Using Science Notebooks in Elementary Classrooms

By: Michael P. Klentschy

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i. Introduction

In an era of standards, assessment, and accountability, increased demands are placed on students to demonstrate an understanding of science content and on teachers to assess and determine the depth of student understanding. One of the major goals of elementary science instruction in this context is the development of scientific literacy in students. The American Association for the Advancement of Science (1993) recommends that scientific literacy involve student ability to determine relevant from irrelevant information, explain and predict scientific events, and link claims to evidence to make scientific arguments. The National Research Council (2000) also recommends that both student knowledge and content understanding be included in the assessment of science outcomes. Furthermore, the National Research Council (1999, 2005) recommends that instructional planning and classroom instruction focus on maximizing student opportunity to learn. Teachers can do this when planning, instruction, and assessment focuses on the following three principles:

(1) Engage students to activate prior knowledge.

(2) To develop competence in an area of inquiry, students

  a. must have a deep foundation of factual knowledge;

  b. must understand facts in the context of conceptual frameworks; and

  c. must organize knowledge in ways that facilitate retrieval and application.

(3) Recognize that metacognitive approaches to instruction can help students take control of their own learning by defining goals and monitoring their progress.

In addressing these three principles in instructional planning, teachers must also determine appropriate methods to assess student progress. These three principles align to a model of metacognition developed by Glynn and Muth (1994). In this model, students develop metacognitive ability through learning science by accessing prior science content knowledge; using science-process skills; and applying reading, writing, listening, and speaking skills to learn content. In using this model to address the three principles, student science notebooks and class discussion may be effective assessment tools for teachers.

Songer and Ho (2005) identify three challenges of instructional programs that foster student development of scientific inquiry. These challenges focus on the development of reasoning skills closely aligned to scientific literacy:

(1) the formulation of scientific explanations from evidence (and the actual linking of claims to evidence);

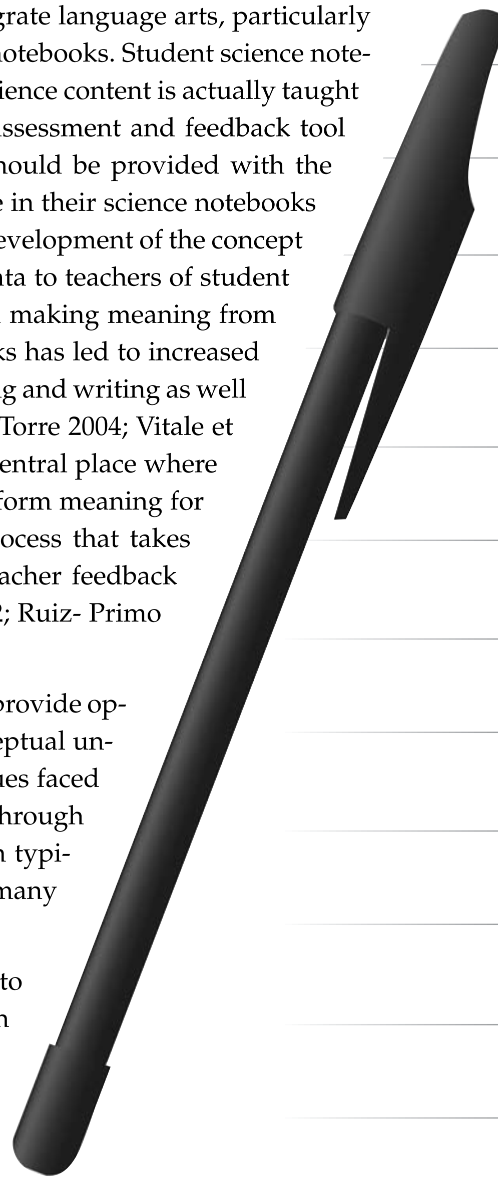
Introduction

(2) analysis of various types of scientific data (evidence); and

(3) the formulation of conclusions based upon relevant evidence.

