

DOES PEER REVIEW IMPROVE LAB REPORT QUALITY IN HIGH SCHOOL
SCIENCE STUDENTS?

by

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June 2011

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ABSTRACT

My students are, for the most part, potentially very good writers. However, when I get these students, their lab report writing skills are quite limited, and therefore, are very poor. Focus for doing labs thus far in their science career has been how well they can perform the lab from verbal instructions not written instructions. The students have a difficult time reading and understanding what the protocol wants them to do, and they have an even more difficult time explaining what they performed during the lab activity in a lab report.

This project investigated how well the students discussed their course of action after performing the lab activity in a written report. The students were given written lab protocols and were expected to follow the procedure and make observations along the way. The labs were all completed in one 45 minute class period. The students were then given one day in class to work on their lab report following the lab report rubric (Appendix A).

Data collection for this project not only included lab report writing, but what the students' comfort levels were in different elements of the lab, how well they reviewed their own work, how well they reviewed other peer's work, and how they felt about the whole lab report writing process throughout the year. Several teachers were also asked to evaluate how well these particular students processed and followed directions in their classrooms as well.

The results indicated that by implementing a peer review session into the lab report writing process the report score significantly improved. The students who struggled at the beginning of the process were now completing quality lab reports in half the time and the peer review rubrics were being scored with the highest marks. Because of these positive outcomes, I know that peer review is an integral part of the learning process to produce quality lab reports and I will continue to conduct this practice in my classroom in years to come.

INTRODUCTION AND BACKGROUND

Project Background

School Demographics

Northern Potter High School, in Ulysses, is located in a little farming community in northern Pennsylvania with a town population of 631. The average family income is about \$31,000 and the town's people are fairly young with the median age of 33 years (Informatics, 2010). While driving to the school one may encounter an Amish buggy or two, various farms, a four-way stop sign, a bank, and a post office.

Northern Potter High School, located up on top of a hill, is connected to the Children's School by a large parking lot. The 625 students are bused in from over eight towns in Potter County with 320 students in the Children's School and 305 students in the High School. Ninety-eight percent of the student body is Caucasian (Informatics, 2010).

Family, church, and hard work are easily among the top priorities in this rural town. Many of the students work very hard on the family farm and are up extremely early in the morning to complete their chores. After school, the work continues at home. Since farming is woven so tightly into the students' lives, cowboy boots, cowboy hats, pickup trucks, and tractors are a common sight at Northern Potter Schools.

Teaching and Classroom Environment

Upon receiving lab reports from my 10th grade biology students, I noticed many of the students were not able to develop a sequential procedure and did not understand that English and science need to go hand-in-hand. Students were not able to tell me on

paper what they had just completed, what instruments and equipment they had used, and even why they performed the steps written in the protocol. Grammatical, spelling, and formatting errors forced me to re-evaluate how I taught and accepted lab reports. Students wanted to place all portions of the lab report in paragraph form, as shown in the student's report sample below, while bullets and numbering should have been used (Figure 1).

<p><u>Purpose:</u></p> <p>For me to understand inhibiting bacterial growth, to determine that inhibition by an agent was slight.</p> <p><u>Materials:</u></p> <p>Agar plate, sharpie, sterile cotton swabs, 1 type of bacterial broth, commercial antibiotic disks, forceps, and sterile paper disks.</p> <p><u>Procedure:</u></p> <p>We used two Petri plates filled with agar, then we labeled them with our names, the date, and the bacteria we used with a sharpie. We then submerged the sterile cotton swab into the vile of bacteria, swabbed the bacteria in every part of the agar. After that we put antibiotics in three of the four quarters, and put neutral in the blank quarter. Then we put the lid on, turned upside down, and put it in the incubator to grow.</p>	<p><i>inhibiting bacterial growth, and</i></p> <p><i>bullet</i></p> <p><i>This should be numbered</i></p>
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Figure 1. Pre-Treatment Sample of Student's Lab Report

Students ($N=14$) were presented with a preliminary survey to allow an insight into their comfort levels with generating a lab report prior to writing laboratory reports. The survey consisted of eight questions and responses using the Likert Scale rating model that ranged from (5) = *completely comfortable* to (1) = *not comfortable at all*.

The results of the Acker Preliminary Survey (Appendix B) indicated that 36% of the students rated their comfort level in writing the introduction and background information in a lab report as *comfortable*, while 14% felt they were *completely comfortable* with it ($N=14$, Figure 2).

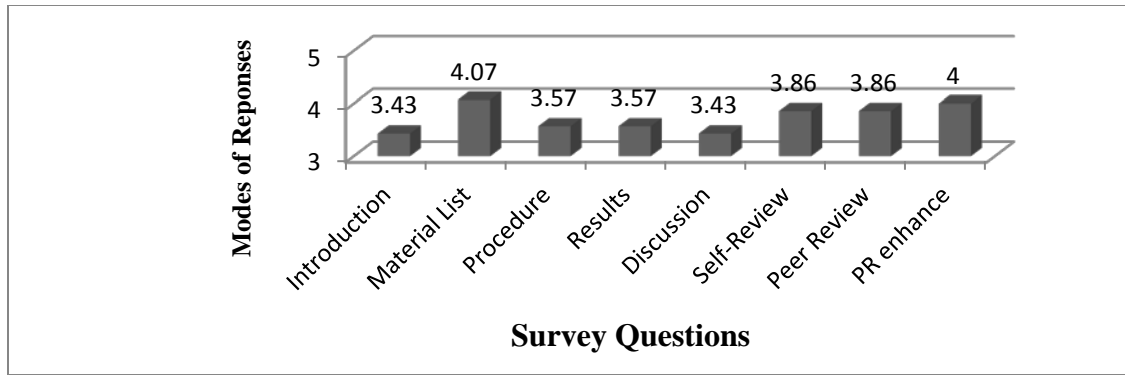


Figure 2. Average of Comfort Levels of Student Responses in the Preliminary Survey, (N=14). 5 = *completely comfortable*, 1 = *not comfortable at all*. Note: PR is Peer Review.

