Inquiry-Based Science:
An Alternative to "Reading the Chapter and Answering the Questions"

Leanne M. Davis
Corl Street Elementary, Intern
Fourth Grade
lmd252@yahoo.com

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BACKGROUND INFORMATION:

"Please read chapter 3 in your science book and answer the questions at the end of the chapter." How do you make science more interesting for students than just reading a chapter and answering questions? I hated science, did you? This study explains ways to make science inquiry-based and students "turned on" to learning in a fourth grade classroom during a unit about electricity.

Teaching Context:

This project took place in a fourth grade classroom at Corl Street Elementary School in the State College Area School District in State College, Pennsylvania. Corl Street is a small neighborhood school that has two classes of each grade. This specific fourth grade classroom was comprised of twenty-two students, thirteen boys and nine girls. For the most part, many of the students worked well independently and with each other. All of the students were enthusiastic to learn, especially in Science.

Purpose for this Inquiry:

As a student I never enjoyed science, but when I taught science for the first time my views of science quickly changed. I was curious as to why my views changed so quickly. As a student, my experience with science came straight out of a textbook. I would read a chapter, listen to my teacher talk about the subject, and then I would take a test. In my science methods course, I was introduced to inquiry-based teaching. It focuses on the idea of students being involved in and shaping the learning experience. I have based my science teaching on this approach. I was curious to find out how the

students felt about both approaches- the traditional textbook, teacher-directed approach and a hands-on inquiry approach. What approach would they prefer?

What Others Think and Know About this Topic:

After reading a number of studies and articles on different approaches to teaching science to children, I became more informed about the experts' views on comparing the different science teaching strategies. A report of the National Research Council, entitled *How People Learn,* presented findings from a study that demonstrated how learning occurs. The first finding in this study was that to understand science one needs to know more than just facts. It pointed out that for students to be able to learn, they need to understand the major concepts and be able to apply them in different situations. The study's next finding was that science concepts build on one another; therefore, students need to master basic concepts in order to understand more complex information. Another finding stated that learning is guided by an interactive environment where students work with each other. Finally, the last finding declared that effective learning requires students to take control of their own learning. All of these findings correlate with an inquiry-based teaching strategy.

In addition, guidelines were also specified in National Science Teachers Association WebNews Digest report written by Anne Tweed, National Science Teachers Association (NSTA) President. The Horizon Research, Inc. conducted a study concluding that 77% of students learned better when taught to design experiments and control variables. While only 23% of students learned better when asked to conduct open-ended inquires without teacher guidance. "Teachers must teach students an experimental design process before students can be asked to conduct their own

experiments when studying science concepts" (Tweed, 2003). Overall, the research favors an inquiry-based approach to teaching science that includes some teacher guidance.

In contrast to inquiry-based instruction, there is the traditional or direct approach to teaching science. According to the NSTA Press publication *The Lingo of Learning*, "direct instruction results in the teacher (who is the expert) passing knowledge directly to students. The student role is a passive one, and the lecture delivery mode is often equated with direct instruction." Although I found articles that described the direct teaching approach, I found no science experts who supported a traditional approach to teaching science. According to Bruce Alberts "…this kind of teaching misses a tremendous opportunity to give all students the problem-solving, communication, and thinking skills that they will need to be effective workers and citizens in the 21st century" (2000). Alberts continues about the direct-teaching method, "In this approach—which remains depressingly common today—teachers provide their students with sets of science facts and with technical words to describe those facts. This type of science teaching assumes that education consists of filling a student's head with vocabulary words and associations…" (2000).

Wonderings/Questions:

As a student I did not enjoy science, but I love to teach the subject to my class. From this change in feelings, I developed the following wonderings.

- Why did I not like learning about science, but love teaching it?
- Do my students enjoy learning about science as much as I like teaching it?

- Do my students prefer learning from an inquiry-based lesson or a teacher-directed lesson?
- Do students retain information better when it is taught in a particular way?
- What observable differences are there between teacher-directed and inquiry-based lessons?
- Can a teacher-directed lesson be made into an inquiry-based lesson?
- What are the noticeable differences between preparing a teacher-directed lesson and an inquiry-based lesson?