Classroom teachers can assist students in developing these reasoning skills by carefully crafting the use of science notebooks as part of their classroom science instruction. This includes specific instruction through the use of scaffolds, sentence starters, and prompts. The science notebook then becomes a thinking tool for the student. The application of language arts is essential for students not only to develop a deep understanding of science content but also to attain scientific literacy.

Science may be the perfect content area to integrate language arts, particularly expository writing in the form of student science notebooks. Student science notebooks have proven to be the best record of what science content is actually taught and learned and provides an excellent ongoing assessment and feedback tool for teachers (Ruiz-Primo et al. 2002). Students should be provided with the opportunity to write to themselves as an audience in their science notebooks and not to the teacher as an audience. This is the development of the concept of "voice" by the student and provides specific data to teachers of student conceptual understanding. Students thinking and making meaning from science instruction through their science notebooks has led to increased student achievement in not only science but reading and writing as well (Amaral et al. 2002; Klentschy and Molina-De La Torre 2004; Vitale et al. 2005). As such, a science notebook becomes a central place where language, data, and experience operate jointly to form meaning for the student. The development of "voice" is a process that takes place over time and is enhanced with specific teacher feedback (Amaral et al. 2002; Jorgenson and Vanosdall 2002; Ruiz- Primo et al. 2002; Saul et al. 2002).

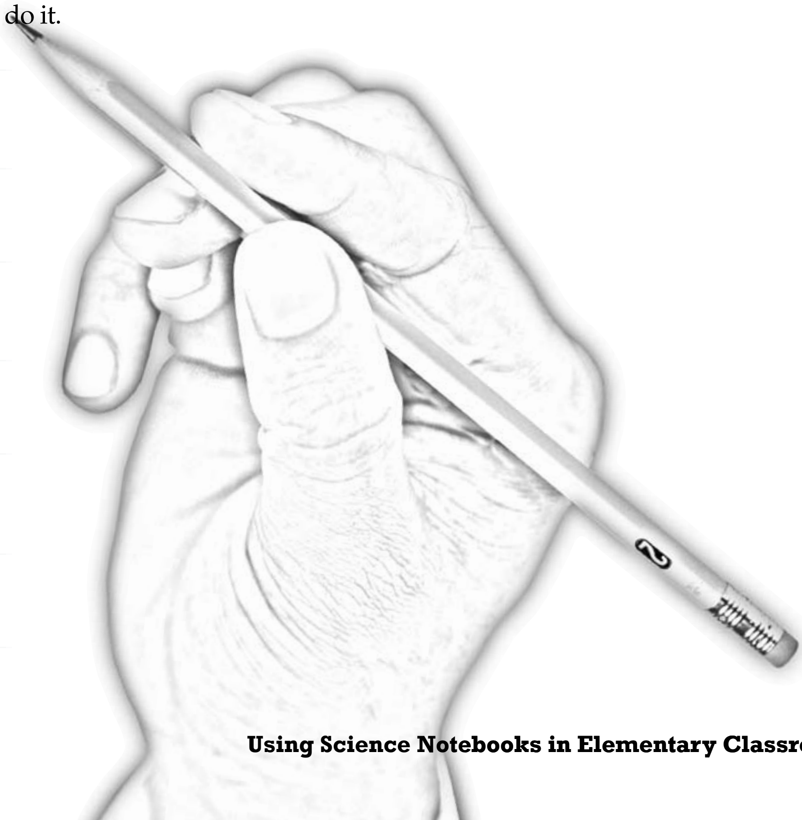


Student science notebooks, used well, not only provide opportunities for students to develop a deeper conceptual understanding of science, but also address other issues faced by classroom teachers today, most notably time, through the integration of language arts and science when typically only reading and mathematics are taught in many classrooms (Klentschy 2006).

Students' written ideas provide a window into their thinking process. The science notebook then can be viewed as a tool utilized by students during their science experiences and investigations and in social interactions with group members and the class, as a tool for personal reflection, and as a tool for constructing personal meaning of the science content being studied. The science notebook has been a tool used by scientists to help them in the same regard.

