

SCIENCE NOTEBOOKS  
A TOOL TO PROMOTE UNDERSTANDING OF  
PROCESS SKILLS AND CONTENT

by

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July 2012

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## ABSTRACT

Many students' lack the skills for academic success and ability to communicate and understand scientific content. In this study, science notebooks were implemented to examine the impact on students' understanding of the science concepts and process skills (observation and communication). The data indicated that science notebooks and the inquiry process did positively impact students' ideas and the development of scientific literacy.

## INTRODUCTION AND BACKGROUND

### School Demographics

I have been teaching fourth grade Hardin Intermediate School in Hardin, Montana for the past 10 years. My classroom consists of 20 students with 12 of them being boys and 8 being girls. The majority of my class qualifies for free or reduced lunch and there is a wide range of cultures represented: Crow, Northern Cheyenne, Caucasian, Mexican, Blackfeet and Asian. Two of my students qualify for special education and are only in my classroom for social studies and science. Five different students leave for math intervention, a supplement program for those students that are working below grade level (Hardin Intermediate PowerSchool, 2011).

Hardin Intermediate School is located in Hardin, Montana, 45 miles south east of Billings and provides service to the Crow and Northern Cheyenne Tribes, as well as the farm and ranch community in the area. Hardin Intermediate School consists of 290 students in grades 3 through 5 with 3 intervention classrooms, 5 3rd-grade rooms, 5 4th grade rooms, and 5 5th-grade rooms along with 25 certified staff and 10 paraprofessionals. The school also provides a strong learning environment for the staff and the students.

The science program at the fourth grade consists of 30 to 50 minutes 4 days a week. It is during the last hour of school so that all the students can participate. Concepts that are covered are weather, rocks, light, sound, solar system, life cycles, matter and simple machines. We introduce the process skills at the beginning of the year and incorporate them throughout the year. This year the students were lucky enough to

have scientists from Montana State University visit our school to learn what Yellowstone Park and Antarctica have in common. Hardin fourth graders seem to really struggle with writing. I am hoping that using notebooks will help students realize that writing is a skill that they will use throughout their lifetime and can be very enjoyable.

### Focus of Study

The overarching purpose of the study was to improve my teaching and my students' understanding of the content being taught. My concern for my students' ability to communicate and understand scientific content led to my primary focus question. Do science notebooks enhance student's conceptual understanding? More specifically, the purpose was to examine the impact on students' understanding of the science concepts and process skills (observation and communication) while using science notebooks. This research will give me the necessary data to determine whether I should continue with science notebooks in my classroom.

### Focus Questions

The purpose was to examine the impact of science notebooks on students' conceptual understanding of the science concepts (Earth Science) and on process skills (communication and observation). Conducting this action research project will give me the tools to improve my teaching skills and my students' conceptual understanding of science. This research will give me necessary data to tell whether I should be using science notebooks in my classroom.

Focus questions:

1. In what ways do science notebooks enhance students' conceptual understanding of the content taught?
2. To what extent do science notebooks increase students' communication skills?
3. In what ways do science notebooks impact students' observation skill?
4. What notebook approaches work best with my students to promote conceptual understanding?

## CONCEPTUAL FRAMEWORK

### Introduction

How students learn science, and how to teach science has been a topic of discussion for many years. Throughout science education you can find varying views on the problems that exist in science education today. As far back as the 1900's there emerged concerns over science education. Professor John Dewey addressed the American Association for the Advancement of Science in Boston, MA in 1909. In his speech, Dewey revealed his concerns with the status and quality of student's science thinking as well as the quality of teaching science within the school system. He stated that, "the subject of science itself is extremely broad in the mass of information needed to be taught. Therefore, teachers were teaching many different science topics across the board, but not teaching in depth to where children truly understood the basic science concepts". The article went on to state, "the attitude toward the study of science is, and should be, fixed during the earlier years of life" (Dewey, 1910, p. 123).

Constructivist theorist Rosalind Driver explains that, “students need to be encouraged to develop their models step by step alongside their experiences. The role of the teacher is to intervene, to pose questions, challenge the students' models, and guide them to a better understanding. The teacher is thus a diagnostician, whose job it is to understand the learner's misconceptions and guide them to a superior understanding” (Driver, 1994, p.11). However, there still exists a difference of opinions over how students learn science, how teachers teach science and how to get students to understand science.

### Scientific Literacy

As defined by the National Science Education Standards (1996), “scientific literacy is the knowledge and understanding of the scientific concepts and processes required for personal decision making, participation in civic and cultural affairs and economic productivity.” Scientific literacy can be achieved through the development of process skills such as, “observing, describing, comparing, classifying, analyzing, discussing, hypothesizing, theorizing, questioning, challenging, arguing, designing experiments, following procedures, judging, evaluating, deciding, concluding generalizing, reporting, writing, lecturing, and teaching in and through the languages of science” (Lemke, 1990, p.16).

“To help students understand science, we need competent, educated and enthusiastic teachers to teach science in a way that can create and nurture a learning environment of scientific understanding” (Braxton, 1998, p. 15).

As educators we must take note that not all students can communicate what they are thinking and to expect students to already know how to communicate within the

structures of the classroom is impractical. It is imperative that we support our students in whatever way possible to nurture the development of science literacy.

### Inquiry

Baxter, Bass and Glasser (2001) stated that, “inquiry is viewed as a key strategy for developing students’ understanding of science concepts” (p. 123). In their study on three fifth grade classrooms, guided inquiry was used in conjunction with notebook writing for students to demonstrate their understanding of science concepts. Pearce (1999) suggests that the job of the educator is to help students recognize, explore, and celebrate logical, rigorous thoughts and elegant reasoning. This inquiry cycle that Pearce refers to includes: the student, testable questions, experimental design, discoveries and student knowledge dissemination. In the midst of these elements lies communication through discussion and writing. He goes on to claim that “students learn best through scientific inquiry and the National Science Education Standards are a blueprint to improve science curricula (p. 66). The National Science Teachers Association (NSTA) 2000 claims, “scientific inquiry is a powerful way of understanding science content. Students collect evidence, develop an explanation from the data, and communicate and defend their conclusions” (p. 1). This evidence of students thinking and questioning can be demonstrated through scientific writing. According to the Department for Children, Schools and Families on Better Writing in Science (2005), “pupils need to develop the skills of writing in science in order to clearly communicate the full extent of their ideas, knowledge and understanding.” Writing in science notebooks is just one avenue to analyze students thought processes.

### Notebooks

Science notebooks are defined as “a compilation of entries that provide a partial record of the instructional experiences a student has in his or her classroom for a certain period of time. Through writing students engage in authentic scientific thinking as they carry out their own investigations” (Shavelson, 2001, p. 2). Science notebooks include questions to explore, predictions, a description of what will be done, and what students learn. Focusing on the development of science literacy, scientific inquiry, and using a constructivist pedagogy, science notebooks can assist in this scientific endeavor.

As a tool, science notebooks allow students to write, draw, and reflect on their thinking and their understanding of science concepts (Wilkins, 2009). Students create their own personal textbook that is written in a language that they understand and in a format that is designed by them. Providing opportunities for differentiated learning ensures that the students’ readiness level, interest, and preferred mode of learning is met. Students of lower ability levels may prefer to use diagrams to represent what they have learned, where higher ability students may choose concept maps (Minogue, Wiebe, Madden, Bedward & Carter, 2010). Even students who may have poor writing skills can use visuals such as observational drawings, graphs, tables or charts to indicate their learning (Wilkins, 2009).

English language learners can draw and write in their notebook in their primary language and as their English language develops, can begin using both languages according to their comfort level. Keeping in mind that the students’ notebook is for the student to make sense of his or her own learning (Minogue et al., 2010): notebooks provide structure and support for all student achievement levels.