The students also rated their ability to generate the procedure and discussion portions of the lab as *completely comfortable*. Upon reading whether or not they felt comfortable self-reviewing themselves and reviewing their peer's lab reports, the majority answered that they felt *very comfortable* to *completely comfortable*. When asked how comfortable they were in formulating the results section, the class was split. Thirty-six percent of students rated this endeavor as *not very comfortable* while another 36% students rated this as a *very comfortable*. Twenty-nine percent of the students believed this section was easily created and felt *completely comfortable* in constructing it. The questions of how well they were able to generate a materials list and how well they would think the peer review process would enhance their writing showed the highest mode in comfort levels. Forty-three percent of the students felt *completely comfortable* in devising the materials list and felt *very comfortable* in believing that doing all of this work with peer review would help their understanding of the lab activity and enhance their writing.

Focus Question

The importance of written communication within the scientific community is widely known. Moreover, understanding the components that generate a well written lab protocol is essential. The following question was addressed during this project: Do students tend to write a better lab report after participating in a peer review session than when they do not? The following sub-questions were addressed 1) Are students able to formulate lab reports from verbal instructions, not just from written protocols? 2) Are students able to evaluate other students' lab reports effectively? and 3) Are students more confident in writing in science class after participating in the peer review process? (Table 1). The goal of this study was to advance students' science writing skills over time through exposure to the repetition of writing, peer reviewing, and re-writing lab reports.

CONCEPTUAL FRAMEWORK

Peer review, or peer evaluation, is a tactic widely used by the scientific community in both undergraduate and graduate school settings to assist students' writing of laboratory reports. Also, it is how real scientists work. The benefits of this practice have been shown to improve students' writing abilities along with increasing the motivation and responsibility for learning in secondary science classrooms. For example, students who normally do not possess the most exemplary writing skills, or students who are not always the most conscientious, can overcome the intimidating task of writing lab reports (Trautmann, 2009).

One way to address the lab report assignment is through peer review. Peer review can be explained as a method of evaluating work performance and results by peers (Liu, Pysarchik & Taylor, 2002). The goal of the peer review is to help students revise drafts of written assignments. This method of improving students' work is not new to the educational system. It has, in fact, been around for more than two hundred years.

In the early nineteenth century British logic and philosophy professor, George Jardine, although not widely known for his contribution to education, first designed the peer review method. His goal was to help prepare his students to become fully functioning members of society. Jardine's method of performing this student-based learning started with choosing ten to twelve of his best writers in the class. He labeled these students "examinators," since the term "critic" usually has a bad connotation (Gaillet, 1994). The examiners' jobs were to read the work and then give a thorough record of what was good and what needed work in a paper. Jardine's peer review was so successful that he then extended the role of examiner to everyone in the class. It not only improved the writing skills of his students, but provided Jardine with some relief from grading papers. In addition, Jardine supplied the educational field with two major breakthroughs with his development of peer review. The conclusions he drew were that both strong and weak students are able to benefit from a peer evaluation system and that learning is a social process (Gaillet, 1994).

Bruner (1973), an educational theorist, agreed with Jardine and stated he found "peer reviewed students display a significant increase in their writing performance while the students performing the review show an enormous increase" (p. 48). Furthermore, Bruner claims by "encouraging students to assume responsibility for the academic

progress of each other, teachers will also foster a notable increase in self-worth and group pride of the students” (p. 48). With these abilities, the students are able to deliver acceptable lab reports, as well as adapt to different types of societal situations in the future. Such situations may include roles that require working with others, perhaps on a committee, or in a position that needs to present or accept constructive criticism (Gaillet, 1994).

Although the majority of schoolwork is expected to be completed independently, it has been shown that group activities have the ability to enhance skills needed in the typical workforce. Not only can these activities encourage teamwork, problem solving, communication, and leadership, but also critical thinking skills and organization. Unfortunately, most students do not acquire this technique until college (Wenzel, 2007). High school students are not commonly challenged with this level of higher order thinking. It is shown when faced with a critical thinking task, they do not just complete it, but excel at it (Nilson, 2003). Teachers must be willing to take the extra time to explain the process, to review the rules for the evaluations, and then to evaluate the students’ efforts. However, time and patience are not always abundantly available.

Since scheduling and lack of patience can be an issue, there are several methods of conducting and designing peer review in the high school classroom. One approach is to have the evaluator and student writer partner with each other. This enables the student to receive immediate feedback from the review. Another technique is that the evaluator is kept anonymous but the student who did the work is known. Depending upon the situation, a teacher may choose which type best suits the classroom. Trautmann (2009) found if peer review systems were designed to support continuing dialogues, students

could reply to issues mentioned by their reviewers. School is not only for learning subject matter but also learning the importance of communication and building on skills the students will need later in life.

