Science the “Write” Way: Integrating Science Notebooks in the Elementary Classroom

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Table of Contents

Chapter 1: Introduction

Introduction

The science notebook is a valuable tool for all developing scientists. It provides a place to record data and facts, document procedures and outcomes, link together evidence, as well as make conclusions and reflect on an investigation. A science notebook is a place where language, data and experience come together to create meaning for a scientist. This is true of our youngest scientists in elementary school as well as the research scientists performing laboratory experiments across the world. Science notebooks link together reading, writing, mathematics, reasoning and communications skills while building a student's understanding and science knowledge. Teachers need to see the benefits and value of teaching science as a tool for integration of literacy and mathematical practices in elementary grades. The science notebook provides a cross-curriculum tool that can strengthen and support instruction in language arts and mathematics. By integrating these constructive tools into the classroom, teachers can increase student performance and achievement across the curriculum.

Nature of the Problem

Since No Child Left Behind passed in 2001, there has been a push nation-wide to emphasize tested material in the classroom in order to improve annual testing scores (ED.gov). This means that reading and math receive more instructional time in the classroom because they are so heavily tested whereas science and social studies, which are each only tested once through elementary grades, receive less time or are cut completely from the curriculum. By cutting science instruction, we are creating a great disservice for our students. Studies have shown that science notebooks integrated with an inquiry-based science curriculum has shown evidence of supporting and enhancing language arts and mathematics instruction (Mintz and Calhoun, 2004). Science instruction does not have to “take time away” from reading and math instruction; in fact it can support it. For example, when a student records a science investigation in his science notebook, he has the opportunity to use a number of different forms of expository writing, not to mention the hands-on experience to help motivate him to write. He might be measuring something, an important skill taught in mathematics, or making inferences and predictions about an experiment. Science notebooks provide a means of practical applications of reading and mathematics instruction while developing science content knowledge and understanding.

By implementing science notebooks in the classroom, teachers provide an opportunity for students to question the world around them and record their thinking process. This provides an important reference tool for young scientists as they can track their growth of understanding from question to prediction to observations and conclusions. The students are able to easily refer back to their notes using the table of contents they create in the first few pages of their notebooks. This helps keep them organized and teaches them the importance of creating a well thought-out, structured, readable reference tool for themselves come test time. Another important aspect of the science notebook is that they belong solely to the student. While this may seem like an obvious point, this individual ownership provides the students with a voice during science investigations and has been shown to increase student achievement in not only science but also reading and writing as well.

Thesis Statement

Integrating science notebooks in the classroom allows the teacher to truly maximize science instruction by supporting the students' learning process and increasing student achievement across the curriculum.

Rationale

The National Research Council (1996) recommends that science be taught in every classroom at every grade level. In the last decade, numerous reports have called for a reform in education. Each report highlights the value of early science education that allows students "to develop important problem-solving skills that empower them to participate in an increasingly scientific and technological world" (NSTA.org/about/positions/ elementary.aspx). Science instruction through the science notebook requires students to record their thinking process in a systematic, organized format. This process develops a student's reasoning and communication skills in a hands-on environment while also stimulating their reading, writing and mathematics skills. Science notebooks create a designated space for students to construct and understand difficult conceptual ideas in science. Building in these notebooks throughout a unit, or the entire school year, can show a student how much they have learned and grown in one year and provides an excellent portfolio of work for both the teacher and the student.

Science instruction can too often turn into "activitymania" where the students are involved in an investigation without any accountability for the important concepts being discovered in the activity or connection to previous science investigations (Moscovici and

Holmlund-Nelson, 1998). Science inquiry, in contrast, is the process of searching for and explaining relationships in the world around us. Science notebooks help hold both the teacher and students accountable for making connections and building understanding of the concept being explored that day. By recording all investigations in a common place, students can start to make connections between experiments as well as form more concrete examples of organized data and information. Eventually, students can design their own experiments to investigate an individual question they might have using their previous investigations as examples.

Delimitations

The research and observations for this thesis will be completed from late fall to early spring in a 5th grade classroom in Colorado Springs, CO. Approval for this aspect of study relies on the support of my cooperating teacher and principal. I believe that science instruction through science notebooks should be emphasized in every classroom to support students' growth and understanding of the world around them while developing important problem-solving skills and supporting language arts and mathematic instruction.

Procedures and Organization of Paper

An extensive literary review will cover the value of science and instruction and the benefits of using science notebooks as a tool for inquiry-based learning. I will review previous studies while attempting to better understand the benefits and implications of teaching elementary level science with the science notebook. By understanding the theories and previous studies of the integration of science notebooks within the classroom, I hope to be able to design a curriculum that can best serve my students in the fall and spring of the 2012-2013 school year. The library research and literary review portion of this thesis is presented in Chapter 2. Next, I will observe and implement inquiry-based science instruction centered on the science notebook in the 5th grade classroom and observe the students' overall performance and participation levels in both science and other areas of instruction. Chapter 3 will outline the design and implementation of the science notebook study as well as the results observed after integrating inquiry-based science curriculum using the science notebook. Finally, Chapter 4 will offer my reflections and recommendations for further applications and research in this area.

Key Terms and Definitions

- Literacy: one's ability to use language, including reading, writing and speaking, to communicate their ideas effectively
- Science literacy: a student demonstrates their understanding of science concepts and terminology in an educated, understandable way. A scientifically literate person expresses the ability to process new and complex information using the steps of the scientific method or process.
- Science notebooks: a teaching tool used during inquiry-based science instruction that encourages students to write their thoughts, experience and questions during investigations in the classroom.

Chapter 2: Review and Analysis of Literature

Introduction

A student's science notebook is a self-constructed textbook (Kuerbis, 2011). It is a record of data collected over the course of the year, facts learned, procedures and practices, predictions made, questions investigated as well as conclusions and reflections on the student's own learning and cognitive processes. The science notebook is an essential teaching tool for solidifying difficult concepts in science while teaching important 21st century skills such as public speaking and being able to present information in an organized, understandable format.

The following chapter outlines the literature review and analysis conducted for this master's research project. First, I will address what concepts are behind science notebooks and the purposes that notebooks serve in an elementary classroom. Next, I will describe and analyze recommended content of a great science notebook based on studies of science notebooks conducted in the classroom. Science notebooks have been studied for more than a decade and the specific components of the notebook vary as educators gain more understanding of what helps support and enhance a student's learning process. There are also many curricular connections that extend beyond science instruction. According to Calhoun and Mintz (2004), "Science [can] be used as a vehicle for increasing student achievement across the curriculum" (p. 30). Science notebooks support instruction across the curriculum. The value of integrating science notebooks can help students develop reading, writing, mathematics and communication skills.

Once the purpose and content of science notebooks has been established, I will analyze multiple educational studies that demonstrate the benefits of science instruction with notebooks. Both the ECSD Valle Imperial Project in Science (VIPS) conducted in 1999 as well as Baxter, Bass and Glaser's study of science instruction with science notebooks in three fifth grade classrooms provide a great amount of insight into implementing science notebooks in the classroom. Following this section is a synthesis of the literature that indicates the specific ideas and concepts I hope to apply to my thesis research. This research and the methods I chose for application are presented in Chapter 3.

Concept and Content

Science education is so valuable to our children because it, in part, promotes an understanding of the ways in which scientists study the natural world (Baxter, Bass and Glaser, 2001). The foundational concepts behind science notebooks support this inherent design of science instruction. When paired with explicit instruction and proper scaffolding techniques, science notebooks provide students with an opportunity to deepen their conceptual understanding of science through writing.

Science notebooks are a method of encouraging students to record their thoughts, procedures and questions during investigations in the science classroom. This processing of an investigation or experiment can help students formulate their own ideas based on their own actions and thoughts. According to Butler and Nesbit (2008), "When students write in science notebooks, they discover what they think and come to a better understanding of what they know" (p. 137). This process is known as metacognitive awareness and is an indicator of higher-level learning happening in the classroom. The act of writing out the scientific definitions and procedure in a structured, formatted way is not enough for students to fully grasp the material. They must be able to connect to the lesson and concepts in order to form a deeper understanding of the higher material being studied. Shepardson and Britsch (1997) state, "Written reflection is essential to promote children's explorations of their own thinking and learning processes" (p. 15). Taking the time to write out predictions, observations and conclusions forms that connection for students. This skill of metacognitive awareness can be applied to math, reading and writing instruction as well, which will be discussed later in this chapter.