In a science notebook students use a variety of expository writing to promote their learning of science concepts. For example: in a lab safety unit, students used narrative writing to explain what went wrong in a science lab to change a scientist into a “*lab-rador*” (Wilkins, 2009). In a unit about lab equipment, students used descriptive writing and labeling to construct a concept map. Additional forms of expository writing that have been included in notebooks were explanatory and persuasive writing. Examples of these forms are included in Table 1.

Table 1  
*Examples of Student Writing*

Descriptive	“This rock is gray with parts that are brownish yellow color. Very vivid, and it feels like velcro. It also looks like it has holes in it”. (4 <sup>th</sup> grade student, Hardin Intermediate School)
Procedural	“The variables I used in A were 3 table spoons of brown sugar, two cups of hot water, string, paper clip, popsicle stick. We first boiled the water and added it to the glass jar, next we add the brown sugar. We stirred it until it was completely dissolved. Next we tied the string to the paper clip and the other end to the popsicle stick and placed the paper clip in the water. I was than done except to start observing it”. (4 <sup>th</sup> grade student, Hardin Intermediate School)
Narrative	“Today when I observed jar A, it didn’t seem like there was any change for yesterday. Although there was white stuff on the string. In jar C, the crystals seem to be getter larger each day that I look at them. I wonder what is causing this to happen”? (4 <sup>th</sup> grade students from Hardin Intermediate School)
Explanatory	“I learned the crystals that formed in the water by the heater were smaller than the ones that cooled more slowly on the counter”. (4 <sup>th</sup> grade student, Hardin Intermediate School)
Persuasive:	“If I want my crystals to grow larger I need to place them where the water evaporate more slowly. If the water evaporates quickly the crystals form smaller. Because the water evaporates fast the crystals don’t have time to grow”. (4 <sup>th</sup> grade student, Hardin Intermediate School)

*Note.* Adapted from Gilbert & Kotelman (2005, p30).

Notebooks offer numerous opportunities to develop and enhance students' communication, writing, visual and oral skills. The examples are from a group of first and second grade students meeting snails for the first time. "I see it coming out of its shell! How far out will its head come? It has funny things on its head—are those its eyes? Its shell curls around—do all snails have the same kind of shell?" (Gilbert & Kotelman, 2005, p. 28). As students wrote and drew more in their notebooks, they began to interact more deeply with the subject matter. Another indication of more in depth thinking was the increased use of details in their observational drawings (Aschbacher & Alonzo, 2004). Notebooks taught students that information and ideas can be communicated in different ways and that some methods of communication are better suited for particular information (Fulton & Campbell, 2004). The act of writing enhances thinking and demands that the students organize language and thoughts to explain (Chesbro, 2006).

"Science notebooks fill many roles. They promote students' science learning and give students the opportunity to enhance their writing skills. They help students organize their learning and by the end of a unit, realize how much they have learned," (Campbell & Fulton 2003).

In conclusion, many studies demonstrate the importance of developing students' scientific literacy and inquiry skills to develop conceptual understanding. Science notebooks can transform a classroom into a dynamic learning environment and, in the process, students connect their prior experience with new material, develop questions based on their experiences, and discuss their observations and reflect upon their learning. Students can have more academic success and learn to acquire knowledge in ways that

will assist them in becoming life-long learners.

## METHODOLOGY

The overall purpose of the study is to examine the impact of science notebooks on students' understanding of a particular science concept (rock cycle) and on two process skills (communication and observation). Conducting this action research project will give me the tools to improve my teaching skills and my students' understanding of science concepts and skills.

This study examines more closely the beneficial outcome and possible challenges of integrating science notebooks as a tool to write, draw, and reflect student's thinking or understanding of science concepts.

As mentioned in the Introduction to this study, my classroom consists of 20 students with 12 of them being boys and 8 being girls. The majority of my class qualifies for free or reduced lunch and there is a wide range of cultures represented: Crow, Northern Cheyenne, Caucasian, Mexican, Blackfeet and Asian. Two of my students qualify for special education and are only in my classroom for social studies and science. Five different students leave for math intervention, a supplemental program for those students that are working below grade level (Hardin Intermediate PowerSchool, 2011).

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.

During a six-week period, science notebook strategies were integrated into science lessons to teach science concepts to my fourth grade classroom. When students

have to write about a topic, they explore it in greater depth than if they were simply having a class discussion. Writing exposes gaps in knowledge that discussion many not reveal. Students' writing skills sharpen when they have to write in specific content areas and their critical- thinking skills improve as well (Shavelson, 2001).

### Treatment

During the treatment students participated in using notebooks as a tool to reflect on their thinking and understanding of science concepts. We talked about how scientist used science notebooks to record data, observations, make predictions, ask questions, and communicate their findings.

Astronomy was the focus for a pre-treatment comparison unit that was taught similarly to the treatment unit, but did not involve the use of science notebooks. The rock cycle was emphasized during the treatment unit, along with the integration of science notebooks throughout the unit.

The students began the pre-treatment unit of the Astronomy with a pre-test. The test included diagrams of the solar system and vocabulary. The vocabulary activity involved matching the words with the right definition and description of the planets and other celestial bodies with the definition. Students also needed to label the planets with the correct name in the correct position relative to other planets, and label other celestial bodies with the correct name.

Before the start of each lesson students would draw and write everything they knew about aspects of the solar system addressed in that lesson. This allowed me to measure students' background knowledge and misconceptions as well as looking at their

communication skills. This also gave me a baseline to compare as they continued their drawing and writing throughout the treatment. At the end of the unit students created their own constellation and wrote a story to tell how the Solar System was created.

The following table gives a brief explanation of the lessons and strategies that were used during the treatment period. I introduced science notebooks by showing the students an example of one. Students then recorded a list of items they observed from the example-notebook and from this list they came up with what they thought should be in the contents of their notebook. The students came up with date, page number, title, tables, graphs, labeled pictures, observations, and notes. We also decided to use the unit of plate tectonics, prior to the rock cycle unit (treatment), to form a class notebook. This gave the students ideas of what was important to put in the notebooks, well as practice time of the process skills communication and observation as a whole group. Through use of the class notebook, it was hoped that students wouldn't feel intimidated or nervous about the expectations. Descriptions of the rock cycle activities are introduced below in Table 2.

Table 2  
*Lessons/Strategies*

Plate Tectonics & Rock Cycle Lessons	Inquiry Activities to promote understanding of the science concepts	Notebook Activities to promote process skills
Plate tectonics (whole class notebook)	Students explored how tectonic plates formed the continents.	Observation: students made observations of examples of how the plates moved: Pangaea, transform, divergent, convergent Communication: students drew each of the examples and gave an explanation
Rock Lab- Classifications	Students explored why rocks are grouped into three categories.	Observation: students made observations of each group of rocks. Communication: students used their five senses to describe a rock from each group and draw that rock in their notebook.
Igneous Rocks	Students observed crystal growth over a period of time.	Communication: students drew a picture to illustrate their predictions. Observation: Each day students observed crystals and described the crystals in each dish.
Sedimentary Rocks	Students observed sedimentary layers using sand, silt and clay.	Observation: students observed the settling process. Communication: Students described which layer appeared to have settled to the bottom first.
Metamorphic Rocks	Students investigated simulated metamorphic process using a granola bar.	Observation: students weighed and measured the granola bar. After the granola bar had gone through the metamorphic process, students took measurements again. Communicate: Students recorded differences in the rocks.
Minerals	Students designed an investigation for the questions: What is one way minerals are formed? How do variables affect the growth?	Communication: Students discussed variables that could change the outcome of the crystal growing process and develop a question to investigate. Observation: Students recorded their data over five days; forming questions and predictions.