While grading in the classroom is usually designated to the instructor, in some cases the task can be shared by the students as well. Grading lab reports can be subjective. The teacher may have the students use a rubric to score the report and use that score for the grade, or he may have the student writer correct the report marked with the revision suggestions and then opt to grade it afterwards. A rubric is a scoring tool that teachers use to assess student learning after a lesson, or in this case, a lab report, and is used to evaluate each student's performance on a wide variety of work, ranging from written essays to class projects. When a rubric is agreed-upon and discussed before the students' work is completed, the grading process is very clear to all participants. Many times it is valuable to have more than one evaluator grade each piece of work. The rubric scores then may be averaged together for a final score (Lewis, 2011). Whichever approach is chosen, a rubric will ensure students know what is required in the reviewer and writer roles. The final paper could be turned in with the rough draft from which the corrections were made (Wenzel, 2007). The value of critiquing can be assessed by the instructor to ensure student evaluators are putting thought into the assessment and not simply carrying out the motions (Nilson, 2003). While rubrics are a way to easily check if the reviewer and reviewee have covered all criteria, they must be concise and easily understood by both parties. Many times, the questions are not specific enough, which leaves the evaluators unsure of how to grade the work. In order for the peer review to

accomplish its goals, the evaluators must be held accountable for their reviews as well (Wenzel, 2007).

One main concern about writing in the science classroom deals with students generating a well-written lab report. For the teacher, it can be quite frustrating trying to grade unsatisfactory reports that include incomplete procedures, incorrect graphs, and missing conclusions (Diaz, 2004). Peer reviewing can significantly reduce these issues. Diaz (2004) states that within the one week time frame he allotted to the peer review session, there was a significant improvement in the final copies of the collected lab reports. He supplied his class with an outline of the peer editing process and a grading rubric for which they would grade other students' work. In his conclusion he mentions, "The peer-editing experiment has resulted in higher lab scores, and students are completing their labs with a lot less assistance from me" (p. 39).

Nilson (2003) stated two main problems concerning peer review found in the literature. Research has shown peer reviews are based on the likes and dislikes of the content, not the quality, inaccuracies, and the evaluators being uncritical in general. Depending on the instructor's classroom atmosphere, he or she may want to implement a few adaptations. Nilson also suggests that to decrease the volume of poor remarks or judgments, the instructor may inform the evaluators to just highlight, list, or paraphrase parts in the paper that need some extra attention instead of providing suggestions and other possible revisions.

Because the peer review approach has been shown to improve writing skills and enhances motivation and responsibility for metacognition in the secondary science classroom, students should be encouraged to use this technique often. Their

understanding of peer reviewing can be enriched through awareness of important topics in their own classrooms, and later in professional science. This is extremely vital because scientific knowledge is continuously changing and becoming established through a nonstop process of research, review, revision, and publication of results. Practicing peer review allows students opportunity to fine-tune these skills with supervision, so they can utilize them efficiently in their future careers (Trautmann, 2009).

METHODOLOGY

The treatment of this study included hands-on laboratory activities one day per week either with a written protocol or verbal instructions from the teacher. Upon completion of the lab activity the students were expected to generate a laboratory report within three days.

Data collection began at the beginning of the 2010 school year with the students having no experience with a written lab report in the style required for this biology course. Students were first given a questionnaire that asked whether they were a visual learner, tactile learner, or auditory learner (Appendix E). Students were given the Lab Report Rubric to guide them through the process of writing a lab report after completing the first lab (Appendix A). In addition, verbal instructions were given on how to complete a lab report. A baseline of each student's scores was taken and recorded from Lab Report Rubric. The lab report was worth forty points and included the following ten scored categories: background information, a stated hypothesis, materials used in the lab activity, a well devised procedure, analysis of trends and patterns found during the experiment, data collected, concluding statements, the appearance and organization of the

report, and finally, how well they participated during the activity. Each category was scored from one to four points with one representing a *very poor effort* and four signifying *great effort and accuracy*.

Data were also collected from how the students felt about lab reports and compared with how they felt about lab reports after the treatment was applied (Appendix B). This survey enabled me to understand each student's confidence level in devising each section of the lab report. Some students were very detail oriented and preferred to write the procedure section while other students would rather explain their findings and did well in the conclusion section.

Students continued to perform labs and to construct lab reports every week for four weeks. The students were to complete the Self-Assessment Rubric prior to turning in their lab report (Appendix C). This rubric served as a checkpoint to ensure that the students had included all important information and to have them reflect on how well they thought they performed in writing the lab report. If they believed that they needed help in one particular section of the lab and they all were having trouble with that section, I knew I would have to focus on that area in class. If the students were scoring themselves high in an area and their actual scores were much lower, I would know there were some misconceptions on how a well-constructed lab report should look. The Pre-Review Assessment data was analyzed for general themes and trends and compared against the post survey (Appendix B).

After the fourth week, peer reviewing was introduced. Students were given the same amount of time to complete their lab reports as before, but instead of turning them into me, the due date was set aside for a peer review session. Each student was given a

different colored pencil which they used as they read through the report and made comments on grammatical errors, formatting, and any other items that they found were incorrect. Every student was allotted seven minutes to read though each report. This time was selected based on the average length of time most of these students finished reading similar reports during 2010-2011 school year. They then signed their names on the last page with their colored pencil and passed the report onto the next student. The goal was to review at least three reports in the class. The students then were to take their reviewed lab report home and make any appropriate corrections needed and turn in the final copy the following day. On the peer review day, the writers were also able to comment on the reviews they received from their peers if they so choose. This portion of the project lasted four weeks. Using the Peer Review Rubric, students were asked to anonymously evaluate their group members on how well they performed at the tasks assigned to them during that class period (Appendix D).