Many classroom teachers use student science notebooks as a regular part of their classroom instruction in science. Some teachers have a systematic approach for their use, while some do not. Many teachers who are not using student science notebooks would like to but are not sure exactly how to start or even what format the notebooks should follow.

This book is designed to assist classroom teachers who are currently using student science notebooks as a part of their classroom science instruction by providing them with a systematic research-based approach to extend and to either reinforce or build upon what they are presently doing. This book is also designed to assist classroom teachers who may just be getting started or wish to start using student science notebooks in their classrooms. Research-based best practices such as scaffolds, sentence starters, discussion starters, and writing prompts are included to build upon existing knowledge. Numerous examples of student work are provided to help both categories of teachers develop insight into instructional strategies for their classrooms. A discussion of the needs of English language learners is provided with specific strategies to increase both their language fluency and writing proficiency. Finally, research-based practices to use student science notebooks as an effective assessment tool are provided through scoring guides and other approaches to providing student feedback to both underline the importance of feedback to students and after some classroom-tested ways to do it.



CHAPTER 3

What Are the Essential Components of a Science Notebook?

Seven research-based science notebook components, and associated criteria for each of these components, have been identified and used by teachers in Imperial County, California, since 1996 (Klentschy and Molina-De La Torre 2004). While these seven components will be found in student science notebook entries associated with most lessons, they are not necessarily found in student science notebook entries for all lessons.

What Are the Essential Components of a Science Notebook?

These seven components are:

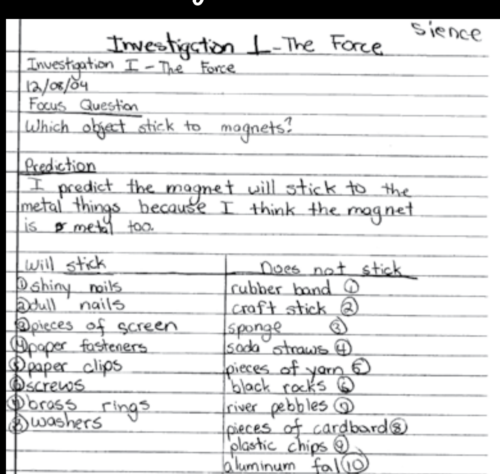
- Question, Problem, Purpose
- Prediction
- Developing a Plan
- Observations, Data, Charts, Graphs, Drawings and Illustrations
- Claims and Evidence
- Drawing Conclusions
- Reflection—Next Steps and New Questions

While each of these components can be viewed as individually important to the process of helping students carry out science activities and investigations, they collectively form a framework classroom teachers can use to help students make sense of what they have investigated. Figure 3.1 is an example of a science notebook entry of a fourth-grade student from a unit on magnetism and electricity. All of the components except planning are present in this entry and the student combined the conclusion and reflection.

The Question/Problem/Purpose component is the starting point for any student science investigation. Questions should be student generated, either from an individual, group, or class set of focus questions related to either solving a problem or answering a question that has been raised. Students should write questions in their own words. The questions should also be clear and concise and relate to the objective or standard being investigated. Student questions should also be investigable and not just simply be answered "yes" or "no." In the sample student science notebook entry (Figure 3.1), the student writes a focus question: Which objects stick to magnets? This is an investigable question. Chapter 5 provides strategies to help students formulate appropriate questions.

Figure 3.1

Fourth-Grade Student's Sample Notebook Entry from Magnetism and Electricity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Focus Question

Which object stick to magnets?

Prediction

I predict the magnet will stick to the metal things because I think the magnet is ~~a~~ metal too.