Descriptions of the rock cycle unit activities introduced in Table 2 follow. When the treatment began in the fall, the students began the rock cycle with a pre- test

(Appendix G). The test included vocabulary, matching the descriptions with definitions, short answer essay and filling in concept map about the rock cycle.

To introduce the use of science notebooks, as mentioned earlier, we created a whole class notebook during our lesson on plate tectonics. I modeled observation and communication skills by demonstrating how to use the senses to observe, asking questions, writing clear explanations using vocabulary, drawing pictures with details, labeling pictures, developing a plan, making predictions and writing a conclusion. This would reinforce what was expected in the notebooks.

The first lesson was for the students to explore why the rocks were classified into three different boxes. The students were put into small groups. Each group was to record their observations of each box, and hypothesize about why the rocks were in that particular box. Prompts were started for the students: I observed..., I noticed..., It reminds me of..., I am curious about... After each group had a chance to rotate to each station, we discussed as a whole class what their observations were. At this point students recorded in their notebooks the vocabulary words, igneous, sedimentary, and metamorphic and definitions for each. The students then drew a diagram of each type of rock.

Before the beginning of the next lesson, the students wrote in their notebooks everything they could recall about the three classifications of rocks. This served two purposes: review from the previous day and identifying misconceptions.

To begin the next lesson, we discussed how igneous rocks are formed and how the cooling process affects the size of the crystals. To help students learn the process, they participated in a crystal formation investigation. Students were assigned a partner

and given water and salt to place in a cup to stir until dissolved. The dish labeled warm was then placed by the heater and the dish labeled cool was placed on the counter.

Students were then asked to make predictions of how the crystals will look after the water has evaporated. Over the next three days students recorded data regarding their crystals. They used the sentence prompts to help with observations and communication to record in their notebooks. The final day when the water was evaporated students answered the questions, "Which dish contained larger crystals and why?" As a class we discussed the process of igneous rock crystals. To finish the lesson students were asked to write for one minute about what they learned. As an introduction to sedimentary rocks, I had the students watch a video showing the rock cycle. As a whole class we discussed what the word sediment meant. Students then participated in a sedimentary rock investigation. Students were put into groups to examine samples of three types of sediment: sand, silt, and clay. With magnifying glasses students observed and discussed what they saw. In their notebooks they were to answer, "What are some of the similarities and differences between the samples?" "Are the grains in the three samples the same size?" "How would you describe the shapes of the grains you observed?" After the questions were answered, students were to draw each of the grains.

As a group we discussed what each group observed. Students then described in their notebook what they observed. Questions to answer included: "Which layer appears to have settled to the bottom first, the one made of coarse-grained material or the one made of finer-grained material?" We discussed one of the distinguishing properties of sedimentary rocks was layered structure. Students were then to record their LOL," Line

of learning.” This was where students wrote a short summary of what was learned. Students were also asked to write their, “muddiest point” for that day’s lesson.

The next lesson in my unit consisted of introducing metamorphic rocks. The goal of this investigation was to observe pressure as an agent of metamorphism. Students were each given a granola bar that served as a model of a rock material. The particles in the bar served as rock-forming minerals. Students recorded in their notebooks the length, width, depth, and weight. With a knife students cut off one end of the bar and observed and sketched the grain arrangement and position of the particles with respect to each other. Students then placed their bars between waxed paper, placed them on the floor and stomped on the granola bars. This simulated the pressure metamorphic rocks go through. Students then placed their bar on their desk and recorded measurements, described the shape and orientation of the grains and sketched what they observed after the process in their notebooks. The class discussed their results and conclusions.

The last lesson in my unit was on minerals. Students looked at different crystals using the Smithsonian website. We discussed shapes of crystals and crystal growth. The goal of the lesson was for students to ask a testable question and conduct a students designed investigation. As a review we discussed the rock cycle and where crystals fit into the process. Students then brainstormed in their notebooks the questions they want to have answered about crystals. We then discussed their questions. As a whole class we discussed different variables that could change the outcome of the crystal growing process. From the list of questions, students chose one question that they were most interested in investigating. Over the next five days, students made observations by drawing and writing to produce their own hypotheses to explain what was happening.

At the end of the unit several students were interviewed using teacher created interview questions (Appendix H). The purpose of the interviews was to gain students' personal thoughts pertaining to how science notebooks helped them apply the information learned.

### Methods of Data Collection and Data Analysis

The methods of data collection and analysis selected for this study are briefly introduced below, and displayed in Table 3 according to the research questions addressed.

The *Science Process Skills Inventory (SPSI)* administered to the students in my classroom ranked their confidence level regarding the use of the process skills within the classroom (Appendix A). I informed the students that this survey was to assess how they felt about using process skills to learn science. To encourage honest and thoughtful answers, students were each assigned a number and asked not to put their names on the survey. The questions were read aloud to clarify any misconceptions about what was being asked. The survey consists of eleven items, each representing a different skill in the science inquiry process. Students were asked to respond to each statement using a 4-point Likert scale indicating how confident they felt about the use each of the items when doing science: never (1), sometimes (2), usually (3), and always (4). One example was, "I can ask a question that can be answered by collecting data" (Arnold & Bourdeau, 2009). This gave me a baseline understanding of how the students felt about the use of process skills.

To answer the questions regarding impact of science notebooks on observation and communication skills, the *Observation and Communication Rubrics* (Appendices B and C) were used to identify proficiency levels and desired outcomes for each level. Students were given points, 1= novice, 2= apprentice, 3= practitioner and 4= expert. Artifacts from students' work were analyzed using the *Observation and Communication Rubric*.

The *Teacher Observation Log* was used to record daily observations regarding students' understanding as well as communication and observation skills throughout the treatment (Appendix D). This log included guided prompts to describe the planned lesson and was used to ensure consistency when recording data.

To document whether or not conceptual understanding increased *Pre/Post-tests* were administered during the Astronomy Unit (pre-treatment) (Appendices E and F) and *Pre/Post-tests* the Rock Cycle Unit (Appendices G and H).

Throughout the treatment, students were given a variety of formative assessments. These Classroom Assessments Techniques (CATS) included the Minute paper, One-sentence Summary or an Exit card. The data collected was reflected upon and adjustments were made as needed in order to gather the most valid results.

Student Interviews were administered at the end of the treatment to gather information on the students' perception of the use of science notebooks in the classroom. Table 3 provides a matrix of the data collection techniques used throughout the study.

Table 3  
*Data Triangulation Matrix*

Research Questions	Data Collection Tools	Data Collection Tools	Data Collection Tools
1. In what way do science notebooks enhance students' conceptual understanding of the content taught?	Teacher observation log	Pre/Post test	CATS
2. To what extent do science notebooks increase students' communication skill?	Teacher observation log	Pre/Post Student Survey	Communication Rubric
3. In what ways do science notebooks impact students' observation skills?	Teacher observation log	Observation Rubric	
4. What notebook approaches work best with my students to promote conceptual understanding?	Teacher observation log	Pre/Post test	Student Interviews

In summary, during the treatment, the notebook strategies were implemented in my classroom. Through a variety of data collection techniques, I was able to determine whether these strategies improved my students' understanding of certain science concepts and process skills. The rubrics I used with the assessments were specific to the expectations I wanted from my students. My teacher observation logs were also essential. I used the results to reflect and adjust my teaching practices. All of the methods-provided me with the necessary data to monitor the students' learning in a consistent way during the treatment.

## DATA AND ANALYSIS

In this section, results are reported for each category of data collected, then revisited to examine how they informed each of the four research questions posed in this study.

### Results for Student Confidence Using Process Skills

The goal of this project was to help students develop their process skills and conceptual understanding of science using science notebooks. Prior to the treatment during the Astronomy unit, nineteen students completed the *Science Process Skills Inventory (SPSI)* in order to gain insight on students' confidence level regarding the use of their process skills within the classroom. I informed the students that this survey was to assess how they felt about using process skills to learn science. To encourage honest and thoughtful answers, students were each assigned a number and asked not to put their names on the survey.