A science notebook is most often a bound composition notebook but can be anything from lined sheets of paper stapled together, a 3-ring binder with writing paper or a bound paper book. The important thing is that the science notebook is separate from all other subjects. This helps maintain the organization of the notebook as it begins to fill up with the students' own predictions, procedures and further questions. It becomes a central place where "language, data and experience work together to form meaning for the student" according to Michael Klentschy (2005), one of the founders of the idea of using science notebooks in the classroom with students. The Valle Imperial Project in Science (VIPS) is a partnership between 14 school districts in California dedicated to research in science for more than a decade, specifically using the science notebook. At the core of VIPS science initiatives is the idea that the very act of writing is the key to enhancing thinking, and therefore learning, in students. Using the six research-based science notebook components in a well-structured environment gives not only stability and permanence to a student's work, but also purpose and clarity (Klentschy, 2005, p. 25).

The components of a well organized investigation inside a student' science notebook are:

1. The question, problem or purpose
2. Prediction
3. Planning the investigation
4. Observations, data and claims of evidence
5. What have you learned? (Interpretation and explanation)
6. Next steps/New questions

These six components establish a foundation for students to build their own meaning from science instruction. While these components are ideally found in a student's entry for each investigation, they are not necessarily found in each entry for all lessons. However, even if time has run out and the teacher must return to the lesson the following day or even week, the most critical component for a student is the interpretation and explanation stage. Without this, students fail to form a full understanding of the concepts being explored.

The question, problem or purpose:

Every investigation begins with a question asking ourselves: What do we want to find out? "How" or "What" questions are usually the best questions for elementary students and are the most likely to become an investigable question in a classroom investigation. Science teachers should guide the students' questions away from "yes" or "no" toward these investigable questions. Providing the students with question stems or prompts is a good way to help guide them in the right direction. Teachers can also work with students to turn a difficult question into an investigable one. For example, when a fifth-grader asks the question, "Why did the light bulb light when we connected the wires, bulb and battery?" the class can work together to reframe the question as "How many ways can we connect the battery, bulb and wires to make the bulb light?" This question then creates an opportunity for the class to enter into a full-blown investigation in which students develop an understanding of the process of a complete electric circuit and the function of the wires, battery and bulb within the complete circuit.

Prediction:

The second step in the investigation is creating a prediction. In this step, students focus on what they already know (or think they know) about the process being explored. It is important to guide students to state what they think will happen AND a reason or explanation for why it will happen. Statement stems are a good way of encouraging this process. For example, *If… then…* or *I think… because….* The predictions often provide the teacher with insight into students' thinking, prior knowledge and misconceptions. It also provides the concrete foundation from which students start to build their reasoning and understanding of the investigation.

Planning:

Planning the investigation is an important step before actually beginning the investigation, especially for young, developing scientists. An investigation should never move forward without planning the procedure and means of data collection and organization. The plan should relate to the investigable question and include the sequence, materials and data organizers (Klentschy, 2005). Students should be prompted to list materials used and to plan a clear sequence of events. This step can often be time consuming for students so the teacher should usually supply the student with this information, especially if time or previous experience with science notebooks is limited. The data organizer can also be difficult for students to create, as most elementary students do not fully understand the patterns and relationships in data tables. Possible data organizers include:

- T-charts
- Tables
- Graphs (bar, column, line, pie, scatter plots, etc.)
- Venn diagrams
- Labeled pictures or diagrams

Once the students have been exposed to multiple experiments with different types of data organizers, allow the students to decide what type of data organizer would best suit the investigation. The important part to remember when introducing the science notebook to students is to model the structure, not the content of the investigation. Students need the freedom to respond to the experiment using whichever model they see best fits the situation at hand. Putting the onus on the students in this way provides an opportunity for them to feel like real scientists designing their own experiment.

Observations, data and claims of evidence:

During this step in the investigation, students use their data organizer to respond to the questions: What do you see? What do you think? This step helps students make meaning that is their own as opposed to listening to what the teacher expects them to know. This opportunity allows students to construct meaning from their science instruction. Teachers should use collected data in a way that helps students support their predictions or hypotheses and form claims of evidence they can use as support. Calhoun and Mintz (2004) suggest a class "making meaning" conference to share data collected and try to make meaning (or form supporting evidence) for their work. "Cumulative knowledge is built as groups share their results and replications within the same investigation" (p. 26).

What have you learned?

According to VIPS, this step in the investigation process is designed to assist the students in interpreting their data and correlating it within the framework of their own existing knowledge. This is often the most difficult task for students as it asks them to draw conclusions based on their own interpretations. Elementary students are often afraid of being wrong, particularly in front of a body of their peers. It is the teacher's responsibility to create an environment of acceptance and a sense of the collective classroom community during this stage, where there is no right or wrong answer as long as we learn from our mistakes and misconceptions. This type of environments can guide students to see the difference between supported vs. unsupported answers compared to right vs. wrong answers. Building knowledge often involves making mistakes, and it is from our mistakes that we make the strongest connections. During a making meaning conference, the teacher should help students form their own conclusions based on their claims of evidence. After the conference, a written reflection is necessary to help students structure their conclusions and summarize what they have learned. As stated before, written reflection promotes exploration of one's own learning process (Shepardson and Britsch, 1997, p. 15). Unfortunately, studies show that this is also the most omitted section from a student’s science notebook, which can be detrimental for a student’s science comprehension process.

Next steps/New questions:

This final step encourages students to put on their own scientist thinking caps and think of a new, related question that the investigation has stimulated for them. Just as when framing the initial question for the experiment, the new questions should be an investigable question that can be built into or added onto a future lesson. There is no wrong answer, just a way for students to push their thinking a little further. For example, after students worked through the investigation with the wire, batter and bulb, a student might wonder, “What would happen if we used two batteries?” or “What if we wanted to light more than one bulb?” This provides the teacher with an opportunity to gage a student’s interest in a topic when that student demonstrates a deeper understanding of the process. Students’ new questions can provide an excellent opportunity for class discussions or extension activities of the original investigation.

Science notebooks often contain a number of key components that are carried throughout the entire notebook, not just for each investigation. These components support science literacy learning while also incorporating important 21st Century Skills.

Page numbers and a Table of Contents:

By numbering each page and having students copy lesson titles from the text onto their table of contents, the teacher provides a structure for the student to be organized in their data collecting. Organization is a key 21st Century Skill that applies to learning and innovation skills but also falls into life and career skills, as described by the Partnership for 21st Century Skills (P21). Students with learning and innovation skills are more prepared for the increasingly complex life and work environments of the 21st century (p21.org). Organized thoughts and presentation of knowledge within science notebooks creates an opportunity for meaningful communication and collaboration. Teaching students at a young age to organize and file their work emphasizes the importance of the skills necessary later in life.

Students are responsible for filling in the lesson titles and adding page numbers to their Table of Contents in the front of their science notebook. This is a symbol of a well-prepared, organized student. When notebooks are first introduced to a class, always skip the first 3-4 pages before beginning the first investigation in order to have adequate room for the Table of Contents.

Glossary, science vocabulary or Kid Words:

Science is inherently filled with lots of language and vocabulary to describe actions, events, images and phenomena. A science glossary is simply a list of important or previously unknown words with a brief explanation beside it. This brief explanation does not always need to be teacher-given, in fact, pushing students to come up with their own definition for a word creates more meaning for that word, and they are more likely to remember it. For example, first grade scientists defined light rays as 'porcupine lights' and the word balanced means, to them, 'not tippy.' These words and their definitions were written in their science vocabulary list in the back of their science notebooks. The glossary becomes yet another reference tool within the science notebook for a student to use to form meaning from the investigations in the classroom.

Line of Learning (LOL)

This simple teaching tool can be used every day, in every subject. It is simply a line drawn in the notebook that separates what you already know or have recorded from what you learn from others. For example, before a making meaning conference, students should draw a line of learning between the work they have completed individually and the work they want to record that is contributed by others. Group discussions often provide important information that the students will want to record, but it is not individual thought of which they could claim ownership. The line of learning is a physical representation of what we learn from collaboration, another important 21st century skill (p21.org). Valuing contributions from a group while using the information to help shape and support your own knowledge is an important skill for students to learn in order to survive in the competitive work force of the 21st century.