MY INQUIRY PLAN

What I did to Implement Inquiry in my Classroom:

I implemented inquiry in my classroom through lesson plans (Appendix A). In order to uncover my students' feelings on science instruction, I prepared three inquiry-based lesson plans and two teacher-directed lesson plans. I taught four of the five lessons; two were inquiry-based two were teacher-directed. These lessons were taught over a two-week span alternating from inquiry-based to teacher-directed. Because it addressed a topic that was previously covered in a teacher-directed lesson, I never taught the third inquiry-based lesson. Because I would be collecting student survey information, I needed to make sure the lessons taught in the classroom were covering different topics. If two lessons covered identical material, the data collected from the students would be difficult to analyze, because the students would be responding to two methods of teaching rather than one.

Data Collection:

The primary method of my data collection was student surveys. After each lesson, the students completed a survey (Appendix B). All four surveys were structured the same. I issued the surveys after each lesson to determine whether students' preferred teacher-directed or inquiry –based instruction. These surveys gave students time to reflect on the lessons by asking if they did or did not enjoy the lesson, what they did and did not like about the lesson, what they learned from the lesson, and, finally, what was easy about the lesson. Additionally, students had the opportunity to make any additional comments about the lesson.

At the conclusion of the series of lessons, a final survey was given to all of the students (Appendix B). This survey was designed to assess how students felt about science and their success in science up to this point in the school year. First, I had the students rank different school subjects in order from their favorite to least favorite. This gave me insight on those students who were or were not passionate about science. I wanted to look carefully at both the students who ranked science high and the students who ranked science low. I wanted to look at the surveys they completed after each lesson to see if there were any correlations. I also had the students list their favorite and least favorite topic we covered in science this year. I was curious to see if the responses for favorite and least favorite topic had any connection with the way the information was presented.

The last type of data collected was actual student work (Appendix C). I assigned an assessment activity after each of the three lessons. This gave me the opportunity to

see if my students understood the information better when it was presented in a particular way.

After the teacher-directed lesson on parallel and series circuits, a homework assignment was given to the students to complete that night. The students had to fold a piece of paper into two columns and write "series" and "parallel" above each column. Then, they had to write three facts about each circuit. Finally, they had to draw and label a picture representing each type of circuit.

Following the inquiry-based lesson on switches, the students were given a brief writing assignment. They had to pretend they were an electron and follow a circuit path that had a switch. They had to write about this journey.

The last assessment was given immediately following the teacher-directed lesson on electromagnets. The students had to complete some questions that were covered during the lesson, and they had to label parts of an electromagnet.

Ways I analyzed the Data:

I analyzed the daily surveys by first looking at the total number of students who enjoyed and not enjoyed the lessons. Then I examined whether the student liked or disliked the lesson and their reasons that supported that feeling. I wanted to see if there was a pattern that developed for the students who identified a dislike for the lesson.

I was particularly interested in response to one question on the final survey. I wanted to calculate the number of students who said science was their favorite subject and the students who put science as one their least favorite subjects. I then took a closer look at the daily surveys of those students who liked science as well as the students who

did not care for science. I looked for a pattern in the final and daily surveys that would reveal if there were any instances that a student disliked a particular lesson and ranked science as one of their least favorite subjects. Furthermore, I searched for an opposite pattern; I looked for students who ranked science high but disliked a lesson. Lastly, I examined if a student ranked science low but liked a particular lesson.

Finally, I looked at the range of scores on each assessment activity. I calculated the average score and score range of each assessment, noting whether or not there was a noticeable difference between scores of each assessment. Also, I wanted to see what type of lesson gained the lowest assessment average and what type of lesson gained the highest average.

WHAT I LEARNED

My Claims:

After collecting and analyzing the data, I formulated the following three claims which address the previously stated wonderings:

- Teacher-directed science lessons can be turned into inquiry-based lessons.
- Inquiry-based lessons require careful attention to organization and management of materials, instruction, and students.
- Students become active learners, make sense of their learning, and enjoy science more when the lessons are inquiry-based.