Upon completion of the study, student scores from lab reports were compiled and computed. This gave quantitative validity to the project. The students were also asked to complete the Through the Students' Eyes verbal interview in order to acquire a student perspective of the peer review process and provide qualitative legitimacy to the study (Appendix E). The students' responses were recorded and similar replies were noted and tabulated.

Since one of the main goals of this project was to enhance the students' ability to assemble a well written lab report, vocabulary and writing skills played an important part in this process. Other teachers of students in the study were given Student Performance Surveys at the beginning of the year to comment on how well these particular students

performed with writing in their classrooms (Appendix F). These teachers were asked to respond to the surveys one more time throughout the course of the study. The teachers were asked to rate their students ability to write in their classroom with an *above average, average, or below average* rating. They were also asked whether they thought that writing in biology class would help with their writing in their subject area. This was easily answered with a yes or no. The last question pertained to the students' ability to follow directions in their classroom. This response included ones such as: *does not follow directions often, follows directions some of the time, and follows directions most of the time* (Table 1).

The research methodology for this project received an exemption by Montana State University's Institutional Review Board and compliance for working with human subjects was maintained.

Table 1
Data Triangulation Matrix

Questions	Data Source		
Focus Question: Does peer reviewing help students write better lab reports?	Student Survey	Before/After Scores	Documentation of comments on peer reviewed lab reports?
Sub-question 1: Do students perform the physical part of the lab with more confidence after performing peer review sessions?	Interviews	Student journaling and self assessment	Observations
Sub-question 2: Are students more engaged in labs (knowing that they have to write about what they completed during lab)?	Observation	Anonymous Peer evaluation of group participants	Written Documentation
Sub-question 3: Do students provide better constructed essay answers on exams?	Pre-peer review baseline scores	Post peer review scores	Teacher surveys

DATA AND ANALYSIS

The results of the Pre-Review Assessment indicated that students' writing improved during the treatment. No one had scored below a *comfortable* on the scale. There were many *completely comfortable* in the questions of how well they could generate the introduction, materials list, procedure. These categories all scored a 50% or higher. For the discussion section, 50% of the students felt they were *very comfortable*, while 33% felt they were *completely comfortable* in generating this portion of the lab report ($N=14$). The results in showed an increase in all aspects of writing a lab report from the time before using peer review to after using peer review (Table 2). Most sections increased two-fold with the exception of writing the results and whether or not peer review would help them write a better lab report. When asked their comfort level writing the introduction/background to a lab, 14% reported being *comfortable* or *completely comfortable* before treatment and 42% reported that comfort level after treatment. Before treatment, 14% of the students reported high comfort level generating the discussion narrative and 45% reported high comfort after the treatment. Prior to the treatment, the comfort levels were quite low, expressing a 21% for *comfortable* or *completely comfortable*, and then increasing to a 68% after the treatment. Students also were not so comfortable reviewing a peer's lab report with only 21% reporting *comfortable* before the treatment and climbing three-fold to a 67% expressing high comfort after the treatment.

Table 2
Average Comfort Levels in Writing Lab Reports Pre-assessments and Post-assessments,
(*N=14*)

Description of Data	Nontreatment (%)	Treatment (%)	Change (%)
Comfortable writing Intro/background Info	14	42	+28
Comfortable generating material list	43	83	+40
Comfortable generating the procedure	21	58	+37
Comfortable generating the results section	29	33	+5
Comfortable generating discussion portion	14	33	+19
Comfortable self-reviewing own report	29	75	+46
Comfortable reviewing peer's lab report	21	67	+46
Feel that the peer review process will/has enhanced their lab writing skills	43	58	+15

The laboratory activities were voted as the best part of class by the *Through the Students' Eyes* interview (Appendix E). Many of the categories from the interview received 100% confirmation that the strategies being utilized with peer review were helping. When asked if they thought that the labs helped them understand the concepts we were currently working on, one student commented, "Yes, we are able to formulate our own ideas about the concepts. We can also see it demonstrated." Another student suggested, "Yes, I strongly believe the labs help us a lot. They give us some firsthand experience on what we are learning." Several students also stated that the labs helped them understand the concepts because they first learned the material and then they can actually do the lab that enforced what they learned prior to the lab.

Several responses were given about whether the students believed that the lab reports were helping them understand the lab activities better or not. While the majority agreed that they did help understand the methods and purpose better, 14% did not ($N=14$). “Yes, it gives us another chance to review what we have learned,” claimed one student. Another student affirmed, “I kind of think that it has helped. It helps tie up all the loose ends and figure out key details.”

When asked if they thought the peer review sessions helped with the creation of a better lab report, most responded with a positive remark. Said one student, “Yes, because they corrected parts that were wrong that you may have thought were right.” Another student commented, “Yes, by reading other’s lab reports, I find things that I did not even think of writing.”

While the class was split with half being visual learners and the other half being tactile learners, both agreed that their favorite part about class was the lab activities ($N=14$). The majority of the class believed that writing the lab reports helped them understand the lab activity better than when they did not write a lab report, while 7% did not think the lab reports helped. One hundred percent of the students felt that the labs helped them understand the lecture material better, they became better at writing the lab reports than when they first started writing them, and the labs themselves became easier to perform over time.