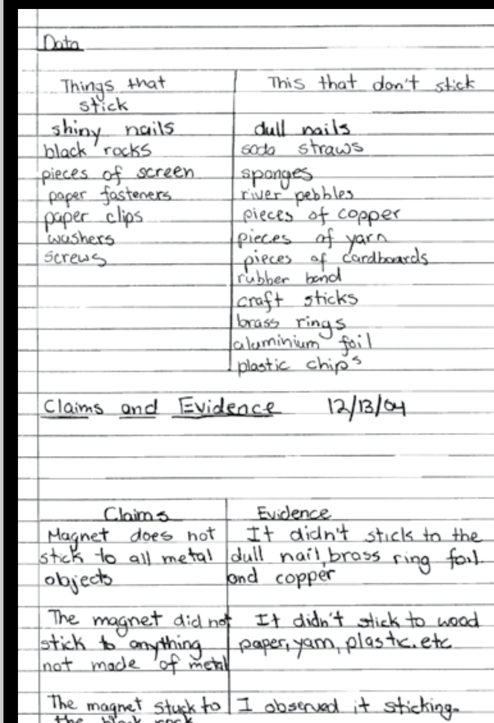
Will stick	Does not stick
1 shiny nails	rubber band 1
2 dull nails	craft stick 2
3 pieces of screen	sponge 3
4 paper fasteners	soda straws 4
5 paper clips	pieces of yarn 5
6 screws	black rocks 6
7 brass rings	river pebbles 7
8 washers	pieces of cardboard 8
	plastic chips 9
	aluminum fal 10

The Prediction component is designed to have students make a prediction regarding a reasonable answer to the question they formulated. Teachers need to assist students in writing predictions that connect to prior experience and relate to the question they formulated. Predictions should be clear and reasonable. A good prediction also gives an explanation or a reason. Using the word "because" assists students in providing an explanation. In the sample notebook entry, the student uses the word "because" in her prediction, providing an explanation based on prior knowledge. Chapter 6 discusses strategies to assist students in developing effective predictions.

Developing a Plan relates to the student detailing a course of action to obtain data for the investigation. This usually takes place in two stages. First the student develops a general plan where variables and controls are identified and then an operational plan where a clear sequence and direction for the investigation is outlined. The operational plan also includes the materials needed for the investigation. In the sample entry, the teacher had the students develop a class plan and it was recorded on the chalkboard. An important aspect for developing a plan is for students to also create a data collection device for the investigation. In the sample entry, a T-Chart was selected as the data collection device. Strategies for developing plans are explored in Chapter 7.

The Observations, Data, Charts, Graphs, Drawings, and Illustrations component is designed to provide students with strategies to collect data related to their question and plan from observations or measurements during the implementation of their plan. These strategies include student-generated drawings and illustrations, charts, graphs, and an accompanying narrative. In the sample student science notebook entry, the student has created a

Figure 3.1 (Cont.)

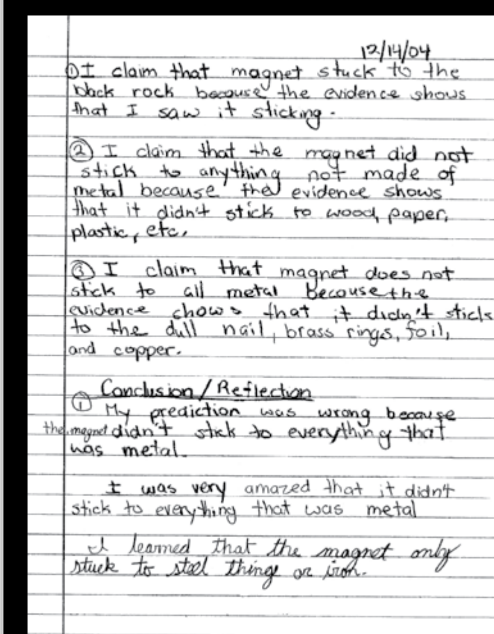


Data

Things that stick	This that don't stick
shiny nails	dull nails
black rocks	soda straws
pieces of screen	sponges
paper fasteners	river pebbles
paper clips	pieces of copper
washers	pieces of yarn
screws	pieces of cardboards
	rubber band
	craft sticks
	brass rings
	aluminium foil
	plastic chips

Claims and Evidence 12/13/04

Claims	Evidence
Magnet does not stick to all metal objects	It didn't stick to the dull nail, brass ring foil. and copper
The magnet did not stick to anything not made of metal	It didn't stick to wood paper, yarn, plastic. etc
The magnet stuck to the black rock	I observed it sticking.