Evidence to Support the Claims:

1) The main evidence for my first claim was two lesson plans that covered the same topic in two totally different ways. I took a topic and developed it as a teacher-directed lesson, then turned the same topic into an inquiry-based lesson (Appendix A).

After looking at the same plans, the same information was covered, but in a much different way.

In the teacher-directed lesson, the students sat on the carpet and took notes on new information that I put on the board. Also, the definitions of a parallel and series circuit were put on the board with a few drawings to help the students visualize the circuits. I encouraged students to ask questions throughout the lesson. The only experience the students had with circuits during this lesson was listening to the information I gave them and examining the diagrams I drew on the board.

Image1-1 shows me drawing diagrams during the teacher-directed lesson on parallel and series circuits.

Image 1-2 shows the students taking notes during the teacher-directed lesson on parallel and series circuits

The same ideas and concepts were addressed in the inquiry-based lesson, but in a much different manner (Appendix A). At the beginning of the lesson, the following materials would be put out on each set of desks: 2 D batteries, 2 battery holders, 3 bulbs, 3 bulb holders, 7 pieces of wire, and poster paper with “series” and “parallel” questions. The students would follow the directions on worksheets that were located in their science journals to build different circuits and answer the given questions (Appendix A). In both lessons, the students would be exposed to information about parallel and series circuits, but by using different teaching strategies the students would have different learning experiences.

2) My second claim stated that I believe an inquiry-based lesson requires careful attention to organization and management of materials, instruction, and students. I took careful notes as I prepared an inquiry-based lesson and a teacher-directed lesson. The inquiry-based lesson did indeed involve much more organization and management.

I will now explain the steps that I took to prepare and carry out the inquiry -based lesson about a switch within a circuit (Appendix A). Several days prior to the actual day of teaching, I needed to construct a lesson plan that would help me carryout the lesson. It took careful planning, because an inquiry-based lesson needs to be organized for it to be successful. After constructing the lesson plan, the materials needed to be gathered for the actual lesson. Two days prior to teaching, I had to gather enough materials to have four different groups. The following materials were put in each group's material bag: D cell battery, 5 pieces of wire, 6 brass paper fasteners, light bulb, bulb holder, battery holder, 2 paper clips, and 2 (8x8cm) squares of tag board. Before putting the materials in the bag, I needed to test the batteries and bulbs to ensure that the lesson would run smoothly. After looking over the directions on the worksheets provided to the students, I realized that switches needed to be made with the paper clips, tag board, and paper brass fasteners. Since there are only 50 minutes set aside for science, I thought it was necessary to have the switches already made for the students. This way, the students did not spend any time preparing materials for the experiment. Now that I had all the materials ready, I had to test out the procedures. This was completed to ensure that the directions were clearly stated for the students to follow. I also wanted to be familiar with the experiment so I could answer any questions that the students posed. Usually for this type of lesson I

group the students prior to the lesson; however, for this lesson, I decided to allow the students to work within their regular table sets.

The previous tasks were all completed prior to the actual day of the lesson. On the actual day of the lesson, I had to set up each table for the lesson. First, I made sure that every table had a bag of materials. Then, I took into consideration any students who were absent; if one table had fewer students, I rearranged the groups to be more equal in size. When the actual lesson started, I needed to explain the expectations for the day, and because the students were working in groups, it was important for the students to understand the expectations. During an inquiry-based lesson, students can easily get side-tracked. As soon as the groups started the experiment, I had to be available to answer any questions, help the groups when necessary, and take advantage of any teachable moments. As I walked around, I took notes on a checklist (Appendix D) to make sure the students were using their "12 inch" voice, working together, and staying on task. This was very helpful with behavior management. At the conclusion of my lesson, my work was not finished; I needed to take inventory of the materials that were handed in by each group. After I checked if all the materials were returned, I needed to place them in the necessary storage bins in order for the other teachers to be able to use them.