When asked whether they believed that the peer review process helped them write a better lab report, 85% of the class reported it did while the remaining 15% did not, although 100% reported they felt they were able to provide valuable feedback when peer reviewing a classmate’s lab report ($N=14$). When asked their best place to write their lab

reports, students responded with 71% saying they preferred to write at school and 29% of them rather write at home (Figure 3).

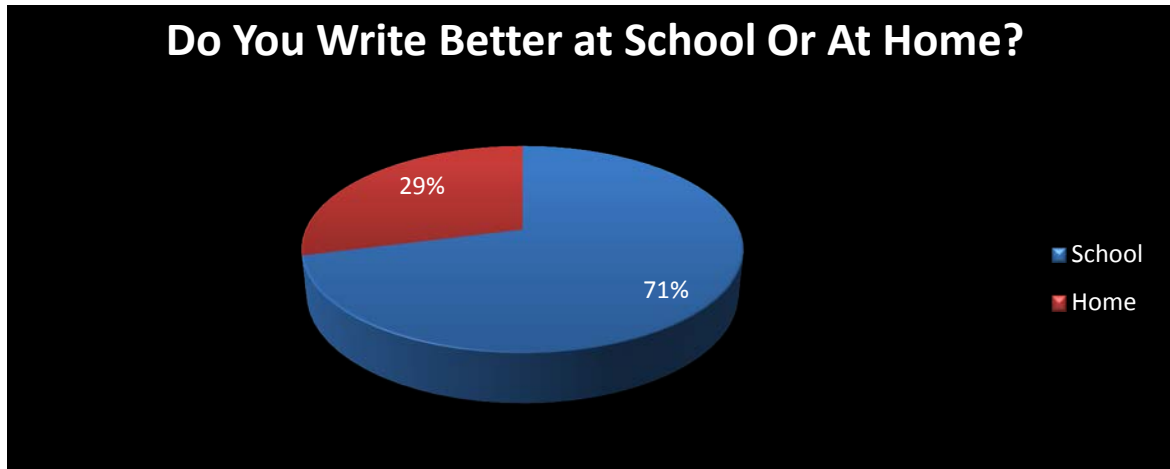


Figure 3. Does the Student Write Better at School or at Home?

The peer review process delivered a divided response to how it should be carried out with 21% with having the teacher decide who reads which papers during the class period instead of the students choosing, 29% wanting more time to read and review the reports, and the remaining 50% not wanting to change anything (Figure 4).

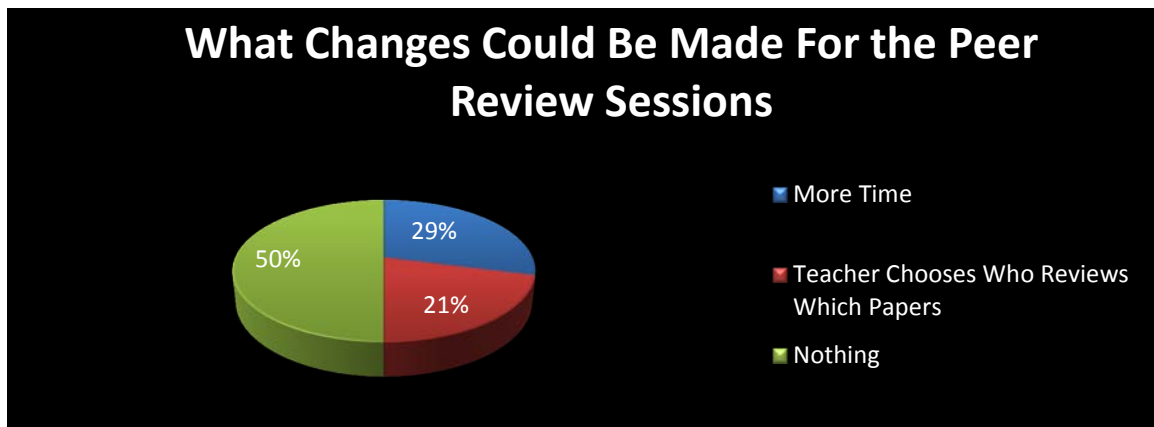


Figure 4. Peer Review Session Changes ($N=14$).

The class averages for lab report grades increased by 15 percentage points from pre- to post-treatment. While the students started out with a range of 70 to 75% average on their lab reports before peer review was introduced, they were able to achieve an 85 to 90% lab report grade average after the treatment. I observed many fewer errors and more proper formatting as the treatment progressed (Figure 5).

Running the Gel

1. After the DNA samples are loaded, carefully snap the cover down onto the electrode terminals. Make sure the negative and positive color-coated indicator on the cover and apparatus are properly oriented.
2. Insert the plug of the black wire into the black input of the power source (-). Insert the plug of the red wire into the red input of the power source (+).
3. Set the power source and required voltage and conduct electrophoresis.
4. Check to see if the current is flowing properly. If it indeed is, you should see bubbles.
5. After the electrophoresis is completed, turn off the power and unplug. Disconnect the leads, and remove the cover.
6. Remove the Gel beds for staining

Observation

- Before you will be able to see any of the bands, you will have to remove the stain from the gels. To do this, follow these instructions and repeat as many times as necessary.
 1. Carefully hold the gels with one finger and drip the excess stain out into the sink.
 2. With a beaker full of water, slowly pour some of it into the gel dish so that it covers the gel.
 3. Repeat steps one and two until you can see the DNA bands and the gel is quite clear.