Curricular Connections

Over the past decade or so, science notebooks have been proven as a means of increasing student achievement across the curriculum. With the help of science notebook strategies, teachers have come to realize that skills are skills regardless of the subject matter in which they are practiced (Calhoun and Mintz, 2004, p. 34). Learning the value of accurate measurement or building reading comprehension skills are skills that can be taught in science, math or literacy class periods. Practicing these skills in science instruction provides a foundation of interaction and experience from which to build skills. For example, comparing and contrasting is done in science as well as language arts. Measurement is a skill important in both science and mathematics. Making inferences and predictions is a skill emphasized in reading as well as science investigations. Science notebooks give students a 'real world' application of the skills they learn in language arts and reading in a productive way. Science motivates students to read, write and put these skills to use where they can see a measurable outcome. Instead of comparing and contrasting the main characters of a story the class read chorally last week, why not practice comparing and contrasting two beetles found on the playground during recess or two planets in the solar system or even two famous discoveries made by scientists in the 21st century? By providing a real-world context to the skills we are asking our students to use, we provide the motivation and inspiration necessary for them to complete a task at their fullest potential.

If we look at a comparison of skills between reading and science, we can see just how much overlap there is between instructions (see following table):

Science Skills	Reading Skills
• Observing • Collecting data • Interpreting data • Predicting • Inferring • Comparing/contrasting • Classifying • Recognizing cause and effect • Formulate conclusions • Communicating	• Discriminating patterns within the text • Sequencing • Summarizing data • Predicting outcomes • Inferring • Comparing/contrasting • Recognizing cause and effect • Recognizing main idea • Communicating

Table provided by Comstock, 2012

Literature can help students relate science to their lives. Reading informational texts can be used to verify data or provide important background information before beginning an experiment (Campbell and Fulton, 2003). Reading and science can work together to spark interest, promote questioning and support or check conclusions made by students in class.

Science notebooks provide an opportunity for students to synthesize the skills they learn in reading, language arts and math into a real-world context. Investigations provide an effective 'teachable moment' for improving vocabulary by introducing new words, providing a context by which to define them and giving students an opportunity to use them with a variety of audiences—themselves, their peers and their teachers (Prain and Hand, 2006). By holding students accountable to record information in their science notebooks using their scientific vocabulary, they are able to explore and clarify the meaning of words within their own constructs as opposed to copying the word and definition from the board silently. This helps them integrate a richer, more complex vocabulary into their everyday speech.

Metacognition is the awareness of one's own thought process, or "cognition about cognition" and is an important skill for problem solving and defending or explaining why you think an answer is correct (Metcalfe and Shimamura, 1994). This is a very difficult skill to grasp, especially as an elementary student. However, it is a skill that they are asked to prove in almost every class across the curriculum. In math class, you are asked to defend your answer, or explain how you found it. The simple process of showing your work is an example of metacognition. In language arts, a student might be asked to solve a problem based on the text, and must understand their own learning process in order to answer the question. Science notebooks help develop and cultivate a student's metacognitive awareness during each and every investigation they record. By writing out each component of the science notebook as described by VIPS, a student is documenting his or her learning process from initial problem to conclusions and new questions. This processing of an investigation or experiment helps students formulate their own ideas based on their own actions and thoughts in a concrete, organized format that can be applied in all areas of the curriculum.

As you can see, there are many cross-curricular connections to be made from the science notebook. Having a structured, well-organized science notebook that is guided step-by-step by the teacher in a constructive manner is the most important part in introducing the notebook to students. In the following section, I will discuss and critically analyze two important empirical studies of science notebooks in the classroom to demonstrate how science instruction can effectively integrate science notebooks into the classroom.

Empirical Studies

Notebook Writing in Three Fifth-Grade Science Classrooms (2001) presents the study of Baxter, Bass and Glaser as they examined the ways in which three fifth-grade teachers facilitated notebook writing in their science classrooms during an inquiry of electric circuits in an effort to better understand the most effective ways to support students' learning in science. The study emphasized the relationship between the structure and content of the students' science notebooks and the classroom context in which they were presented and used. In particular, the researchers noted (1) the ways in which the teacher organizes writing, (2) the timing and frequency of opportunities to write in the classroom, (3) the nature of prompts and scaffolding provided to support the students' writing and (4) the particular aspects of writing the teachers attended to via feedback and monitoring (p. 125). An important distinction the authors made helps highlight the purpose of writing in science for me. They discuss the difference between generating a record of science experiences and writing to develop understanding. The former instance describes traditional note taking in a science classroom where the writing is focused on the product, as dictated by the teacher. In contrast, the latter instance helps students "make sense of their investigations in the immediate and broader context" following a specific structure similar to the one outlined earlier in this chapter (pg. 127). The authors agree that when writing becomes a way of thinking about and learning science processes, it positively influences the conduct of science inquiry for students.

In this empirical study, data was collected from 83 students in three fifth-grade classrooms (N=20, 31, 32 for classes A, B and C, respectively) in an urban school district where seventy five percent of students qualified for free and reduced lunch, similar to the present school study presented in Chapter 3. The study was conducted in the fourth quarter when all students were learning about circuits and pathways with 10 investigations, an introductory lesson and a final assessment. Lessons were videotaped for each of the three participating classrooms and the students' science notebooks were collected for data collection and analysis at the end of the unit. Classroom observations were analyzed based on a 3 x 4 item matrix defining the teacher's role in notebook writing (organization, opportunities and attention) by phases of inquiry present in the students' notebooks (purpose, procedures, observations or results and conclusions). For example, a statement describing the teacher's *attention* to notebook writing during the *purpose* phase of inquiry might read: "The teacher requires students to record their purpose and prediction in their notebooks before they may begin the investigation" (p. 129). The researchers then attempted to study the ways in which notebooks were incorporated into instruction and the implications on teaching, learning and assessment. The four requirements for a complete notebook includes information from each phase of inquiry:

1. Introduction or purpose
2. Procedures
3. Observations/results
4. A concluding or summarizing comment

The study's most surprising find, in my opinion, is the small percentage of "complete" entries among the notebooks studied (7.5%, 0% and 25.9% for classes A, B and C respectively). Most often, there was a purpose, procedure and observation entry without any form of conclusion or interpretation of results. In classroom B, there was no record of the purpose or question asked in any investigation. More than 85% of the total notebooks analyzed contained some sort of observation or results aspect in the entry. Classroom observations showed that students followed a teacher-provided structure for recording findings in almost every investigation.

This study is an important building block in the foundation of creating my own empirical study of science notebooks in the classroom. First, the teacher's role in facilitating notebooks use is to scaffold instruction during the recording process to ensure the students are 'set up for success' during later steps in the science notebook process. For example, providing sentence stems or a useful format for recording data during the investigation. This can help clarify for students the purpose of the activity, and enable students to proceed without further direction. If teacher instruction is thorough and explicit on what and how to record the purpose and observations of the study, direction and input can be minimal during the observations and results phase to allow students to record data in their own words, process the information and make an organized, thoughtful interpretation or conclusion during a whole-class discussion or making meaning conference.

Most importantly, this study demonstrates how easily science notebook, just like any science activity, can quickly turn into "activitymania." It is the teacher's responsibility to hold the students accountable for thinking deeper and challenging themselves further in order to make connections and find a concluding remark or interpretation of the results that makes sense to them. This step is the most crucial in helping students "write to learn" in science. The science notebook is a valuable tool in encouraging students to develop science inquiry skills and knowledge of their own development. As Baxter, Bass and Glaser conclude their study, they explain "Notebooks…can facilitate teaching and learning in the science classroom if teachers harness the power of purposeful recording and thoughtful reflection about one's work" (p. 139). Without the purpose behind an investigation and thoughtful, collaborative reflection, science notebooks become another activity in the "activitymania" of the elementary science classroom.

The Valle Imperial Project in Science (VIPS) Four-Year Comparison of Student Achievement Data 1995-1999 is a NSF funded Local Systemic Initiative serving approximately 22,500 K-6 graders and 1100 teachers in 14 school districts in Imperial County, California. Conducted in one of the poorest counties in California, this study is one of the foremost studies in the world of inquiry-based science instruction through science notebooks. As a result of this project, science has become an important vehicle to extend literacy for the students of Imperial County, California. Students in the Imperial County schools are exposed to four modules of science instruction per year (except in kindergarten where students are exposed to three modules per year). The modules are a balance of topics from life, physical and earth sciences that expose students to opportunities to be directly engaged in science process and skill development. All materials, including the science notebooks needed to teach each module are provided by the district materials resource center.

After four years of a kit-based approach to science instruction incorporating science notebooks, the Board of Trustees of the El Centro Elementary School District asked for evidence of the effect the new science instruction had on student learning compared to the more traditional method of teaching from the textbook. The district staff administered the Science Section of the Stanford Achievement Test, 9th Edition to all 4th and 6th grade students in the spring of 1999. The data indicates a strong trend between achievement and the number of years participating in the program. In fact, fourth graders more than doubled their statewide standardized test scores in science, and reading and were just below doubling their scores in mathematics. Even more impressive, the sixth graders tested indicated an almost quadruple score in standardized writing scores. These scores are coming from a majority English language learner student body.

Grade 6 Writing Proficiency Pass Rate

Disaggregated by Years of Participation in District Science Program

Years of Participation	% Pass
0	23% (n=174)
1	68% (n= 119)
2	71% (n= 132)
3	90% (n=107)
4	89% (n=104)
Pass Rate Cumulative	64% (n= 636)

Table adapted from Klentschy, Garrison & Amaral (1999)

The VIPS study places great emphasis on the idea that a student's science notebook is a "special, essential means of communication" (Klentschy and Molina-De La Torre, 2004, p. 10). It is through the writing process that students engage in their own reflection process and are able to reconcile collected data with current conceptions of what is true and what is not. The science notebook is a record of their mental activities and a store of personally valued information as they work through this process on a daily level. This construction of meaning is done in the voice of the student, not the teacher.

This study demonstrates to me the ideal application of science notebooks in the classroom. The science notebook is not only about recording the observations and product of a science investigation but also, writing to understand science and the process of science inquiry.

Chapter 3: Application

Introduction

This chapter outlines ten lessons specifically designed for use in the science classroom with science notebooks. The science notebook provides a student with the opportunity to engage during class time by recording observations, making predictions, drawing conclusions and writing to understand science and the process of science inquiry. These lessons help students construct their own meaning out of the science investigation, and in turn out the onus of learning on the student instead of the teacher. These lessons are intended for intermediate grade levels, but can be adapted for younger students by creating more structure and providing more scaffolding of information during the investigations.

The set up of the science notebook is one of the most critical components of the following ten lessons. In order for a student to be successful in constructing their own meaning, you must first set them up to be successful by providing them the framework in which to do so. The first lesson, "Introducing the Science Notebook," creates the structure of the science notebook so that the students can record, predict and conclude in a logical, systematic way. The key components of a science notebook might include an investigable question, orientation information (date, time, location), a prediction, planning or procedures for the investigation, observations and data, explanations, and new questions/the next step. These components are all key stages as the students create their own knowledge about a process. As we say in science, "You have to start slow to go fast."

The same applies to the science classroom; if you want your students to be successful, independent scientists you must first teach them how to do that.

The second lesson teaches students how to record what they see in an investigation. Again, this does not come easily for most students and is a skill they must learn. During this investigation, they get to do so in a fun, relaxed experiment. Ideally, and if time allows, the teacher models every step of the process during this first investigation and slowly releases responsibility to the students to do their own recording.

The third and fourth lessons outline two investigations that introduce the concept of variables to students. This is a very difficult concept for some students to grasp, but the main purpose of these lessons is to provide students with another opportunity to practice recoding in the science notebook. These investigations should be heavily modeled by the teacher to ensure confidence and success as the complexity of the experiments increases.

The remaining five lessons span a number of units and topics from geology to weather and climate. They focus on the student's construction of knowledge through investigation and experimentation and can be modified for more or less information provided by the teacher. Ultimately, a student's science notebook is a compilation of his or her own observations, insights and conclusions. The less teacher input and critique, the more likely the science notebook becomes a product of their own knowledge.

Lessons

Lesson 1 Title: Introducing the Science Notebook

Time frame: 50 minutes

Materials:

- Science notebook, one per student
- Pens, pencils, markers
- Document camera
- Teacher notebook/model notebook

The science notebook is a student's own self-constructed textbook. In order for it to become a useful tool for him or her, however, it must first be set up in a logical, systematic way. The key components of a science notebook, as discussed earlier might include an investigable question, orientation information (date, time, location), a prediction, planning or procedures for the investigation, observations and data, explanations, and new questions/the next step. Decide beforehand what is important or required information for every investigation, what is good information to include but not necessarily for every investigation, and what should not be in your science notebook. Having clear, concise guidelines for the students will increase their likelihood of success in creating a valuable, useful document of data and information for themselves and will create less stress for the teacher once the procedures are in place.

For the purpose of this investigation, students will include the following components in their notebooks for each investigation:

1. The question, problem or purpose
2. Prediction
3. Observations, data and claims of evidence

4. What have you learned? (Interpretation and explanation)
5. Next steps/New questions

Once you have discussed the content of the students' science notebooks, it is time to set up the general structure of the notebook. Start with creating a Table of Contents in the first few pages of the notebook. Discuss how you would like your students to organize the table of contents (Alphabetically, numerically, etc.). What purpose does a table of contents serve? Transition into discussing page numbers to help record information in the table of contents and number the first 20-30 pages of the notebook together as a class.

Another key concept to the science notebook is the page layout. Instruct students that their records should be readable and understandable to any of their classmates should they trade notebooks. This means transcribing clearly and neatly as well as in a logical order. Also introduce the idea of a line of learning (LOL) to mark individual work vs. class work. A good mantra to help students remember this is, "Above the line is **me**, below the line is **we!"**

Once the structure and content of the students' science notebooks is clear and constructed, the students are ready to start the recording process.

Lesson 2: How Do Scientists Record What They Observe?

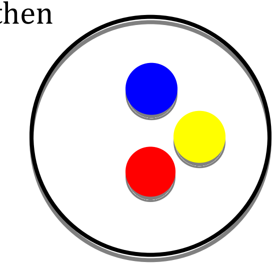
Time frame: 50-65 minutes

Materials:

- Student science notebooks
- Pens, pencils and markers
- Pie pan (1 for every group of 3-5 students, or 1 demonstration table projected using the document camera)
- Whole milk
- Red, yellow, blue food coloring
- Detergent
- Q-tips

This lesson solidifies and applies what was discussed during lesson 1 and allows the students an opportunity to practice their understanding of the content and structure of the science notebook. It also sets the stage for a very important discussion about studying real scientists' notebooks and how they record data.

Begin the lesson by having students record the date, time and investigable question for the day: How do scientists record what they observe? Students can then individually make a jot list to predict the important components they think scientists would need to record information.



Next, set up the investigation by pouring whole milk into the pie pans and putting 2 drops of red, yellow and blue food coloring in the center of the pan to create a triangle. Ask students to record a 'before' image in their notebooks. Explain to students that they must pay very close attention because they are going to also draw a 'during' picture for what occurs during the experiment as well as an 'after' picture for what the pie pan looks like after the reaction has taken place. Once everyone is ready, place a large drop of detergent in the middle of the pan, between the three dots of food coloring. (SPOILER: The detergent will break down the fats in the milk. This will cause the detergent to create a film on the surface of the milk and "push" the food coloring to the sides of the pan and create convection cells, swirling the colors around in the pan.)

Instruct students that they need to create a visual representation of what happened during the three steps of the investigation (before, during and after the detergent was dropped). They must also write out their observations *in their own words*, either using bullets or in paragraph form.

Now have students hold a science conference where the class can discuss (1) what happened during the experiment and (2) how our recordings and observations can help us remember what happened. Share exceptional examples of student work that highlight either in pictures or words what was happening. What about these examples were so helpful? Identify the most successful components in the classmates' science notebook that help them document the investigation. To conclude the lesson, have students record next step investigations or new questions in the science notebook based on what happened in the experiment and what we now know.

For an extension activity, have students go through scientist's actual notebooks (a primary resource!) and identify the key components of a well-documented investigation discussed in class.

Lesson 3: What is a Variable?

Time frame: 50 minutes

Materials:

- Student science notebooks
- Pencils
- Multiple kid-friendly science experiments printed out (1-2 pages in length)

There is no actual experiment for this lesson, but instead students understand the very difficult concept of a variable. Begin by writing down the investigable question in the science notebook. For this lesson, there are no predictions, procedures or observations but the students will be recording important vocabulary words and identifying variables in various experiments. Start a discussion around the new questions or next step investigations recorded at the end of the last investigation. The different things in the experiment that you might change or manipulate are called *variables*. The things that stay the same, or are not changed, are called *controls*. Record a definition for controls and variables in your science notebooks.

Next, introduce that there are 2 different kinds of variables: independent and dependent. Project the procedures for a short experiment on the board:

> You notice a weird green slime in your shower one morning. A friend tells you that coconut milk will get rid of it so you decide to spray half the shower with coconut milk and the other half with water. After 3 days, you notice that the green slime that was sprayed with coconut milk has disappeared.

As a class, discuss the difference between independent and dependent variables. Identify them within the context of the coconut milk example. How can we remember the difference? Brainstorm with elbow scientists and collaborate. Record the definitions and any sort of mnemonic device or drawing that will help you remember in your science notebook. Connect the idea of controls and variables with a language arts concept—cause and effect relationships. What changes? What happened because of that change? What stays the same?

Pass out a worksheet of things that happen everyday and ask students to identify independent variable, dependent variable and control variables (ex. If you sleep in, you will be late and miss the bus). Then have students come up with their own examples of independent variables, dependent variables and control variables. Create an illustration to explain your scenario and hang them up around the classroom.

Control variable: What stays the same

Independent variable: What I change in the investigation (only 1 at a time)

Dependent variable: What I see happening depends on (or because of) the independent variable

Lesson 4: How Does a Lifesaver Dissolve in Your Mouth? (Changing Variables Investigation)

Time frame: 2 days, 50-60 minutes each

Materials:

- Student science notebooks
- Water
- Vinegar
- Life Savers
- pH strips
- Plastic cup (preferably clear)
- Stop watches

Begin the lesson by engaging the students with a Life Saver candy. Ask them to quietly sit at their desks, suck on the candy and brainstorm: *How does a Life Saver dissolve in your mouth?* Write down as many different possibilities as you can come up with.

Next, hold a science conference and ask students to share their predictions. Start a list on the board and have students copy down possibilities in their notebook (under a line of learning, of course). Possible causes for dissolution might include agitation/movement, saliva amount, pressure, acidity of saliva, temperature, broken pieces (increases surface area), color of Life Saver, etc.

In groups of 2-4 students, ask students to design an experiment where they would test one of these variables and determine the length of time a Life Saver takes to dissolve under the conditions of the investigation. Once students are in groups, have them decide on what variable they are testing and how they will represent it during the experiment (ex. Vinegar to test acidity, agitation to test movement, hot vs. cold water to test temperature, whole vs. pieces of Life Saver to test surface area). Another option is to have the teacher assign an investigation to each group of students to ensure that all variables are being tested. Before students begin their experiment, they must write out:

1. What is the independent variable (what will you manipulate?)?
2. What are the constants (what will you not change?)?
3. What do you predict will happen?

These items must be approved by the teacher before the investigation can proceed.

While the students wait for the Life Saver to dissolve, discuss different ways to graphically represent data from a science investigation. This might be using pictures, in a chart, with a graph, written words, or any other number of ways.

Make sure that students record the information and data in their science notebooks, most importantly time it took for the Life Savers involved in the investigation to dissolve.

On Day 2 hold a science conference where students spend the first 20-25 minutes creating a poster in their groups to present their findings to their peers. If technology is available in the classroom, have them create a PowerPoint presentation to do the same thing. This is where they will be able to graphically represent the data they collected from their experiment any way they see fit. The second half of class should be spent presenting their posters in 3 to 5 minutes to their classmates.

Lesson 5: Rock and Mineral Identification Lab

Time frame: 2 days, 50-60 minutes each

Materials:

- Student science notebooks
- Pencils, colored pencils
- Rock type worksheet
- Various rock samples, including but not limited to:
  - Igneous rocks- basalt, granite, marble, rhyolite
  - Metamorphic rocks- gneiss, schist, slate
  - Sedimentary rocks- sandstone, mudstone, limestone

At this point in their elementary careers, students should be relatively familiar with the three different rock types that are found on this earth: Igneous, Metamorphic and Sedimentary. Focus on these following characteristics of each rock type: common colors, texture, how it formed (Earth processes), examples of the rock type, quick tricks on how to identify this rock type, fun/unique facts. Work through a PowerPoint or Prezi presentation that includes this information and ask students to fill out the Rock Type Chart (attached). This chart should be glued into their science notebooks as a reference for the second half of the lesson.

On day two, there should be 10-15 stations set up around the room with a rock specimen at each station. Students will travel with a partner to different stations and try to identify first what type of rock it is based on the characteristics they filled out in their Rock Type Charts the previous day. Once they analyze the rock and identify the correct rock type, they should make a sketch of the rock in their science notebook and label any important characteristics of the rock that led them to identify the rock type. Also make sure that they label the rock type of the rock and create a scale for the drawing, as any good science notebook should include scales with the drawings. Once they have completed this, move to the next rock station.

Once students have travelled to all the stations, go over as a class each rock by naming the rock type and what characteristic of the rock was useful in helping the students identify the rock type.

Rock Type:	Sedimentary	Metamorphic	Igneous
Common colors:			
Texture:			
How it formed:			
Different kinds of this rock type:			
How to identify it:			
Fun Fact: (Ex. Does it fizz?)			

Lesson 6: Earth's Spheres

Time frame: 50-60 minutes

Materials:

- Student's science notebooks
- 3 sheets of colored paper for each student
- Stapler
- Pencils, colored pencils, markers

The Earth has four main spheres: atmosphere, biosphere, hydrosphere and lithosphere. These spheres demonstrate how the four main components of earth work together to form a complete system. Understanding that these are four parts of a whole can be a difficult concept for students to create conceptually in their minds, but using a foldable will help them visualize the connections.

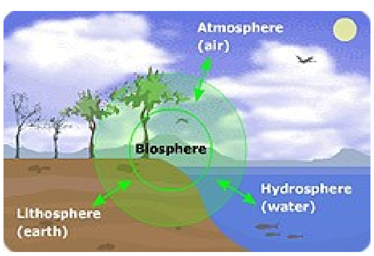
Start with three pieces of paper for each student. Three of the same color works great, but three different colors works, too. Line up the papers so that they overlap with a small tab of each color on the left. Then fold the papers so that you have six tabs in all. Staple the top so you have a book.

Label the cover "Earth's Spheres" and each tab will be for the Atmosphere, Biosphere, Hydrosphere, Lithosphere and finally, a tab labeled "How it all connects." You have now provided the students the structure to take notes about the four spheres of the Earth. It is their job to create their own knowledge and identify what they find as the most important information pertaining to each subject. If the students require more structure, inform them that they must have at least six facts on each tab.

Work your way through a PowerPoint or Prezi presentation that focuses on each of the spheres. Again, the onus is on the student to build their own information inside their foldable. They must choose what information is most important and pull it out. Important information to cover might include:

- What makes up the sphere
- Timescale it changes on (minutes, days, millions of years)
- Thickness/size of sphere
- Why does this sphere exist? Why is it important?
- Open or closed system
- Mass of the sphere
- % of Earth it constitutes

On the final tab, have students create a visual representation or diagram that



expresses how the four spheres are all connected. They may use pictures, words, arrows, columns, etc. Whatever they see will best represent how the four spheres are connected to create our Earth.

Lesson 7: The Water Cycle

Adapted from: http://thewaterproject.org/resources/lesson-plans/create-a-mini-water-cycle.php

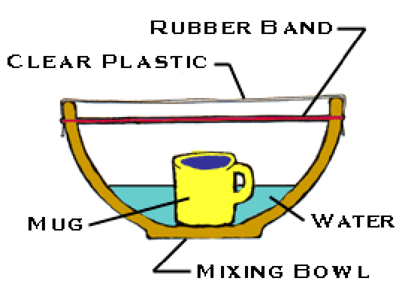
Time frame: 50-60 minutes

Materials:

- Student's science notebooks
- Large metal or plastic bowl
- Pitcher
- Dry coffee mug
- Plastic wrap
- Large rubber band (to fit around the large bowl)
- Water

The water that we drink, wash and play in today is the same water that existed millions of years ago when the Earth formed. It is continually recycled through a process we call the water cycle. Water is one of our most precious resources and helping students understand the process by which it cycles around our planet is an important piece of any resources, environments or weather and climate unit.

This water cycle lesson begins with an activity to introduce students in a visual, interactive way to the water cycle. First, find a sunny place outside and use the pitcher to



fill the large bowl about ¼ of the way full. Explain to students that this represents our Earth's oceans. Next place the mug in the middle of the bowl, but be sure to keep it dry inside. This mug can represent the school, the city or state we live in or even the United States. Choose something you think will resonate with the students. Cover the top of the bowl tightly with plastic wrap and secure it in place using the large rubber band. The plastic wrap now represents the atmosphere, where gases dominate and clouds form. Now watch the bowl carefully and see what happens!

A small mist will begin to form on the plastic wrap and then eventually begin to drip. After the drips have gotten pretty big, peel back the plastic wrap and look inside the mug. Is our school still dry? The water from the ocean evaporates up into the atmosphere. It condenses to form misty clouds on the plastic wrap, or in the atmosphere. Once the cloud becomes saturated, it rains down on the mug and forms precipitation. In the real world, the precipitation flows down rivers and streams until it reaches the ocean and the cycle begins again.

After the experiment, have students create a diagram of the water cycle in their science notebooks. Label each step of the process and encourage students to make a jot list under each heading of what the water is doing during this stage in the water cycle. Again, science notebooks aren't filled with essays- they should be detailed enough notes to be useful at a later date, but do not have to be full paragraphs or even complete sentences.

Lesson 8 Title: Glaciers and Landforms

Adapted from: CU Science Discovery, CAST conference presentation 2012

Summary: In this activity, students will simulate the erosional effects of glaciers and rivers on a sedimentary plane. First, students will compress snow or shaved ice to simulate snow pack and glacial erosion over time. The class will be able to create characteristic features of glacial erosion on their model such as cirques, glacial lakes and U-shaped valleys. Finally, students will use squirt bottles to simulate river and stream erosion associated with glacial episodes. Students will create and identify landforms such as river deltas, oxbow lakes, V-shaped valleys and flood planes.

Grade: 5-8

Time frame: 50-60 minutes

Subject: Science

Topic: Glacial erosion, landforms, distinctive characteristics of both glacial and river/stream erosion

Standards:

- 3.2.a: Analyze and interpret data identifying ways Earth's surface is constantly changing through a variety of processes and forces such as plate tectonics, erosion, deposition, solar influences, climate, and human activity
- 3.2.b: Develop and communicate an evidence based scientific explanation around one or more factors that change Earth's surface
- 3.2 21st Century skills:

- How does Earth's surface change?
- Ask testable questions about how the earth surface changes.
- Assess and provide feedback on scientific explanations about factors that change Earth's surface, pushing for reasoning based on evidence and scientific principles

Objectives:

1. The students will know or understand:
   a. Characteristic landforms associated with both glacial erosion and river erosion
   b. How weather processes from thousands of years ago can shape the landscape we see today
   c. The role glaciers play in forming the landscape
2. Based on what the students know or understand, they will be able to:
   a. Create and identify landforms that are characteristic of both glacial and river erosional processes.
   b. Simulate the impacts glaciers have in forming the landscape
   c. Describe how glaciers have impacted and shaped the Colorado landscape

Materials:

The materials for this experiment require a fair amount of set up prior to the investigation begins in class.

- Multiple pieces of felt, 6-10 cm thick in total
- Play sand, plaster and food coloring
- Hard base layer to simulate basement rock or mountains
- A layer of sedimentary rock (prepare in advance)
- 2000-3000 ml of snow or shaved ice
- Spray bottles, watering can, pitchers and basting pipettes
- Tear-drop shaped sanding block
- Brooms, dustpans, rags and paper towels for clean up
- Stream tables with drains or a slopped outdoor space

Management: Because of the nature of this investigation and the amount of materials and set-up required, it is extremely important to set guidelines and expectations for the students before anything starts. By explicitly setting the expectations for behaviors and academic work to be completed, the students know what is expected of them if they wish to continue with the investigation. Students who do not meet the expectations will be expected to complete a worksheet individually that identifies and defines different glacial landforms.

Introduction:

- 12 hours before the investigation begins, prepare the sedimentary rock layers by:
    - Line the bottom of a cookie sheet with plastic wrap
    - Follow directions for plaster and cover the bottom of the pan with 1-2 cm of plaster. As the plaster sets, create troughs and depressions in the top of the plaster to hold the sand layer in place.
    - Create the sedimentary layer by mixing 2000 ml of play sand, 250 ml of water, 150 ml of plaster, and 40 drops of red food coloring in a large mixing bowl. The resulting material will be durable yet soft enough to scratch with your fingernail, and 'melts' when warm water is added.
    - Immediately spread the mixture in the pan on top of the plaster, press down firmly and let dry.
- Prepare the streambeds or sloped outdoors space and the hard base layer that simulates basement rock or mountain layers.
- <u>Anticipatory set:</u> Begin by reviewing the folding and uplift of sedimentary layers by granitic basement rock using the layers of felt. Have students mimic the motion with their hands. Show the YouTube video to remind students how mountain building occurs: https://www.youtube.com/watch?v=ngV66m00UvU
  This investigation will begin in geologic time after the mountains have formed and are now beginning to erode due to glacial and river processes.

Development:

1. Begin by explaining the slap of sedimentary the students see in front of them represents the Fountain Formation, the oldest sedimentary layer found in Colorado Springs. Before the investigation can begin, we have to first create the younger sedimentary layers found in Colorado Springs. Do this by layering pieces of the sedimentary layer on either side of the "mountain."

2. Begin by dousing the entire mountain with the watering can for approximately 5-10 seconds on each side. This simulates ten thousand years worth of rain and snow on our mountain. It also allows the sedimentary layer to loosen up so it can later be deformed by glaciers and rivers.
3. Have students create a compact snowball out of the snow or crushed ice. This represents our first glacier. Gently, press the snowballs down the slope, flattening them out and slowly deforming the surface. Ideally, this process forms a U-shaped valley, a distinct characteristic of valleys formed by valleys. Where the U-shaped valley begins is the cirque. Notice the buildup or material on either side of the valley. These are the arêtes (higher up the mountain) and moraines (lower down the mountain) that form as a glacier pushes its way down a valley.

4. Make another snowball and this time, instead of pressing down the slope, press the snowball directly *into* the slope. This will create our glacial lake.

5. Now use the watering can, spray bottles, and basting pipettes to form rivers and streams throughout the mountain. How does the shape of these valleys compare to the valleys created by the snowball glacier?

6. Before wrapping up, be sure to give students 5 minutes to play with the materials and see what other landforms they can create.

Conclusion: In the students' science notebooks, have them sketch the mountain they have created and label the important landforms we have created. Color-code the labels to differentiate between glacially formed features (blue) and river formed features (red). If time allows, have students write out the procedures for today's investigation.

Differentiated Instruction: For smaller classes or limited time/budget, create one mountain model for the entire class to manipulate, erode and record. Make sure that it is not just a teacher demo with students solely observing. Students should be involved in each step of the creation and erosion processes.

Assessment:

- Informal Assessment: In their science notebooks, students will answer the question: How can glaciers impact the landscape?
- Formal Assessment: For the Demonstration of Learning (DOL), give students a satellite image of a glacially eroded area in the Colorado Rocky Mountains with arrows pointing to characteristic landforms we have investigated today. Have students label as many of the landforms as they can.

Lesson 9 Title: Renewable and Nonrenewable Resources

Summary: Students will use different materials to simulate the process of oil deposition and formation in the earth as well as the process of extraction of oil for energy. We will then compare and contrast renewable and nonrenewable resources using a Venn diagram or a T-chart. By the end of the lesson, students will understand the difference between renewable and nonrenewable resources, and have an understanding of the ratio of material put into the earth vs. the material we get out of the earth.

Grade: 4-6

Time frame: 50-65 minutes

Subject: Science

Topic: Renewable and nonrenewable energy sources, oil deposition and extraction

Standards:

- 1.1.a Develop, communicate, and justify a procedure to separate simple mixtures based on physical properties
- 1.1 21st Century Skills
    - What are some ways that mixtures can be separated?
    - Mixtures make up Earth's layers. For example, rocks are mixtures of minerals, and minerals are mixtures of elements and compounds.
- 3.1.a Develop and communicate a scientific explanation addressing a question of local relevance about resources generated by the sun or Earth

- 3.1.b Analyze and interpret a variety of data to understand the origin, utilization, and concerns associated with natural resources
- 3.1 21st Century Skills
    - What types of energy sources exist on Earth?
    - Mining operations provide nonrenewable resources.
    - Earth and Sun provide a variety of renewable and nonrenewable resources.