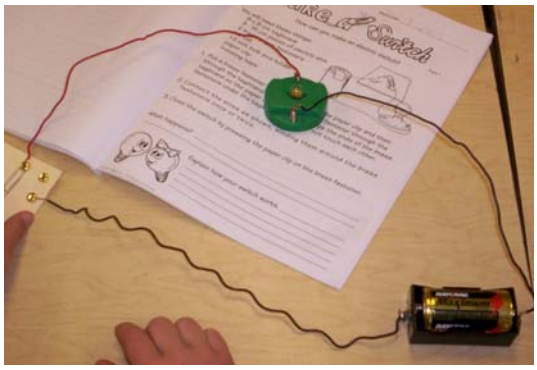

Image 1-3 shows a complete circuit built by a group during the inquiry-based lesson about switches.

Image 1-4 shows a student working the switch during the inquiry-based lesson about switches

On the other hand, the teacher-directed lesson on parallel and series circuits did not take as much preparation and management of materials and behavior. Like the inquiry-based lesson, I created a lesson plan several days before I actually taught it. Because I was serving as the expert and passing along information to the students, this lesson plan consisted of more factual information. The only materials I needed to gather, prior to the lesson, were an erasable marker and construction paper for the homework. When comparing the two types of lessons it was obvious that the inquiry-based lesson took much more preparation and close observation. Is it worth it? The third grouping of evidence provides insight as to how the students feel about the different teaching styles.

3) The student surveys gave me great evidence about the students' feelings regarding each teaching strategy. The two surveys that were administered after each inquiry-based lesson were quite conclusive. After analyzing the data from the survey about the inquiry-based lesson on circuits, I noticed that 95% of the students enjoyed the lesson. One student (Student A) gave a response of "yes and no" to the question asking about enjoyment of the lesson. I looked further into what he did not like about the lesson. Student A commented on the cooperation of his group. The group did not work well together, which lead to Student A's frustration and consequential dislike of the lesson. I looked at how Student A felt about the other inquiry-based lesson on the switch. Student A liked the lesson, which made me conclude that his dislike of the group placement truly influenced his feeling on that particular lesson. Other students had very positive experiences with the circuit lesson. Student B explained what she liked about the lesson by saying, "I liked that you got to experement [sic] with the light"(2005). Student C

commented, “[I] liked everything about this lesson. I thought it was fun and I liked my group”(2005).

The other inquiry-based lesson was not as lop-sided, but the evidence still suggested that students overall, enjoyed this lesson. Sixteen out of 21 students (76%) enjoyed the inquiry-based lesson on switches. Three out of 21 students (14%) were noncommittal about the lesson. Two out of 21 students (about 10%) did not like the lesson. Initially, I wanted to examine the students who were noncommittal- I wanted to know what they disliked about the lesson. As it turned out, all three of the students enjoyed the other inquiry-based lesson. Two of the students had complications within their groups, and the other student did not like the homework assigned at the conclusion of the lesson. These circumstances show me that it was not the actual instruction of the lesson that the noncommittal students disliked. I then looked at the two students who did not like the lesson. One student disliked the lesson because of the group in which he was placed, but I noticed that this same student enjoyed the other inquiry-based lesson. The second student, and his group, had difficulty successfully completing the procedures of the experiment, but, like the other student, this student enjoyed the other inquiry-based lesson.

On the other hand, the students had different opinions about the teacher-directed lessons. The results were not as unbalanced, but they were noticeably different when compared to the inquiry-based lesson reflections.

Starting with the teacher-directed lesson on parallel and series circuits, 9 out of 21 students (43%) enjoyed the lesson. Five out of 21 students (24%) were noncommittal about the lesson. A large amount of 7 out of 21 students (33%) did not enjoy the lesson.

This was noticeably different, because the “yes” responses did not overwhelmingly appear more than the “no” responses. The number of responses for each choice was almost equal. Two of the students stressed that sitting so long was something they did not like about the lesson. Another student, Student F, was very honest and said he liked “nothing” and disliked “everything.” I found this quite interesting, because there were no similar responses for the inquiry-based lessons. Two of the students who were undecided stated their dislike for sitting so long and writing so much. Another undecided student stressed that he liked the way that I explained the information. I must say, I was surprised at the number of students that actually enjoyed the lesson. Every one of those students said the information was easy to learn, because they just had to write it down; the pictures on the board were helpful; or I explained the information in a helpful manner.