Data

The diagram shows a gel with six lanes. Lane A is labeled 'crime scene', Lane B is 'crime scene', Lane C is 'suspect one', Lane D is 'suspect one', Lane E is 'suspect two', and Lane F is 'suspect two'. Arrows point from these labels to the corresponding lanes. A handwritten note 'Did these move?' with an arrow points to the bands in Lane E.

Figure 5. Post-Treatment Sample of Student's Lab Report

The very first lab reports had several scores of 50%, and while the students were getting better at writing the reports over time prior to the peer review being introduced, there were several that were still receiving 60% on the reports. However, after the peer review was introduced, there were no reports less than 85% in the first two labs and none less than a 90% on the last two labs (Figure 6).

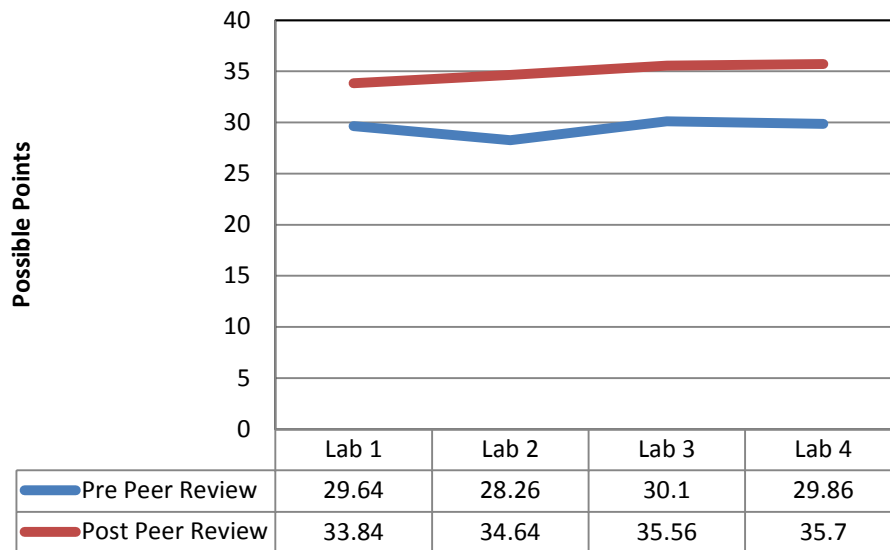


Figure 6. Average scores of students' lab reports of pre and post treatment, ($N=14$).

The results of the Student Performance Survey taken by teachers indicated that half of the teachers believed that the students had average to above average abilities in writing skills at the beginning of the year, while 75% of the teachers scored the students at above average and 25% scored average at the end of the year ($N=4$). They all believed that writing lab reports in biology helped the students' writing in their classes, and 50% said that they would also start using writing rubrics and peer reviewing in their classes as well. All agreed that these students follow directions most of the time and the English

teacher suggested doing several research papers together that would include her material and biology all in one report.

INTERPRETATION AND CONCLUSION

I was very impressed with the results. According to the data, the students *did* write a better lab report while utilizing the peer review method than when they did not. Not only did the students really seem to value the experience, they seem to really enjoy engaging in it. They not only wanted to peer review their lab reports, but other graded papers and reports as well. They were currently reading several high level scientific journals about carcinogens that require much thought and effort to generate a well written report during the end of my project. While I did not originally have time set aside for a peer review session, several of the students requested it. The students are seeing the value stemming from these peer review sessions. The students grades increased from these sessions by about 15% on average and by the end of the treatment period, the students noticed that their papers were receiving fewer and fewer markings needed for correction.

There were some lab reports that were given without a written lab protocol. I visually and verbally showed them how to do the lab and set them free to conduct the lab activity and write the lab report.

Using the rubrics provided for them, the students did very well evaluating each other's lab reports. Initially, while the students mostly agreed that they would not have any difficulty peer reviewing other members of the class in the Pre-Review Assessment looking back, I would say they were a bit apprehensive. However, that apprehensiveness did not take long to dissolve. The students tend to be very critical about each other's

work, but at the same time want to offer suggestions to help the reviewee. One of the reasons I did not do this anonymously is because I wanted this interaction. This is a good natured class and I knew this type of interaction would help, not hinder, their writing.

Since the introduction of peer review, there has been a noteworthy increase in confidence levels in the students' writing abilities. Because of this I have been able to introduce some very high level reading to them that I am not able to do with my other classes. The students might not understand the full benefit that they received this year until they are in college, but I along with several other teachers, have been able to see it firsthand.

The goal of this study was to advance students' science writing skills over time through exposure to the repetition of writing, peer reviewing, and re-writing lab reports. Jardine concluded that both strong and weak students are able to benefit from a peer evaluation system and that learning is a social process (Gaillet, 1994). Trautmann (2009) believes practicing peer review allows students opportunity to fine-tune these skills with supervision, so they can utilize them efficiently in their future careers. I believe the previous two statements summarize how my students reacted to the treatment of peer review. Everyone benefited from the peer review process and they were very engaged in the social process of how and why something needed to be changed or why something was well written. This also helped them understand that because learning is a social process, they are able to take these skills and apply them to other aspects of their schooling and future careers.