Objectives:

1. The students will know or understand:
    a. The difference between renewable and nonrenewable energy sources on earth.
    b. How oil and other fossil fuels form over millions of years inside Earth's layers.
    c. The process by which oil is extracted from the Earth.
2. Based on what the students know or understand, they will be able to:
    a. Create a model of the earth's layers, deposit and extract 'oil' from the system and explain the relative relationship between materials put into the system and materials taken out of the system.
    b. Identify alternative energy sources (renewable energies).
    c. Extract oil from their model system.

Materials:

- Plastic cup per student
- Fudge brownies
- Rice Krispie treats
- Chocolate milk
- Mini marshmallows
- Baby nose cleaner with the tip cut down to ~2 cm
- Plastic bins, 1 per group

Management: Because of the nature of this investigation and the amount of materials and set-up required, it is extremely important to set guidelines and expectations for the students before anything starts. By explicitly setting the expectations for behaviors and academic work to be completed, the students know what is expected of them if they wish to continue with the investigation. Students who do not meet the expectations will be expected to complete a worksheet individually that identifies and defines different glacial landforms.

Introduction:

- Before the investigation begins, prepare supplies and give each group or pair (however you choose to break up the students) should be given a plastic bin with a plastic cup, one brownie, one rice krispie treat, exactly ½ cup of chocolate milk, a handful of baby marshmallows and a baby nose cleaner. This makes it much easier to manage supplies.

- Anticipatory set: Begin the lesson by creating a T-chart outline on the white board with renewable resources in one column and non-renewable resources in the other column. On a sticky note, have students add to the chart with all previous information they have about renewable and non-renewable resources. Review the final T-chart with the class and be sure to clear up any misconceptions with the class. Have students copy the final T-chart into their science notebooks.

Development:

1. Begin by explaining during today's investigation we will all be oil miners and drill operators extracting oil from deep below the earth's surface. Review the process of how oil forms with the kids in a 5 minute review mini-lesson:
    a. Remains of animals and plants that lived in a marine environment millions of years ago are deposited.
    b. As time passes, the animal and plant remains are covered by layers of mud, silt and sand.
    c. Heat and pressure from these layers helps turn the remains into what is known as crude oil. Petroleum means "rock oil" or "oil from the earth."
2. Now we must assemble our own "oil pit" where we will deposit oil into the system and see if we can extract the same amount. As we add a layer or an ingredient to our cup, be sure to record the real-world equivalent in their science notebooks. This can also be recorded as the investigations procedures in list form.

3. Begin with forming the solid layer of basement rock or granite. This is the fudge brownie and it is placed at the bottom of the plastic cup.
4. Next the rice krispie is millions of years of mud, silt and sand that is deposited after the marine critters have been deposited.
5. Now it is time to introduce the oil to the system. For our investigation, we are going to add chocolate milk. Make sure the students measure and record exactly how much chocolate milk they add to the system.
6. Finally, add baby marshmallows to the top of the system to signify the modern day soils and vegetation.
7. Time for the fun part! Students must now drill for oil using their baby nose cleaner drills. They MUST NOT disturb the marshmallow layer, or they will have to pay a reclamation fee (determine what this will be ahead of time).
8. Make sure students carefully measure how much “oil” they extract from their system. To make a competition out of it, provide a reward for the team that can extract the most oil from the system.
9. For students who finish early, brainstorm ideas: Why did you extract less oil then you put in? What is the real-world equivalent for this phenomenon? Make a jot-list in the science notebook individually.

Conclusion: Discuss with the students either through a “science conference” open-inquiry discussion with the teacher posing several guided question as the students discuss hypotheses and ideas or as a more teacher-guided approach with a structured power-point, for example. Two important conclusions from the experiment that students should walk away from the investigation with:

1. Discuss the reclamation fees and how difficult it was to extract oil without disturbing the environment. Relate to how difficult it is to mine for nonrenewable resources without damaging the environment.
2. Less oil is extracted from the system than we originally deposited. This is what makes oil a nonrenewable resource, because it not easily replenished.

Differentiated Instruction: For shorter class periods, divide the lesson into two days, allowing the oil systems to sit overnight after the chocolate milk and marshmallows are added. This will also make it more difficult to extract oil from the system. For this lesson, the overnight wait might represent the millions of years between deposition of marine animals and the extraction of crude oil.

Assessment:

- <u>Informal Assessment:</u> Write a letter to your senator *to persuade* him/her to choose renewable energy sources instead of nonrenewable energy resources. Provide examples from the investigation.
- <u>Formal Assessment:</u> For the Demonstration of Learning (DOL), ask students to explain why oil is a non-renewable energy resource. Provide at least 1 example from the investigation.

Lesson 10 Title: Measuring Relative Humidity with a Hygrometer

Summary: A hygrometer, which measures the relative humidity of an environment, can be made with a few simple tools. Relative humidity is the ratio of the amount of water the air is holding compared to how much water the air can hold at the same temperature. This investigation will help students record data and use a chart of information to help them find the final answer.

Grade: 5

Time frame: 60 minutes

Subject: Science

Topic: Weather, humidity, water cycle

Standards:

- 3.3.b Gather, analyze, and interpret data such as temperature, air pressure, wind, and humidity in relation to daily weather conditions
- 3.3.c Describe weather conditions based on data collected using a variety of weather tools
- 3.3.d.ii Use data collection tools and measuring devices to gather, organize, and analyze data such as temperature, air pressure, wind, and humidity in relation to daily weather conditions
- 3.3 21st Century Skills
    - Support explanations of weather using evidence.

Objectives:

1. The students will know or understand:
    a. What is relative humidity?
    b. How do we measure relative humidity using a hygrometer?
    c. The importance of relative humidity measurements.
    d. How to calculate relative humidity.
2. Based on what the students know or understand, they will be able to:
    a. Create their own hygrometer using materials provided.
    b. Record data from the hygrometer to calculate relative humidity.

Materials:

- Two good quality thermometers
- Cotton shoe lace
- Piece of wood (for mounting thermometers)
- Small cup of water
- Straps with tacks and scissors

Management: Because of the nature of any investigation, it is extremely important to set guidelines and expectations for the students before anything starts. By explicitly setting the expectations for behaviors and academic work to be completed, the students know what is expected of them if they wish to continue with the investigation. Students who do not meet the expectations will be expected to complete calculations for relative humidity given a number of different data sets.

Introduction:

- Before the investigation begins, prepare all supplies and have them available for easy access. Be sure to mount the thermometers to the wood using straps and tacks. Cut any plastic ends off of the shoe laces.
- Anticipatory Set: Begin by defining humidity vs. relative humidity with the students. These definitions should be recorded in their science notebooks for later reference. Discuss or point out different parts of the country that have high relative humidity. What do they all have in common? Are there any differences between these areas of the country?

Development:

1. Make sure that your two thermometers register the same temperature before the investigation begins. Calibrations on inexpensive thermometers are not very accurate which is why it is necessary to have nicer thermometers for this experiment.
2. Take your shoelace with the ends cut off and separate or pull apart one end to make a sleeve for the bulb of the thermometer. Pull the shoelace up over the bottom of the thermometer; be careful not to break or crack the thermometer!

3. Now, dip the shoelace into some water so that it can absorb water until it is saturated up to the thermometer. Be sure to keep the wet bulb actually wet for an accurate reading.
4. Now read the temperature on both thermometers. Subtract the wet bulb from the temperature. Use this number to calculate the relative humidity from the humidity chart below:
    a. http://www.engineeringtoolbox.com/humidity-measurement-d_561.html

Conclusion: Discuss with students in a science conference format about what factors might contribute to having higher or lower relative humidity. Does the environment we live in favor high or low humidity? What parts of the US might have high humidity? Low humidity? Why?

Differentiated Instruction: Extension activity: To figure dew point from the data from your hygrometer, subtract the relative humidity from 100, then divide by 5. Subtract this number from the air temperature to get the dew point, or temperature at which the air will be completely saturated. Generally speaking, the higher the dew point, the more likely the formation of rain and storms. For example, if the air temperature is 85 degrees (F) and the relative humidity is 60%, the dew point would be 77 degrees. Dew points over 70 degrees are considered tropical.

Assessment:

- Informal Assessment: Given a black and white map of the United States, students will be able to work in partners or groups and create a color-coded map of humidity in the United States based on what they now know about relative humidity and what causes it.

- Formal Assessment: Demonstration of Learning (DOL) ask students to define relative humidity and where in the country or the world they would expect to find high humidity or low humidity.

Conclusion

The final chapter of this thesis will present a summary of the project and a reflection on the process of integrating science notebooks into the elementary classroom. While it is not always easy to demand a high level of accountability and rigor in the classroom, the science notebook can help create such a curriculum. The chapter will also discuss the applicability of the project beyond my classroom and recommendations for future educators.

Chapter 4: Summary and Recommendations

Introduction

The science notebook is a valuable tool for all developing scientists. It provides a place to record data and facts, document procedures and outcomes, link together evidence, as well as make conclusions and reflect on an investigation. The goal of this project was to integrate science notebooks in an elementary science classroom. This would provide the structure and content by which to maximize science instruction and support student achievement across the curriculum. This thesis provides the means by which to assimilate such a program in the classroom.

The introduction to the concept as well as a discussion of the nature of the problem can be found in Chapter 1. This chapter also describes the rationale behind the thesis study. In Chapter 2, the content and structure of the science notebook is laid out in detail. This chapter discusses the extensive literature and research that has been conducted on the topic of science notebooks in the classroom. In Chapter 2, there are also detailed connections to different curricular fields (i.e. math, writing and reading). Chapter 3 outlines ten detailed lessons that introduce, emphasize and utilize the important structures inherent in the science notebook. These lessons are only a starter kit to a yearlong tool used in the science classroom. Finally, Chapter 4 offers recommendations and reflections of the entire project.

Summary of Student Learning

Through inquiry-based science instruction structured around science notebooks, students gain hands-on applications of concepts learned in every class—from literacy to mathematics.

Science Knowledge

The science notebook helps students build their science knowledge on their own terms. As a self-constructed textbook, students are free to fill the pages with what they view as important information to the investigation. For example, students may be required to record the procedure, any observations and a conclusion for each investigation per the teacher's instructions but *how* they chose to record the information (with drawings and labels, in a list, or as complete sentences) is up to them to decide what makes the most sense to them. This methodology increases the likelihood that the student will constructively retain concepts, even years later.

Building science knowledge is a gradual process, especially in the elementary grades. Students need to have a space to record their thinking, trace their thought process and come to a solid conclusion. Working with peers and instructors during different stages of this process can help scaffold the information for different levels of learners, but the outcome is the same. The science notebook helps students draw their own conclusions from a given set of data or observations. It is when information is learned through this open-inquiry process that students *get it* and the light bulb turns on.

Writing Ability

Through constructing and building a science notebook, students practice expressing their observations and thoughts through writing. This is not an easy skill, and takes time to cultivate and master. In the Valle Imperial Project in Science (VIPS), the National Science Foundation studied the use of kit-based science instruction structured around science notebooks (Klentschy and Molina-De La Torre, 2004, p. 10). The study, conducted from 1995-1999, found that after four years of inquiry-based science instruction, sixth grade students almost quadrupled their scores in a standardized writing assessment. The science notebook is a storehouse of data, observations and recordings through which students build their comprehension of science in the classroom. The science notebook becomes an essential means of communication, and the main form this communication takes is through the written word. Undeniably, the science notebook can help develop students' ability to express themselves through their writing in a hands-on, student-driven, thought-provoking environment.

Observation Skills and 21st Century Skills

So much of what students learn in an inquiry-based science classroom is contingent upon the power of their observations. Being able to thoughtfully and critically observe the world around you is a skill. The earlier this skill is introduced to students, the more powerful their observations will be. The science notebook again provides the structure with which to teach the skill of observation. Observing and recording weather patterns on a day-to-day basis, or the miniscule parts of a grasshopper or an onion cell, taking note of the way two materials interact—these observations can attune a student's awareness to a specific point. The ability to bring awareness to fine details is a skill that is transferable to almost any profession.

Organized thoughts and presentation of knowledge within science notebooks creates an opportunity for meaningful communication and collaboration between students. Emphasizing the importance of staying organized and record their work in a logical, neat way teaches students that these are essential skills to being successful later in life. The science notebook provides a practical classroom application to highlighting such skills. If a student is messy, untidy and unorganized, their science notebook will be unsuccessful.

Reflection

Although these lessons could not be implemented in the classroom in a cohesive, measurable way, this thesis provides the framework with which to implement a structured system of critical thinking through instruction with science notebooks. It can be applied to any science classroom in any school, given that students are capable of taking responsibility for their own learning as well as recording their own hypotheses, observations, procedures, and conclusions (3^{rd} grade and up for independent motivations, but can be accomplished in younger grades as well). Obviously, providing more or less teacher guidance and structure through scaffolding can modify any of the lessons described in Chapter 3 to better suit a younger audience.

Science notebooks have the unique ability to improve student achievement, increase student responsibility, raise the level of rigor and relevance in the classroom and increase student participation in the classroom. They put the onus of learning back on the student, spark their interest and demand their inquiry. So often in science you can't help but ask yourself, "But why?!" The set-up requires structure and scaffolding in the beginning, but by the middle of the year students are capable of creating and recording their own science investigations from start to finish. The science notebook is a textbook that students feel ownership for—which means they are more likely to remember the information contained in their pages.

If I were to implement this investigation in the future, I would start with a clear plan for assessment. It is often important to assess the students' science knowledge in order to better understand the growth of the students' understanding. Pre- and post- tests can serve this purpose, rather than too many pencil and paper tests, practical hands-on assessments are a fantastic way to ask students to prove their knowledge on a topic.

In the future, I would also use a number of cross-curricular data points to assess the impact of science notebooks on their overall student achievement. I would collect non-fiction writing samples at the beginning of the year and compare them to middle and end of year writing samples. Non-fiction writing in particular has been shown to improve because of observation and recording in science notebooks (Calhoun and Mintz, 2004). I would provide them with simple observe-and-record tasks to measure the power of their observation over similar time scales. Most of all, I would assess their knowledge of science notebook structure and content from the beginning of the year to the end of the year (see Appendix 1).

Conclusion

Based on the body of evidence detailed in this thesis, there are several benefits across the curriculum to implementing the science notebook in the classroom. Science notebooks help students learn to improve their self-expression through writing, increase their class participation and responsibility, strengthen their metacognitive processes, practice collecting, recording and interpreting data, as well as teach them how to organize and record their thoughts.

In the future, I hope to apply what I have learned throughout this process to my own classroom. First, science notebooks have taught me the importance of providing hands-on applications of knowledge in the classroom. This often provides students something concrete to attach learned information and more easily recall it later on. Students also should practice observing and collecting data in the classroom, especially when they are responsible for analyzing and interpreting their own findings. This instills a sense of curiosity that many children are without these days. It also allows students to feel capable of finding a solution or an answer to a question they have—designing your own investigations is an important skill learned through inquiry-based science instruction with science notebooks (sometimes these moments are more structured than others). Science inquiry searches for explanations about relationships in the world around us. Finally, science notebooks provide the structure by which to avoid ‘activitymania’ in the science classroom. It provides a rhyme and a reason to an investigation, with a structured place to record thoughts, procedures and interpretations about an incredible scientific phenomenon being investigated.

Hopefully, one day I will find myself leading a classroom full of scientists as they choose to investigate a unique relationship found in this world. They all work intensely at their stations, with smiles on their faces when the light bulb of discovery turns on. They record their procedures and findings with careful precision, and come to a conclusion to answer the question with which they started the investigation.

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APPENDIX 1

Appendix 1.

Science Notebook Content Knowledge Pre/Post Test

1. Where would you find the table of contents in a science notebook?
    a. In the front
    b. In the back
    c. In the middle
    d. There is no table of contents in a science notebook

2. Where would you find the glossary in a science notebook?
    a. In the front
    b. In the back
    c. In the middle
    d. There is no table of contents in a science notebook

3. Name the 6 components of a complete investigation:
    1. ______________________________
    2. ______________________________
    3. ______________________________
    4. ______________________________
    5. ______________________________
    6. ______________________________

4. What do drawings in a science notebook need? (Circle all that apply)
    a. Color
    b. Straight lines
    c. Detail
    d. Labels
    e. Scale
    f. Pen
    g. Pencil
    h. Shading

5. Who is the audience for your science notebook?
    ____

    ____

6. What would you find in the glossary?
    ____

    ____

7. Complete the sentence:

    My science notebook is a ________________________.

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