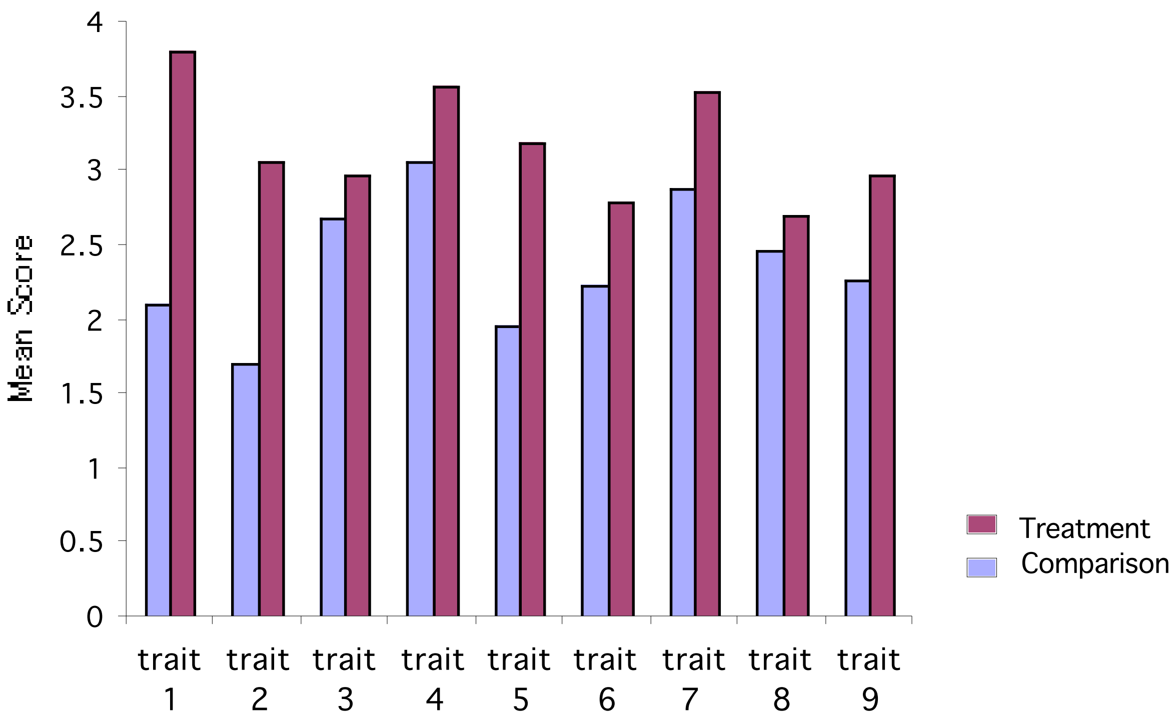


*Figure 2.* Group Comparison of Composite Primary Trait Scores