Prior to the treatment, 84% of the 19 students completing the survey answered they could sometimes use science terms or vocabulary when sharing results, while 15% chose usually could use vocabulary. After the treatment, 5% of the 19 respondents chose sometimes and 89% chose usually could use vocabulary. Observational notes recorded on March 7<sup>th</sup> 2012, in the *Teacher Observation Log* concurred (Appendix D). "Students are using more vocabulary words in their conversations then earlier in the treatment."

In addition, the *Process Skills Inventory* showed growth in response to the comments, "I can design a scientific procedure and communicate a scientific procedure." Prior to the treatment, 63% of students indicated they sometimes could communicate and design scientific procedure, while 84% indicated usually for these statements at the end

of the treatment period. Research shows (Minogue, Wiebe, Madden, Bedward & Carter, 2010) that providing opportunities for differentiated learning ensures that the students' readiness level, interest, and preferred mode of learning is met. Even students who may have poor writing skills can use visuals such as observational drawings, graphs, tables or charts to indicate their learning. Student Interviews corroborated this in that during the final interviews one student said, "I can't write what I always want to say but I can draw a picture and talk about it."

Other questions indicating growth on the *Process Skills Inventory* question were questions five and six, "I can record and use data to create a graph for presentation to others." At the beginning of the treatment 84% of students indicated sometimes, while 0% said usually. By the end of the treatment 68% had indicated usually. We had just finished our unit on data collection in math, so the students were feeling very confident in using and collecting data.

Five statements indicated minimal or no change from pre to post treatment. Questions one, two, and eleven all have to do with asking questions. Asking good questions was a skill we had practiced from the beginning of the school year and students were feeling very confident with their skill. Question eight stated, "I can analyze the results of a scientific investigation." The students were asking a lot of questions about what this question was asking and I am not sure they understood what the question was asking even though it was explained. The last question that indicated little growth was ten. "I can use models to explain my results." Students have made models but not for explaining results of an investigation so this would explain little or no growth. Table 4 represents the Science Process Skill Inventory response distribution.

Table 4  
 2012 Fourth Grade Science Process Skills Inventory Response Distribution (N=19)

Answers	Never		Sometimes		Usually		Always	
	Pre Treatment	Post Treatment						
1. I can use scientific knowledge to form a question	2	0	11	11	6	8	0	0
2. I can ask a question that can be answered by collecting data	4	0	13	16	2	3	0	0
3. I can design a scientific procedure to answer a question	4	2	13	2	2	15	0	0
4. I can communicate a scientific procedure to others	1	1	12	2	6	16	0	0
5. I can record data accurately	0	0	18	3	1	15	0	1
6. I can use data to create a graph for presentation to others	3	1	16	2	0	13	0	3
7. I can create a display to communicate my data and observation	3	1	8	5	7	12	1	1
8. I can analyze the results of scientific investigation	2	0	14	13	3	6	0	0
9. I can use science terms to share my results	0	0	16	1	3	17	0	1
10. I can use models to explain my results	4	1	10	10	5	7	0	1
11. I can use the results to my investigation to answer the question that I asked	3	0	16	15	0	3	0	1

The data from the *Science Process Skills Inventory* provided the necessary information that I needed to answer several of my focus questions. I was able to compare my students' perceptions of their ability to use the process skills of communication and observation before and after implementing the science notebooks. The data indicated 70% of students chose "sometimes" to items one through eleven prior to the treatment

and 16% chose “usually.” After notebooks were implemented, 38% of students responded to “sometimes” while the “usually” category rose to 55%. This growth in the “usually” category indicated that student confidence level using process skills did improve during the treatment.

### Results for Making Observations

Throughout the treatment students were given instruction and opportunities to practice making good observations. Figure 1 indicates the performance levels students attained for each lesson when their work was evaluated using the observation rubric.

During the Astronomy Unit, (pre-treatment), students made drawings of planets from pictures. Sixty-three percent of students made a list of what they saw and recorded one or two traits to describe a planet: “Venus looks gray with white spots,” “Saturn has rings,” Jupiter looks the biggest. “While 37% of students were able to draw the planets and communicate what they had learned about the planet, however there was no vocabulary used. In February during treatment, when students were assigned to record the characteristics of a rock, the majority of the students (68%) identified more than three traits and made a comparison. For example, one student wrote, “It sparkles more than the flat, gray rock, it has many rocks pressed together. It has pebbles, silt, quartz and granite all smashed together.” Another student wrote, “This rock looks like magma from a volcano.” By the end of the treatment, the same percentage of students (68%) described crystals using three or more traits and included an explanation or comparison and some vocabulary. One student wrote, “The crystals in jar C are twice the size as crystal in jar A. They have edges and sides are cubed shaped. They look more solid than the day before.” Further examination of the notebooks revealed 16% of students had very

detailed observations. Students progressed from using just color and size to making comparisons, using vocabulary and asking further questions. As I reviewed my notes, I recorded on March 7, “Students are starting to talk to their partner about their observations, using more details in their conversations.”

Figure 1 represents students’ observation scores of the three units taught.

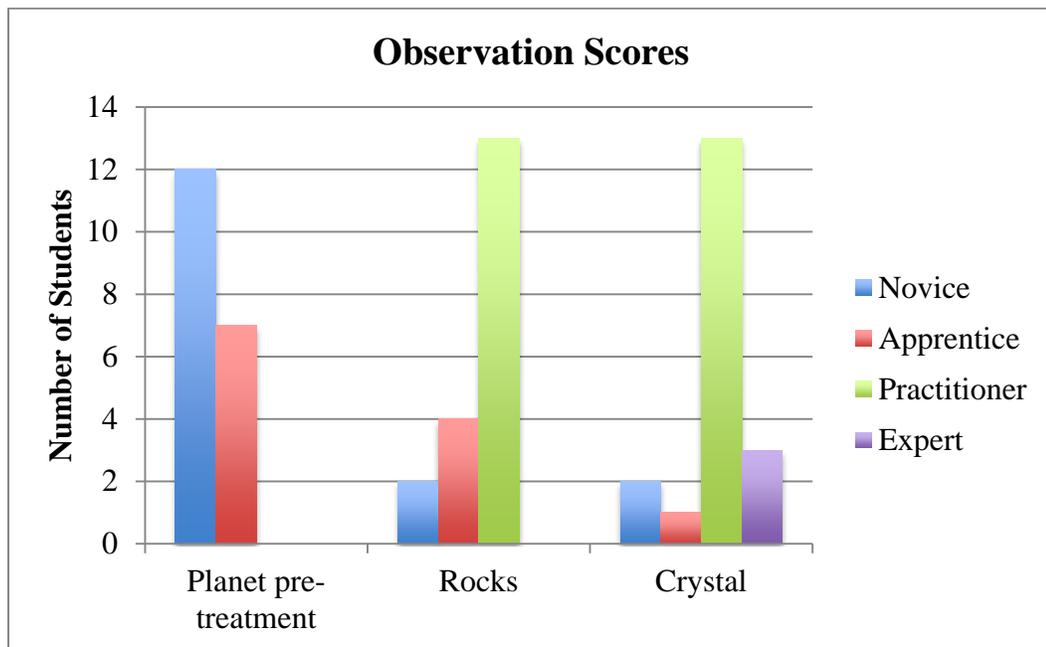


Figure 1. 2012 Fourth Grade Rubric Scores of Observations, (N=19).

Table 5 represents observation rubric results from the three units taught, planets (pre-treatment), rocks and crystals.

Table 5  
2012 Fourth Grade Observation Rubric Results (N=19)

Observation Rubric		Planets pre-treatment	Rocks	Crystals
Novice - 1 point	<ul style="list-style-type: none"> <li>• A drawing is included to show what the student observed, however the drawing lacks detail and labels.</li> <li>• The observation is confusing and not clearly explained or described.</li> <li>• No vocabulary is used to indicate any understanding.</li> <li>• A new question is given, but it is unclear and not a testable question as written.</li> </ul>	12	2	2
Apprentice- 2 points	<ul style="list-style-type: none"> <li>• A drawing is included to show what the student observed, however the drawing lacks detail and labels.</li> <li>• The observation is confusing and not clearly explained or described.</li> <li>• No vocabulary is used to indicate any understanding.</li> <li>• A new question is given, but it is unclear and not a testable question as written.</li> </ul>	7	4	1
Practitioner - 3 points	<ul style="list-style-type: none"> <li>• A drawing is included to show the student tested or observed. The drawing is detailed and includes labels and measurements.</li> <li>• Observations include what the student observed, measured and learned.</li> <li>• Science vocabulary is used, indicating some prior and/or conceptual understanding.</li> <li>• A new question is given that could be tested.</li> </ul>	0	13	13
Expert - 4 points	<ul style="list-style-type: none"> <li>• Several drawings are included to show many of the things that the student tested and observed. The drawings are very detailed and include labels.</li> <li>• Observations include what the student observed, the result of testing ideas, and what was learned.</li> <li>• Science vocabulary is used appropriately, indicating use of prior and/or conceptual understanding.</li> <li>• A new question is given that extends the observations that the student made and link to prior knowledge.</li> </ul>	0	0	3

### Results for Communication

In order to discern the effectiveness of the science notebooks on communication, student's ability to write, draw and reflect on their thinking was evaluated using the *Communication Rubric*. Data collected during the Astronomy Unit (pre-treatment) indicated that 63% of students scored at the apprentice level when writing about their planet. Explanations were not clearly presented, and there was lack of organization when forming sentences and/or vocabulary was used incorrectly. Thirty-seven percent of students scored 1 point or novice, with explanations that could not be understood or no explanation at all.

At the beginning of the rock cycle unit (treatment) 31% of students scored at the novice level when describing their simulated metamorphic rock. One student stated, "It looks smashed together" no further explanation or drawing was indicated in the notebook. Another student had a drawing of the rock, but no labels and explanation. Further examination indicated that over half (68%) of students were able to draw their metamorphic rock with labels and write a conclusion partly supported by their investigation. There were no students who scored at the expert level during this investigation.

During the crystal investigation students progressed in their ability to communicate through writing, drawing and labeling. Again, data regarding communication was collected. Students attempted to use appropriate representation of labels and writing a conclusion. Twenty-six percent scored in the novice level, while 58% in the apprentice level. The greatest change in communication growth occurred in

the practitioner level from 0% to 16%. Students were beginning to write with explanations that were clearer and drawings were organized with details. Conclusions were starting to raise new questions about their investigation. One student wrote,

My crystals are the same exact size as yesterday, but there are a lot more in the jar. The weird thing is the crystals are starting to grow up on the popsicle stick. What would cause them to do that and why are there more crystals?

Observations showed students were starting to use their “voice” in their writing.

Another student stated in her conclusion,

Over all the borax soap grew bigger crystals than my hypothesis of using brown sugar. I think it is because borax is a crystal and as it cools it releases some of the borax into its natural mineral shapes and form crystals.

Evidence from the *Science Process Inventory* also supported the students’ progress in their ability to communicate. The post-treatment *Science Process Inventory* showed that 95% of students reported they could sometimes or usually communicate a scientific procedure. Data from the *Teacher Observation Log* recorded on March 9 supported this trend. I wrote, “Wow! Students are showing improvement. More students are recording more accurately and writing more details and not complaining about it. Great day!” Figure 2 represents students’ communication score for the three units taught.

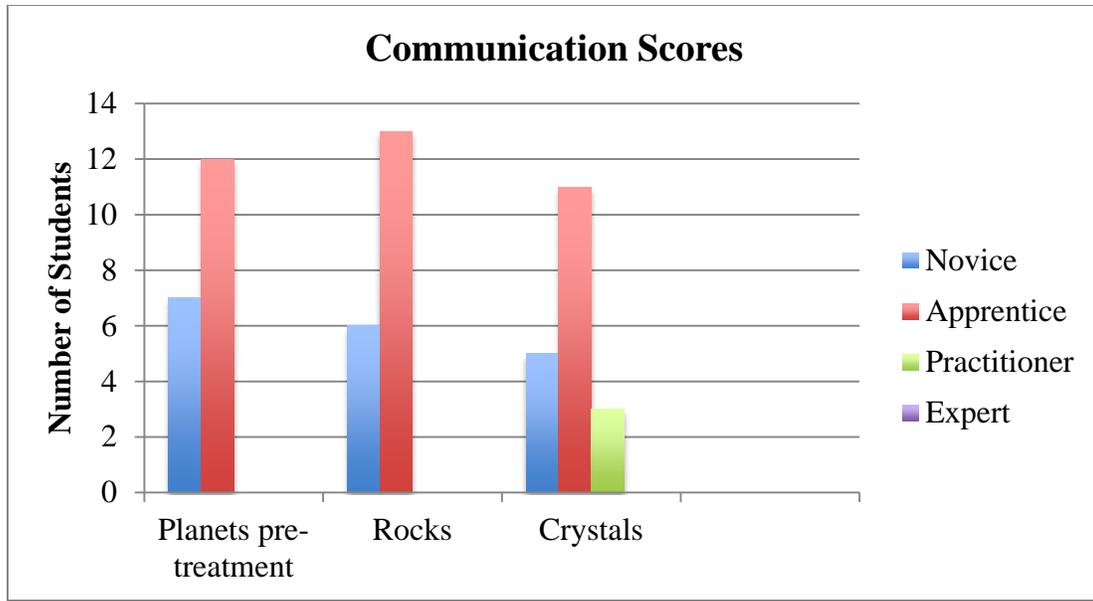


Figure 2. 2012 Fourth Grade Rubric Scores of Communication, ( $N=19$ ).

Table 6 represents communication rubric results from the three units taught, planets (pre-treatment), rocks and crystals.

Table 6  
2012 Fourth Grade Communication Rubric Results (N=19)

Observation Rubric		Planets pre- treatment	Rocks	Crystals
Novice- 1 point	<ul style="list-style-type: none"> <li>No explanation or the explanation could not be understood or was unrelated to the task or investigation.</li> <li>Did not use, or inappropriately used scientific representations (e.g. symbols, diagrams, graphs or tables).</li> <li>No conclusion stated or no data recorded</li> </ul>	7	6	5
Apprentice- 2 points	<ul style="list-style-type: none"> <li>An incomplete explanation or explanation not clearly presented (e.g. out of sequence, missing step).</li> <li>Attempted to use appropriate scientific representations, but were incomplete (e.g. no labels on chart).</li> <li>Conclusion not supported or were only partly supported by data.</li> </ul>	12	13	11
Practitioner- 3 points	<ul style="list-style-type: none"> <li>A clear explanation was presented.</li> <li>Effectively used scientific representations to organize and display information</li> <li>Appropriately used data to support conclusion.</li> </ul>	0	0	3
Expert- 4 points	<ul style="list-style-type: none"> <li>Provide clear, effective explanations detailing how the task was carried out. The reader does not have to infer how and why decisions were made.</li> <li>Precisely and appropriately used multiple scientific representations to organize and display information.</li> <li>Interpretation of data supported conclusions, and raised new questions or was applied to new contexts.</li> <li>Disagreements with data</li> </ul>	0	0	0

#### Results Regarding Conceptual Understanding

Students completed their own investigation of forming crystals. Students demonstrated their conceptual understanding of scientific concepts in verbal and written

forms. This was exhibited by their use of appropriate scientific vocabulary and their ability to explain procedures and conclusion. Students made significant growth in their ability to accurately state the steps of their procedure. However, at the mid-point of the treatment, there was not a substantial change in the students' ability to clearly state an explanation or understanding of the concept. It is not clear whether this represented the lack of understanding or a weakness in the ability to write to explain a cause and effect relationship. For example, the following statement reported on the crystal investigation earned two points for stating, "The white stuff is left, when the water is all gone." This discombobulated statement, "The effect that happened when the water left is when the white power stayed in," earned one point for stating a conclusion. At the end of the treatment, 74% of students clearly explained the results of their crystal investigations. Students were highly motivated to find answers to their questions and started asking more questions. Their statements expressing their understanding became sophisticated. For example, one student wrote, "In conclusion, heat evaporates the water faster but the crystals will form smaller. If the water evaporates slower the crystals will form larger."

Designing an investigation is a significant inquiry process. The treatment provided opportunities for students to participate in a variety of investigations. Students indicated on the *Science Process Inventory* an improved confidence in their ability to develop testable questions and investigate. On the pre-treatment survey, 68% of students reported they could sometimes ask a question that could be answered by collecting data. On the post-treatment survey 84% indicated they could develop a testable question.

Other data sources indicated that students learned scientific concepts. On the pretest, all nineteen students scored below 75%. The average score on the pretest was

33%. On the post-test, 68% of the students scored 75% or above. Figure 3 summarizes the students' growth on their conceptual understanding of the rock cycle.

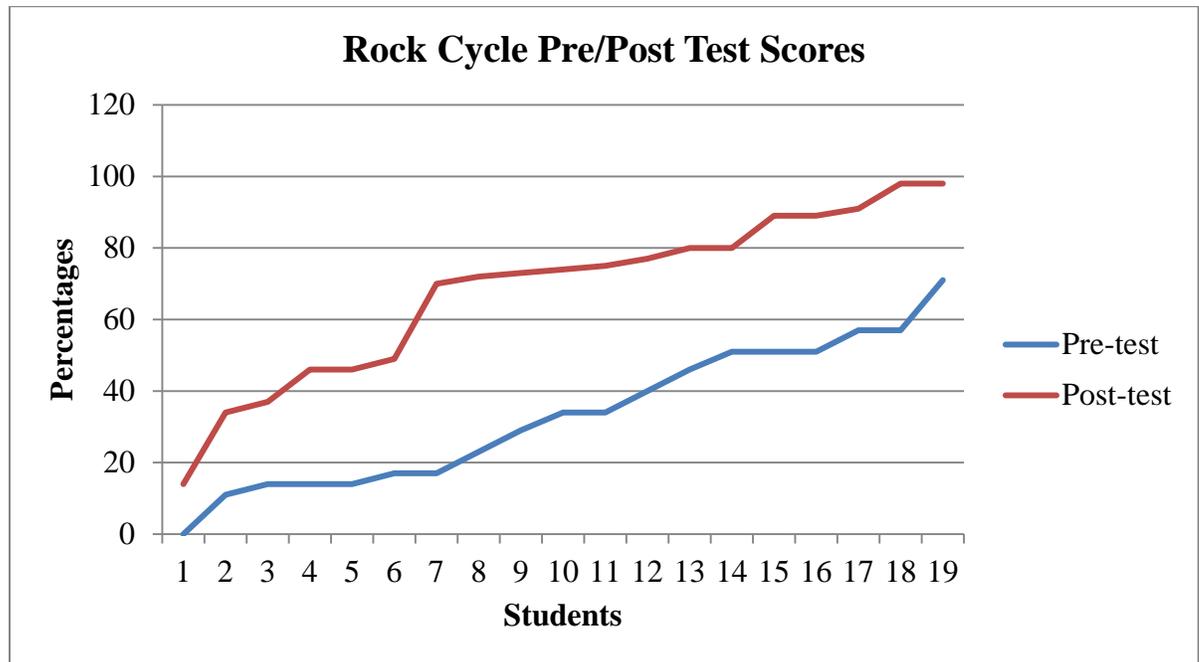


Figure 3. 2012 Student Rock Cycle Pre/Post Test Scores, (N=19).

From my notes on February 28, I was observing a student who was typically quiet and reticent to participate. He hadn't had as much success as the other students making observations and recording what he had learned. He was just staring at his dish that contained little water, with crystals left from the salt. I asked, "Does it look different from yesterday?"

"Yes."

"How is it different?"

"Well, the water is almost all gone and I think those are crystals that are left behind."

"What do you think happened to the water?"

"It went into the air and when that happened the crystals started to grow."

Although he hadn't yet acquired the vocabulary to explain evaporation, the student was able to explain his understanding of the concept based on a simple observation. If I hadn't taken the time to engage him in conversation, he wouldn't have been able to communicate his learning.

Differentiated learning ensures that the students' readiness level, interest, and preferred mode of learning is met. Students of lower ability levels may prefer to use diagrams to represent what they have learned, where higher ability students may choose concept maps (Minogue, Wiebe, Madden, Bedward & Carter, 2010). Even students who may have poor writing skills can use visuals such as observational drawings, graphs, tables or charts to indicate their learning (Wilkins, 2009).

Analysis of the interview conducted with students revealed several statements that communicated learning and understanding of the scientific concepts. I asked the question, "What did you learn by using the science notebooks?" One student stated, "I learned that if I write down my thoughts today about my crystals I can look in it and see if I need to change my mind." Another student exclaimed, "I learned that I could have used salt and hot water instead of borax and hot water and I could have had a better investigation."

The interview with this student revealed the benefits of the notebook. I asked, "What did you like about using notebooks?" He stated, "I feel like everything I learned is in this notebook, and I can draw it or write about it. I'm not very good at writing so sometimes it's easier to draw about it. It was great!"

## INTERPRETATION AND CONCLUSION

In this research project, the students and I both benefited. The students were introduced to a new strategy—notebooks. Students were given the freedom to write, draw and reflect the concept the way they understood it. As a tool, science notebooks allowed students to write, draw, and reflect on their thinking and their understanding of science concepts (Wilkins, 2009). The students and I were able to address misconceptions in a positive manner before the summative assessment. I plan to continue to use notebooks as part of my science instruction in order to benefit the students and myself. In this conclusion I will address my focus questions for my research.

*1. In what ways do science notebooks enhance students' conceptual understanding of the content taught?*

The use of notebooks allowed the students to develop their skills much more than in the past because everyone could look back into their own notebooks to remember prior experiences and students could look at their peers' notebooks to see what questions other students tried to answer and data that they had collected. The post-tests also indicated that 68% of the students scored 70% or above, a substantial increase from the pretest. My findings supported the claim that science notebooks in conjunction with guided inquiry help students to demonstrate their understanding of science concepts (Baxter, Bass & Glasser, 2001).

*2. To what extent do science notebooks increase students' communication skills?*

Specific data regarding communication, as mentioned in Figure 2, indicated 26% of students scored at the novice level, 58% at the apprentice level and 16% at the practitioner level at the end of the treatment, compared to the pre-treatment scores of

37% at the novice level, 63% at the apprentice level and 16% at the practitioner level.

In looking at the quality of student's communication skills, students showed improvement in writing with explanations that were clearer and drawings were organized with more details. Conclusions were starting to raise new questions about their investigation, however they still struggle with the writing process. My students started out at the beginning of the year with very low writing skills; still there was improvement but not where they should be as fourth graders.

*3. In what ways do science notebooks impact students' observation skill?*

The student's understanding of science was affected by how they observed. At the start of the pre-treatment, students made drawings of planets. Sixty-three percent of students made a list of what they saw and recorded one or two traits to describe a planet. In February during treatment, when students were assigned to record the characteristics of a rock, the majority of the students (68%) identified more than three traits and made a comparison. This supports the claim below.