The reflections about the electromagnet teacher-directed lesson were similar to those of the aforementioned teacher-directed lesson. There were more students who enjoyed the lesson; 13 out of 21 students (62%). Ten of those 13 students said they thought it was easy to learn the information. Three out of the 21 students (14%) were undecided as to whether or not they liked or dislike the lesson. Five out of 21 students (24%) disliked the lesson. Every student who disliked this lesson said they did not like anything at all. One of those students, Student G, said, “I didn’t really do anything” (2005). For this reason, he did not like the lesson.

Because I wanted to see how each student ranked science compared to other school subjects, I gave the students an overall response survey. Then I wanted to see if those students who did not enjoy a particular lesson ranked science high on their list. If so, it showed me that there was a higher chance that these students did not like this type

of lesson specifically. If they do not really like science, then I thought they simply did not like any type of lesson about a science concept.

In reference to the teacher-directed lesson on electromagnets, 4 out of the 5 students who disliked the lesson were available for the final survey. Those four students ranked science as one of their top three subjects. This made me believe that these students really did not like the teacher-directed lesson.

Out of the 7 students who disliked the teacher-directed lesson on parallel and series circuits, 6 of them were available to take the final survey. Four of those students ranked science as one of their top three subjects, while two of those students ranked science as one of their least favorite subjects. I looked further into the reflections that these two students completed, and this was the only lesson they did not like. As a result, I came to the belief that these two students truly did not like this particular lesson.

Similarly, I looked at the students who disliked the inquiry-based lesson on switches. These two students ranked science as one of their top three favorite subjects. The one student mentioned that he disliked the group, so I concluded that grouping was the main reason for disliking the lesson.

Since no student disliked the inquiry-based lesson on circuits, I decided to look no further into comparing that reflection to the final surveys.

In my last claim, I stated that the students would be able to make sense of their learning. The evidence I considered for this part of the claim was the scores that the class received on each assessment activity.

The first assessment I looked at was the assessment that followed the inquiry-based lesson on switches (Appendix C). The students had to write a piece, pretending

they were an electron traveling on a circuit with a switch. The average score on this exercise was 7 out of 8 (88%). Points were given when parts of the circuit were correctly described.

The next assessment that was analyzed was the parallel and series homework assigned after the teacher-directed lesson (Appendix C). The average score on this homework was 12 out of 15 (80%). The scores on this homework were not as high as the writing assignment.

The lowest average on all of the assessments was the activity that followed the teacher-directed lesson on electromagnets (Appendix C). The average score on this assessment was 7 out of 9 (78%). After reviewing the averages of each assessment, I am convinced that the students showed a better understanding of a topic after it was presented in an inquiry-based lesson.

CONCLUSIONS

Implications for my Future Practice as a Teacher:

As a future teacher, I will consider the results of this study before I teach science to my students. After conducting my surveys, it was obvious that students favor a more inquiry-based science lesson. In the future, I will use this information and approach science with inquiry in mind. I will consider what the experts said and approach an inquiry-based lesson with some level of direction for the students. I believe it is important to allow the students to experience their own learning, but I also believe it is important to provide them an opportunity to reflect on the experience.

New Wonderings:

Although many of my initial wonderings were answered, several new wonderings developed as I conducted the study. After I taught the inquiry-based lessons and analyzed the data, I noticed that several students did not like those lessons because of the group in which they were placed.

- What is the best way to group students for success in an inquiry-based science lesson?

Another wondering involves other subject areas. It was evident that students enjoyed science with an inquiry-based approach.

- Can the inquiry-based approach be successfully used in other subjects?
- Would the students enjoy it as much as science?

I taught inquiry-based lessons with two units this year, the simple machines unit and the energy and electricity unit.

- Is it possible to teach inquiry-based science with every science topic in a curriculum?

In conclusion, I answered many of my wonderings about teaching approaches for science, and, as a result of the study, I have new wonderings. This inquiry process has been a helpful experience, and I will be sure to implement the inquiry process as a classroom teacher.

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Appendices Index

E_3- Photographs from the Parallel and Series Teacher-Directed Lesson (April 5, 2005)