VALUE

The students gained a great deal of self worth and empowerment. They know they are able to generate high quality lab reports and are able to give insightful reviews of other peer's reports. I plan on using this process for all reports and papers to be turned in to me for a grade. The students seem to learn so much more than if they just sat down and wrote what they *thought* I wanted them to write. The rubric gives clear concise instruction of what should be included in each part of the report and allowing students to read and correct others' work enables them to see mistakes they may have also made. They may use these strategies in classes other than mine and achieve better grades because of them.

I know English classes use a rubric and peer review sessions for all of the papers that are turned in. The students are used to writing in almost every subject, so this type of writing is just an extension of what they do every day. The students truly took to this type of learning. These students want to better their scores and achieve high marks and the peer review process enables them to do just that. I will continue to do peer reviewing for all assignments of this nature, lab reports and papers, in the coming years. I have had much success with last year's class and this year's class. Next year I would like to include some differentiated classes and see how well the lower functioning classes would perform with this process.

I have found that is a very important tool for me to see the different stages of growth from where the students were weak in formulating the different sections of the lab report and where they were strong. The strength started to over-power the weaknesses by the second round of peer review, which was much quicker than I anticipated. Next year,

I will not need a “control time” and will start the students almost right away on peer review.

This experience has changed how I teach with this class. It is a very open and question-oriented class. It may look like chaos; it is *organized* chaos. The students are engaged, learning, and, yes, talking. While someone walking by may hear a low rumble of talking, if they stopped to listen, they would hear some great scientific comments and discussions. The students in this class are quite focused and have well exceeded my expectations for what I needed them to accomplish this year. These students, by the third semester, were prepping their labs they would be using that week. I call it the “Divide and Conquer” portion of the lab. I put the jobs that need to be completed and prepped up on the board. Usually there are about four to five different jobs that need to be finished that day such as making the agarose gel for DNA profiling or cutting up plastic bottles for Microdensity of Plastics. The students were able to choose their own groups they can work well with, and then choose a job they think they would do well. This is the “divide” part. The “conquer” part describes them actually performing the lab preparation itself. I have noticed that the similar learning styles tend to clump together. The ones who are tactile learners love to make things, such as the gels, while the visual learner would rather measure or weigh items. Either way, they know that everything must be completed in the 45 minutes so that the lab is ready for the following day or days. This saved me countless hours trying to prep every lab by myself. The students say that prepping the lab has not only taught them additional lab techniques, but has given them an appreciation of the efforts required by their science teachers to get a lab ready-to-go for their students. The students have also taught me that everything is a learning process. While they may

have not been able to write a lab report very well at the beginning of the course, they sure can now; and that is without even batting an eye. Because of the steps taken with the lab writing and peer review, other, more in-depth assignments came more easily. These students were able to generate well written two to three page paper from college level scientific journals because of the confidence they had in themselves and in their classmates from peer reviewing. I could not be happier and more proud of these students and their accomplishments this year.

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APPENDICES

APPENDIX A

LAB REPORT RUBRIC

Lab Report Rubric

Lab Activity: _____

Student Name: _____

Date: _____

CATEGORY	4	3	2	1
Background Information	Several reputable background sources were used and cited correctly. Material is translated into student's own words.	A few reputable background sources are used and cited correctly. Material is translated into student's own words.	A few background sources are used and cited correctly, but some are not reputable sources. Material is translated into student's own words.	Material is directly copied rather than put into student's own words and/or background sources are cited incorrectly.
Hypothesis	Hypothesized relationship between the variables and the predicted results is clear and reasonable based on what has been studied.	Hypothesized relationship between the variables and the predicted results is reasonable based on general knowledge and observations.	Hypothesized relationship between the variables and the predicted results has been stated, but appears to be based on flawed logic.	No hypothesis has been stated.
Materials	All materials and setup used in the experiment are clearly and accurately described.	Almost all materials and the setup used in the experiment are clearly and accurately described.	Most of the materials and the setup used in the experiment are accurately described.	Many materials are described inaccurately OR are not described at all.
Procedures	Procedures are listed in clear steps. Each step is numbered and is a complete sentence.	Procedures are listed in a logical order, but steps are not numbered and/or are not in complete sentences.	Procedures are listed but are not in a logical order or are difficult to follow.	Procedures do not accurately list the steps of the experiment.
Analysis	The relationship between the variables is discussed and trends/patterns logically analyzed. Predictions are made about what might happen if part of the lab were changed or how the experimental design could be changed.	The relationship between the variables is discussed and trends/patterns logically analyzed.	The relationship between the variables is discussed but no patterns, trends or predictions are made based on the data.	The relationship between the variables is not discussed.
Data	Professional looking and accurate representation of the data in tables and/or graphs. Graphs and tables are labeled and titled.	Accurate representation of the data in tables and/or graphs. Graphs and tables are labeled and titled.	Accurate representations of the data in written form, but no graphs or tables are presented.	Data are not shown OR are inaccurate.
Conclusion	Conclusion includes whether the findings supported the hypothesis, possible sources of error, and what was learned from the experiment.	Conclusion includes whether the findings supported the hypothesis and what was learned from the experiment.	Conclusion includes what was learned from the experiment.	No conclusion was included in the report OR shows little effort and reflection.
Appearance/Organization	Lab report is typed and uses headings and subheadings to visually organize the material.	Lab report is neatly handwritten and uses headings and subheadings to visually organize the material.	Lab report is neatly written or typed, but formatting does not help visually organize the material.	Lab report is handwritten and looks sloppy with cross-outs, multiple erasures and/or tears and creases.
Participation	Used time well in lab and focused attention on the experiment.	Used time pretty well. Stayed focused on the experiment most of the time.	Did the lab but did not appear very interested. Focus was lost on several occasions.	Participation was minimal OR student was hostile about participating.