Scientific literacy can be achieved through the development of process skills such as, observing, describing, comparing, classifying, analyzing, discussing, hypothesizing, theorizing, questioning, challenging, arguing, designing experiments, following procedures, judging, evaluating, deciding, concluding generalizing, reporting, writing, lecturing, and teaching in and through the languages of science. (Lemke, 1990, p 16)

*4. What notebook approaches work best with my students to promote conceptual understanding?*

Several factors contributing to the developing students' conceptual understanding were

revealed during this study. Students mentioned it was easier to draw in order to explain a scientific concept than write an explanation. This supports the claim that even students who may have poor writing skills can use visuals such as observational drawings, graphs, tables or charts to indicate their learning (Wilkins, 2009). The results of the study also gave evidence that drawings, graphs, tables, or charts are tools of formative assessment. The students found it beneficial going over mistakes in general before the summative test (13 out of 15 students interviewed agreed). I was able to quickly walk around and mention positives and misconceptions that students were making. Some students needed to be explicitly taught skills such as listening, posing questions, reasoning, observing, describing and comparing to help them to be more successful. Due to the implementation of these skills, an increase in students helping one another on a daily basis was noted. As mentioned earlier, students could look back into their notebooks to remember prior experiences, this helped students to recall information learned previously. Several students mentioned it was easy to look back in the notebook to see what had been done. Test scores indicated that the use of the notebooks were beneficial to the students.

The last conclusion I made was that the use of science notebooks needed to start at the beginning of the year. Six weeks is not enough time, we were just getting started. I also feel if more examples of notebooks were brought into class, and if there had been more discussion of the purpose, students would have bought into the notebooks sooner.

In conclusion, many studies demonstrate the importance of developing students' scientific literacy and inquiry skills to develop conceptual understanding. Science notebooks can transform a classroom into a dynamic learning environment and, in the process, students connect their prior experience with new material, develop questions

based on their experiences, discuss their observations and reflect upon their learning.

## VALUE

Over the past three years I have devoted most of my family time to my action research. Now seeing my coursework come to an end, I can now elaborate on what and how I have changed as a teacher and professional. Throughout the process of this study I have become a more effective teacher because I am better at connecting science concepts with the process of science. Throughout my reflections and the use of science notebooks to organize our class I can see a much closer connection between the two aspects of science.

Another area of change was assessment. Looking back on my project, I really learned a lot about assessment. The first was formative assessment, which determines what students are learning during instruction. Minute paper, probes, muddiest point, exit cards are a few examples of classroom assessment techniques I now have in my arsenal stored ready for use and now I am promoting their use to other teachers. I will now also incorporate drawings, labels, and graphs into my summative assessments as well. This will allow students to communicate in a more productive way.

A last area of change was inquiry. I learned inquiry processes require specific instruction and practice. Just like any other topic, I need to teach, model and allow students to practice new skills. Students needed to be taught how to make detailed observations so I modeled how to observe and draw. The outcome of inquiry is answering questions, developing scientific knowledge, and reflecting what was learned. I learned that I can step into the role of facilitator and my class won't fall apart. I did give

them hints and suggestions, but I didn't feel compelled to intervene with the answers. Science notebooks and the inquiry process gave the students and I the opportunity to do this.

I will continue the use of science notebooks as a means of engaging students in the scientific inquiry process. When students generate their own questions they are highly motivated to pursue answers through investigations. Through the use of notebooks students can save their questions, drawings, writing, vocabulary and investigations.

In conclusion, this has been a valuable learning experience for me as a teacher and professional. Action research is to base conclusions on scientific research rather than opinions and trends. I believe I have now come closer to becoming the teacher that my school and my students deserve.

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APPENDICES

APPENDIX A

SCIENCE PROCESS SKILLS INVENTORY



## My Science Skills

We'd like to know how good of a scientist you are!

Please fill in the circle that tells how much you currently can use each of the following skills when you work on a science investigation.

	Never	Sometimes	Usually	Always
1. I can use scientific knowledge to form a question	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
2. I can ask a question that can be answered by collecting data	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
3. I can design a scientific procedure to answer a question	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
4. I can communicate a scientific procedure to others	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
5. I can record data accurately	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
6. I can use data to create a graph for presentation to others	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
7. I can create a display to communicate my data and observations	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
8. I can analyze the results of a scientific investigation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
9. I can use science terms to share my results	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
10. I can use models to explain my results	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
11. I can use the results of my investigation to answer the question that I asked	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

APPENDIX B

OBSERVATION RUBRIC

Novice = 1pt.	<ul style="list-style-type: none"> <li>• A drawing is included to show what the student observed, however the drawing lacks detail and labels.</li> <li>• The observation is confusing and not clearly explained or described.</li> <li>• No vocabulary is used to indicate any understanding.</li> <li>• A new question is given, but it is unclear and not a testable question as written.</li> </ul>	
Apprentice= 2pts.	<ul style="list-style-type: none"> <li>• A drawing is included to show what the student observed, however the drawing lacks detail and labels.</li> <li>• The observation is confusing and not clearly explained or described.</li> <li>• No vocabulary is used to indicate any understanding.</li> <li>• A new question is given, but it is unclear and not a testable question as written.</li> </ul>	
Practitioner= 3pts	<ul style="list-style-type: none"> <li>• A drawing is included to show the student tested or observed. The drawing is detailed and includes labels and measurements.</li> <li>• Observations include what the student observed, measured and learned.</li> <li>• Science vocabulary is used, indicating some prior and/or conceptual understanding.</li> <li>• A new question is given that could be tested.</li> </ul>	
Expert= 4pts	<ul style="list-style-type: none"> <li>• Several drawings are included to show many of the things that the student tested and observed. The drawings are very detailed and include labels.</li> <li>• Observations include what the student observed, the result of testing ideas, and what was learned.</li> <li>• Science vocabulary is used appropriately, indicating use of prior and/or conceptual understanding.</li> <li>• A new question is given that extends the observations that the student made and link to prior knowledge.</li> </ul>	

APPENDIX C

COMMUNICATION RUBRIC

COMMUNICATION RUBRIC	
Novice 1pt	<ul style="list-style-type: none"> <li>• No explanation or the explanation could not be understood or was unrelated to the task or investigation.</li> <li>• Did not use, or inappropriately used scientific representations (e.g. symbols, diagrams, graphs or tables).</li> <li>• No conclusion stated or no data recorded</li> </ul>
Apprentice 2 pts	<ul style="list-style-type: none"> <li>• An incomplete explanation or explanation not clearly presented (e.g. out of sequence, missing step).</li> <li>• Attempted to use appropriate scientific representations, but were incomplete (e.g. no labels on chart).</li> <li>• Conclusion not supported or were only partly supported by data.</li> </ul>
Practitioner 3 pts	<ul style="list-style-type: none"> <li>• A clear explanation was presented.</li> <li>• Effectively used scientific representations to organize and display information</li> <li>• Appropriately used data to support conclusion.</li> </ul>
Expert 4pts	<ul style="list-style-type: none"> <li>• Provide clear, effective explanations detailing how the task was carried out. The reader does not have to infer how and why decisions were made.</li> <li>• Precisely and appropriately used multiple scientific representations to organize and display information.</li> <li>• Interpretation of data supported conclusions, and raised new questions or was applied to new contexts.</li> <li>• Disagreements with data</li> </ul>

APPENDIX D

TEACHER OBSERVATION LOG

Teacher Observation Log:

Content:

Date:

Objective:

Comments on Lesson (goals met, strengths and weakness of lesson.)

Strategies used in notebook (graph, table, sentence prompts)

Changes for the future:

Other relevant information:

APPENDIX E

ASTRONOMY UNIT PRE/POST-TEST

## Astronomy Pre/Post Test

Fill in the blank from the word bank below.

Solar system	phases of the moon	universe	planet	revolution
lunar eclipse	orbit	galaxy	gas giants	star

1. Different shapes of the Moon when viewed from Earth\_\_\_\_\_.
2. The Sun is at the center of\_\_\_\_\_.
3. The Moon moves into the shadow of the Earth during\_\_\_\_\_.
4. All the objects in space, including the Milky Way and other galaxies make up the  
\_\_\_\_\_.
5. Earth travels around the Sun along a path\_\_\_\_\_.
6. A large body that travels in an orbit around the Sun\_\_\_\_\_.
7. It takes one year for the Earth to make one\_\_\_\_\_ around the Sun.
8. A large group of stars held together by gravity is a \_\_\_\_\_.
9. The largest planets in the solar system that are made up mostly of gases are  
\_\_\_\_\_.
10. The Sun is a medium sized\_\_\_\_\_.

Write the answer to the questions below.

11. What are the four ways stars are classified?

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12. What makes up the Solar System?

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13. How is the Sun important to the Earth?

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14. What causes the Earth's seasons to change?

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15. Suppose you spot the Big Dipper in a certain place in the sky? A few hours later, it is in a different place. Did the stars move? Explain your answer.

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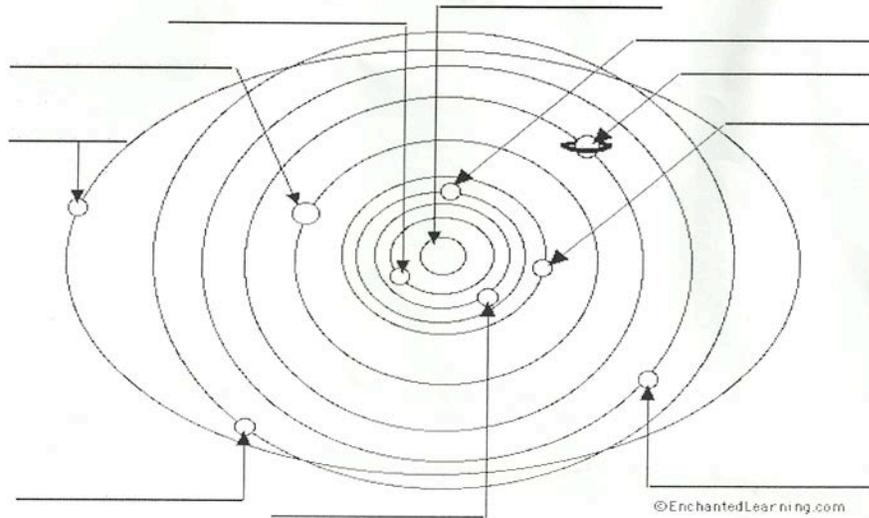
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Read each definition. Then write the letter of the word that matches.

- |   |                       |
|---|-----------------------|
| ___1. The path Earth takes as it travels around the Sun.                                    | a. planet             |
| ___2. A large body made of rock or gas that moves around a star                             | b. orbit              |
| ___3. Occurs when the Moon passes into Earth's shadow                                       | c. solar system       |
| ___4. Is made up of the Sun, nine planets, and other smaller bodies that orbit the Sun      | d. phases of the Moon |
| ___5. The largest planets in the solar system that are made up mostly of gases              | e. lunar eclipse      |
| ___6. The changes in the amount of the lighted side of the Moon that are visible from Earth | f. gas planets        |

Label the solar system with the appropriate names.



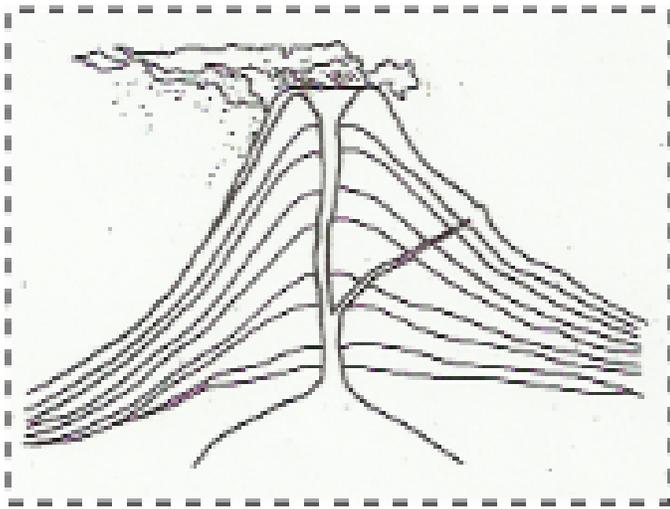
APPENDIX F

ROCK CYCLE PRE/POST TEST

## Rock Cycle Test

Complete each sentence with the correct vocabulary term.

1. \_\_\_\_\_ is the rock that forms when melted rock from Earth's mantle cools and hardens.



2. The material flowing from the Earth's crust shown in the picture is called \_\_\_\_\_.
3. Molten rock that reaches the Earth's surface is called \_\_\_\_\_.
4. A solid material made of one or more minerals is a \_\_\_\_\_.

Match each definition to the correct vocabulary term.

- |  |                  |
|--|------------------|
| 5. solid material in Earth's crust that has a definite chemical makeup | sedimentary rock |
| 6. dropping of sediment moved by water, wind, and ice                  | weathering       |
| 7. slow wearing away of rock into smaller pieces                       | mineral          |
| 8. rock formed when rock particles are deposited and later harden      | deposition       |

**Complete each sentence with the vocabulary word from the word bank.**

core	erosion	magma	mineral	sedimentary rock
crust	igneous rock	mantle	rock cycle	sediment
deposition	lava	metamorphic rock	rock	weathering

9. Molten rock that flows onto Earth's surface is \_\_\_\_\_.
10. The formation of sand dunes by winds is an example of \_\_\_\_\_.
11. Molten rock cools to form\_\_\_\_\_.
12. A solid material found in nature that has a definite chemical makeup is \_\_\_\_\_.
13. The melting, cooling, and hardening of rock are part of the\_\_\_\_\_.
14. Bits of sand, soil, rock and once-living remains are called\_\_\_\_\_.
15. A canyon formed by river is an example of \_\_\_\_\_.
16. Molten rock below the surface of Earth is\_\_\_\_\_.
17. A solid material made up of one or more minerals is \_\_\_\_\_.
18. The hot innermost layer of Earth is called\_\_\_\_\_.

**Write the letter of the best answer choice.**

19. Rock that is formed under heat and pressure is\_\_\_\_\_.
  - a. conglomerate rock
  - b. igneous rock
  - c. metamorphic rock
  - d. sedimentary rock
20. The thick layer of rock between the crust and the core is called\_\_\_\_\_.
  - a. lava
  - b. core
  - c. magma
  - d. mantle

21. Which statement is **NOT** true of the Earth's crust\_\_\_\_\_.
- a. It is Earth's thinnest layer.
  - b. It has a liquid outer part.
  - c. It includes the ocean floor.
  - d. It is made of rock.

22. An example of sedimentary rock is\_\_\_\_\_.
- a. marble
  - b. granite
  - c. obsidian
  - d. shale

23. Draw a model of the inside of the Earth. Label each layer and identify one feature of each layer.

24. Write a short paragraph explaining how igneous rock becomes sedimentary rock.

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APPENDIX G

Student Interview Questions

## Student Interview Questions

1. Did you like using science notebooks? Why or why not?
2. What was the best thing about using notebooks? Why?
3. What did you like the least about notebooks? Why?
4. How did the notebooks help you to learn about the rock cycle?
5. Do you think we should use science notebooks again? Why or why not?
6. What did you learn by using the science notebooks?
7. Is there anything else that you would like me to know?