12/14/04

1 I claim that magnet stuck to the black rock because the evidence shows that I saw it sticking.

2 I claim that the magnet did not stick to anything not made of metal because the evidence shows that it didn't stick to wood, paper, plastic, etc.

3 I claim that magnet does not stick to all metal Becouse the evidence chows that it didn't stick to the dull nail, brass rings, foil, and copper.

Conclusion / Reflection

1 My prediction was wrong because the magnet didn't stick to everything that was metal.

I was very amazed that it didn't stick to everything that was metal

I learned that the magnet only stuck to steel things or iron.

T-Chart with column headings of "Things that stick" and "This [sic] that don't stick" to collect and organize data. Chapter 8 introduces strategies to assist students in effectively collecting, organizing, and displaying their data.

Claims and Evidence is where students use the data they have collected during their investigation to make sense or meaning from the investigation. Students need to understand that their data is their evidence. Students often make many claims in science without supporting them with evidence from their investigation. In the sample entry, the student again is using a T-Chart to record claims and evidence and then rewriting the listings as complete sentences. Chapter 9 provides classroom teachers with several writing supports to assist students in effectively linking claims to evidence.

The Drawing Conclusions component is designed to assist students in recording what they learned from the investigation, not simply what they did during the investigation. While this may seem easy on face value, it is actually quite difficult for many students to do. In the sample notebook entry, the student comes to the conclusion that, "the magnet only stuck to steel things or iron." This was the teacher's content objective for this lesson. The teacher also had the student revisit her prediction and revise her thinking regarding what would "stick" to the magnet. Chapter 10 discusses effective strategies to assist students in drawing conclusions.

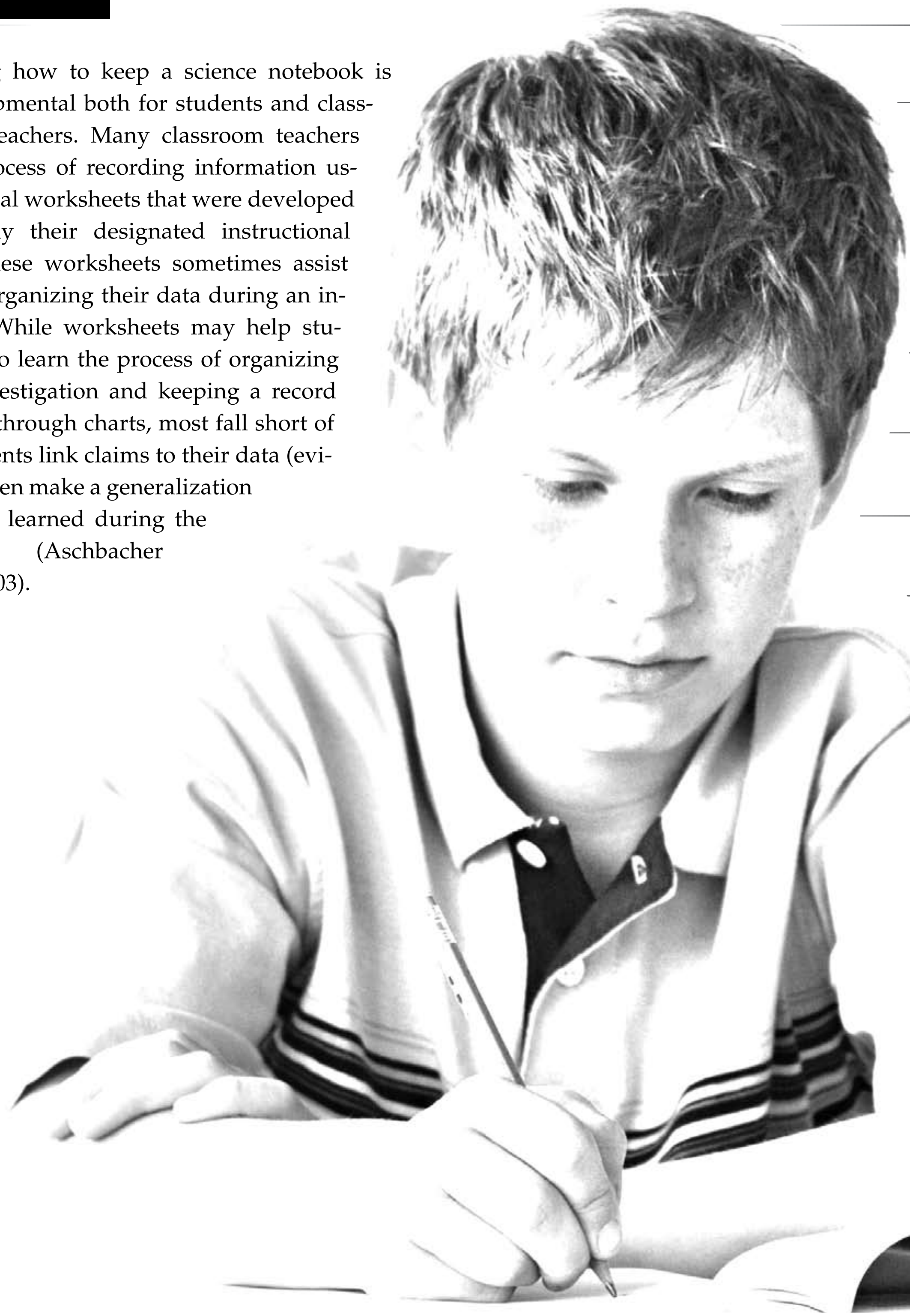
After students complete an investigation, teachers should consider providing students the opportunity to reflect on what they learned. The Reflection: Next Steps, New Questions component is for that purpose. In the sample entry, the student comments, "I was very amazed that it didn't stick to everything that was metal." Students should also have the opportunity to extend their investigation with a new application of their original question. Chapter 11 explores strategies to help students become more reflective in both their thinking and in their writing in their science notebooks.

When viewed as a whole, these components provide students with the tools to make greater meaning from their science investigations and to use the science notebook as the communication method to do such. Again, time and practice are essential to achieve this end.

CHAPTER 4

Getting Started

Learning how to keep a science notebook is developmental both for students and classroom teachers. Many classroom teachers begin the process of recording information using commercial worksheets that were developed to accompany their designated instructional materials. These worksheets sometimes assist students in organizing their data during an investigation. While worksheets may help students begin to learn the process of organizing a science investigation and keeping a record of their data through charts, most fall short of helping students link claims to their data (evidence) and then make a generalization of what they learned during the investigation (Aschbacher and Baker 2003).



Getting Started

There are a variety of ways classroom teachers can use worksheets as a starting point. Some teachers reproduce them and have students staple or paste them into their science notebooks. Others only use the data collection devices such as charts and tables as a way of modeling the tools for recording data, observations, or measurements.

Students may have difficulty recording items in science notebooks in the early stages. It is important that classroom teachers provide writing prompts or sentence stems to facilitate the process. There are several ways to get started with student science notebooks. Sentence stems such as those listed below can be initially introduced and then gradually removed as students gain experience. These stems introduce students to the essential science notebook components.

My question: ______________________ (Question)

Today I (or we) want to find out________________ (Problem)

I think ________ will happen because ________ (Prediction)

I noticed (or observed) ____________ (Observation)

Today I learned _____________ (Conclusion)

I wonder __________________ (Reflection)

Questions I have now are _____________ (Next Steps/New Questions)

Students should also be encouraged in the early stages of development to record the date and time in their notebooks along with any other important headings or titles for their work. This will add purpose to their work and allow students to return to previous entries to determine how their thinking has changed over time. Students will also be introduced to the notion that the science notebook is their record of what was observed or measured and that this information is available for future use.

For more ideas on stems, visit the Valle Imperial Project in Science website at *www.vipscience.com.* Additional websites such as the East Bay, Rhode Island Collaborative at *www.ebecri.org/custom/toolkit.html* and the North Cascades and Olympic Science Partnership at *www.sciencenotebooks.org* offer resources to help classroom teachers get started using science notebooks.

Students will develop proficiency if classroom teachers give them time and multiple recording experiences. In the early stages of using science notebooks, students may have difficulty deciding how and what to record. Classroom discussion at key junctures in the investigation helps students focus their science notebook entries, provides opportunities for teachers to model suggested formats, and allows teachers to use examples from other students as models.

Just as students develop the ability to use science notebooks over time with practice, teachers also master the use of science notebooks by making them part of their instructional practice. For example, a kindergarten teacher integrated the use of science notebooks in her classroom instruction over a period of time, reaching a comfort level both in her expectations for what students had the ability to do and with her existing beliefs regarding the use of science notebooks in her classroom.

In Figure 4.1, the teacher is using a commercially developed worksheet and has traced the letter shapes for her students. While this is not the most effective practice, because the ownership for the work belongs to the teacher, it still represents a recognition that having her students record information from their science investigation will increase their understanding of what they were supposed to learn.

The second stage of this teacher's development is depicted in Figure 4.2. The teacher has given the student a blank sheet of paper and the student has drawn his observation of the relationship between the Sun, himself, and his shadow. The student has dictated a title for his observation and the teacher has recorded the title. It is evident from the drawing that two important pieces of information are being noted by the student: (1) he activated prior knowledge in drawing his likeness (the previous unit of study was

Figure 4.1

Initial Stage of Teacher Development with Commercial Worksheet

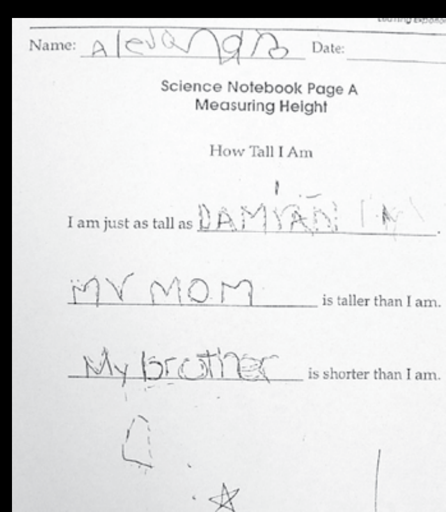


Figure 4.2

Stage 2: Student Dictation and Illustration

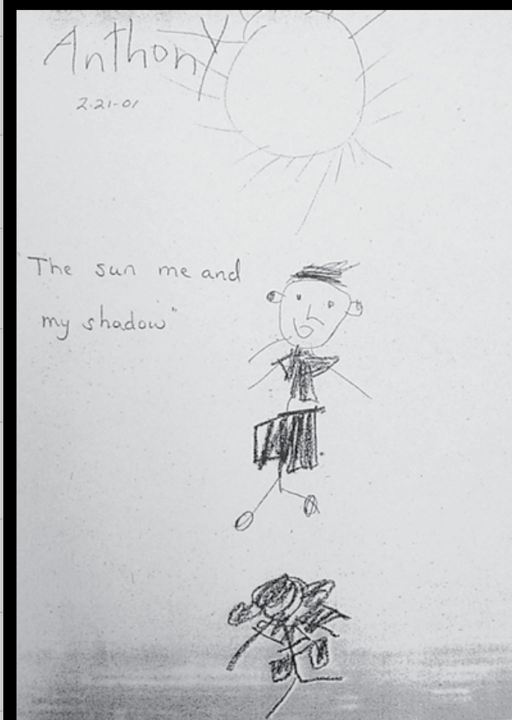
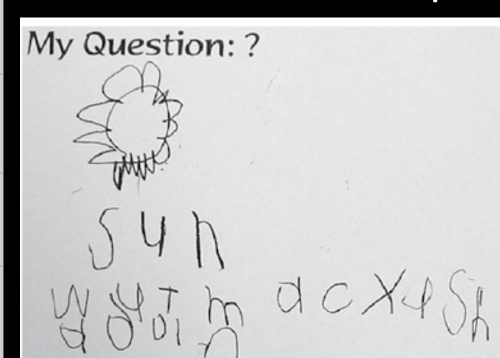


Figure 4.3

Stage 3: Use of Writing Prompt



Myself and Others); and (2) the student has a misconception in the alignment of where his shadow belongs. Using this information, the teacher can work with the student to clarify this misconception before proceeding. The task of just tracing letters on a commercial worksheet would not have revealed this misconception.

The teacher gave the students writing prompts and sentence starters to record and illustrate their observations. In Figure 4.3, the student has responded to the writing prompt of "My Question" by drawing and labeling the Sun and then recording a question: What makes a shadow? This question was student-generated from a class discussion about shadows after the teacher had read a story about shadows to the students.

Another example of this stage is depicted in Figure 4.4, where the teacher again provides a sentence starter for the student: "Today I learned…."

The student responded to the sentence starter by drawing a picture of a flashlight, an object, and the resulting shadow created by shining the flashlight on the object. The student has also recorded that he learned that the "[shadow is] opposite the light."

Both of these examples provide a cognitive map of what students observed and their thoughts of the observation. This process was facilitated by the teacher through the use of sentence starters or writing prompts. The students demonstrated a good understanding of the primary focus of the lesson in both the formulation of a question and in recording what they had learned.

Figure 4.5 illustrates the final stage of this teacher's development in the integration of science notebooks into her science instruction.

In this stage, the teacher gave the students paper with a large blank space on top for illustrating observations and lines on the bottom for recording findings. This student is writing a prediction regarding the number of paper clips she thinks will be needed to sink the piece of plywood floating in a small tub of water. The student wrote: " Prediction—I wil (sic) need 5 clips to sico (sic) the wood." After conducting the investigation, the student recorded: " I iyou (sic) 3 clips."

In this stage the student has taken control and is making her own meaning from the investigation. The teacher has the role of facilitator, providing the prompts or supports to help the student become more experienced in the use of science notebooks.

In summary, the process of using science notebooks is developmental for both students and classroom teachers. Student supports through commercial worksheets, writing prompts, and sentence starters are effective ways for students to begin using science notebooks to make sense from their science investigations. Integration of these strategies into classroom science curriculum is also a key element in this developmental process.

Figure 4.4

Stage 4—Use of Sentense Starter

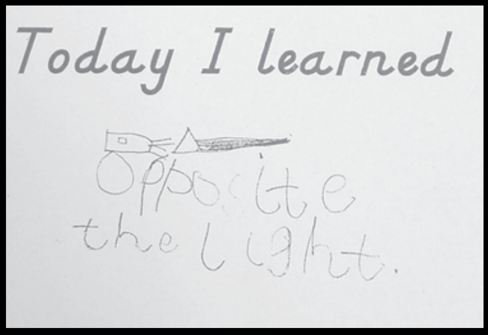
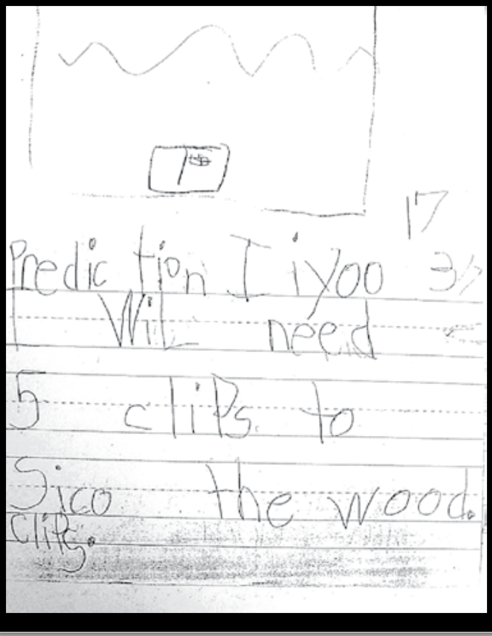


Figure 4.5

Stage 5: Independent Student Notebook Entry



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