APPENDIX B

PRE-REVIEW ASSESSMENT

Please circle the number that most represents your comfort level on that particular question.

****Please note: This survey is completely voluntary and will in no way affect your grade or class standing****

1. I feel comfortable writing the introduction/background information on a lab report.

	Not at all comfortable		Completely Comfortable		
Level	1	2	3	4	5

2. I feel comfortable generating the lab report's materials list.

	Not at all comfortable		Completely Comfortable		
Level	1	2	3	4	5

3. I am comfortable generating the procedure on the lab report.

	Not at all comfortable		Completely Comfortable		
Level	1	2	3	4	5

4. I feel comfortable in generating the results section of the lab report.

	Not at all comfortable		Completely Comfortable		
Level	1	2	3	4	5

5. I feel comfortable generating the discussion part of the lab report.

	Not at all comfortable		Completely Comfortable		
Level	1	2	3	4	5

6. I feel comfortable self-reviewing my own lab report.

	Not at all comfortable		Completely Comfortable		
Level	1	2	3	4	5

7. I feel comfortable reviewing one of my peer's lab reports.

	Not at all comfortable		Completely Comfortable		
Level	1	2	3	4	5

8. I feel the peer review process will/has enhance(d) my lab report writing skills.

	Not at all comfortable		Completely Comfortable		
Level	1	2	3	4	5

APPENDIX C

SELF-ASSESSMENT RUBRIC

Self-Assessment Rubric

Name _____

****Please note: This survey is completely voluntary and will in no way affect your grade or class standing****

Rate yourself 1-5. 1= Poor 3=Avg 5=Superb N/A = Not applicable

I have provided sufficient and accurate background information in the introductory paragraph.	
I have defined a hypothesis statement for the lab performed.	
I have listed all materials in which I used during the experiment in the "Materials" section of the lab report.	
I have created a procedure in which someone would be able to follow my directions directly from my lab report.	
I have provided a data chart that is correctly labeled.	
I have provided ample analysis for my findings.	
I have a well written conclusion (with citations) that states whether I accept or reject my hypothesis.	
My paper is free of grammatical errors and is in the correct lab report format.	

APPENDIX D

PEER REVIEW RUBRIC

Peer-Review Rubric

Name of Reviewer _____

****Please note:** This assessment is completely voluntary and will in no way affect your grade or class standing**

Rate the Writer on a scale of 1-5. 1= Poor 3=Avg 5=Superb N/A = Not applicable

Writer has provided sufficient and accurate background information in the introductory paragraph.	
Writer has defined a hypothesis statement for the lab performed.	
Writer has listed all materials in which I used during the experiment in the "Materials" section of the lab report.	
Writer has created a procedure in which someone would be able to follow my directions directly from my lab report.	
Writer has provided a data chart that is correctly labeled.	
Writer has provided ample analysis for my findings.	
Writer has a well written conclusion (with citations) that states whether I accept or reject my hypothesis.	
His/Her paper is free of grammatical errors and is in the correct lab report format.	

Questions of the Writer:

Writer's Rebuttal:

Comments to the Writer:

Writer's Rebuttal:

APPENDIX E

THROUGH THE STUDENTS' EYES

THROUGH THE STUDENTS' EYES INTERVIEW

****Please note: This interview is completely voluntary and will in no way affect your grade or class standing****

1. In what category would you place your learning style: auditory, visual, tactile?
2. What is your favorite part of science class? What is your least favorite part?
3. Do you think the labs that we do in class help you to understand the concepts we are working on in the book? Why or why not?
4. Do you think performing a lab has gotten easier or harder as the year has progressed? Why or why not?
5. Do you think writing a lab report has helped with your understanding of the hands-on activities that you did in lab (laboratory objectives)?
6. Do you think you are better at writing a lab report than when you first started at the beginning of the year? Which part do you write the best? (Introduction, Procedure, Results, Discussion, or Conclusion) Why do you think this may be?
7. Do you think the peer review sessions have helped you write a better lab report than when you were just writing the report yourself? If so, how? If not, why?
8. Are you able to give valuable feedback to other students' work when participating in the peer review sessions?
9. How can I improve the peer review sessions to make them more beneficial to everyone?
10. Does working during scheduled class time help you write a better report or do you write better at home?
11. Is there anything else I should know?

APPENDIX F

STUDENT PERFORMANCE SURVEYS

Student Performance Survey—Please put an “X” in the appropriate selection.

Teacher Name _____

Teachers: For my action research project I am conducting how students improve in writing lab reports when peer review is introduced into the curriculum. While totally voluntary, I would appreciate any time you can spare to complete this survey. Please place the completed survey in my mailbox at your earliest convenience. Thank you.

1. How do you perceive the writing abilities of the students within your class?

	Below Average	Average	Above Average
Level	_____	_____	_____

2. Do you think writing lab reports in biology will help the students' writing in your class?

	Yes	No
Answer	___	___

3. How would you rate your students in the ability to follow directions?

___	Does Not Follow Directions Often
___	Follow Direction Some of the Time
___	Follow directions Most of the Time

Other Comments You May Have

4. Suggestions to how I can implement your type of classroom writing into my classroom: