Science Notebooks

Writing About Inquiry

Lori Fulton &
Brian Campbell

SECOND EDITION

Foreword by
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HEINEMANN
Portsmouth, NH

Heinemann
361 Hanover Street
Portsmouth, NH 03801–3912
www.heinemann.com

Offices and agents throughout the world

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Library of Congress Cataloging-in-Publication Data
Fulton, Lori.
Science notebooks : writing about inquiry / Lori Fulton and Brian Campbell ; foreword by Rebecca E. Dyasi, Hubert M. Dyasi. — Second edition.
pages cm
Prev. ed. main entry Campbell, Brian.
Includes bibliographical references.
ISBN 978-0-325-05659-3
1. Science—Study and teaching (Elementary)—United States. 2. School notebooks—United States. 3. Learning by discovery. I. Campbell, Brian. II. Campbell, Brian, Science notebooks. III. Title.

LB1585.3.C36 2014
372.35'044—dc23 2013040600

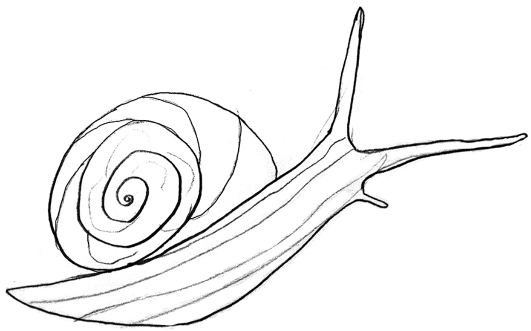
Editor: Katherine Bryant
Production: Vicki Kasabian
Cover and interior designs: Monica Ann Crigler
Typesetter: Kim Arney
Manufacturing: Steve Bernier

Printed in the United States of America on acid-free paper
18 17 16 15 14 VP 1 2 3 4 5

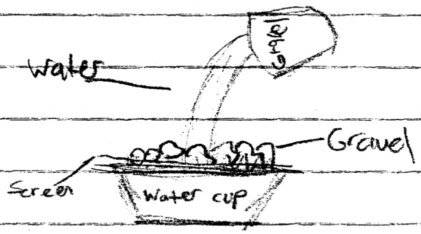
We would like to thank all those students, teachers,
and educators who have supported us in our work.

We want to dedicate this book to young scientists
everywhere, especially Grace and Savannah.
May notebooks serve as tools to help you make
sense of the world around you.

Contents

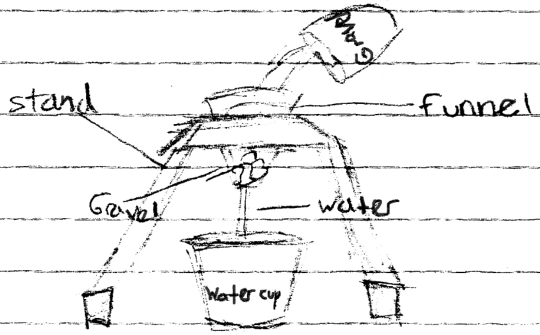


We tried to fiter the material from the water with a screen. Only gravel worked.



Water and earth would not seperate. I guess the fibers are too thin. The salt certainly didn't come out, it had already dissolved.

Going to try filtering with a funnel. Gravel worked again.



Salt worked too! the water was purified and the salt got stuck in the water. Now for earth.

Waiting...  Catherine

Foreword

This book is about the educational power of that constant, venerable, and veritable scientists' companion, the science notebook; but it is also about a lot more. It is about how students can create and use science notebooks both to learn science content and to communicate it effectively. It is also about the respective roles of teachers and of students during inquiry-based science lessons in the elementary school: How students and teachers can interact with one another, individually and jointly assess for learning, and make decisions about further learning. And it is about implementing new science standards and about making links to language arts and literacy.

The authors are experienced elementary school teachers and science education scholars who developed and used science notebooks in their own classrooms. They rightly see the science notebook as the core of an inquiry-based classroom culture characterized by authentic interactions between teacher and students, between students, and between students and their materials and their notebooks, all in pursuit of scientific understanding and explanation.

The authors provide a rich, lucid guide and resource for teachers who want to build that kind of culture. Their book is richly illustrated with lively classroom vignettes showing teachers engaging students in creating and using science notebooks in the context of scientific investigations. These vignettes demonstrate how using science notebooks leads toward the primary goal of science instruction: understanding scientific content. They also illuminate the uniqueness of each student's science notebook as well as elements common to all notebooks (collecting and organizing data, recording questions, and developing explanations, for instance). They describe, for example, how a teacher introduced students to science notebooks through an investigation of water (related to a specific content goal). The process encompasses initial exploration, development of a whole class notebook to serve as a model, and the teacher's orchestration of questions and discussions around collected observations and findings. Fulton and Campbell show how different teachers stimulate students' interest in learning strategies for documenting science practices, core science content, and cross-cutting concepts, and in making meaning of science learning. Students learn to "write purposefully on their understanding" and to "process their thinking."

Throughout the vignettes, the authors give useful practical pointers, such as using learning progressions to be aware of reasonable expectations for students at different stages of development during the year and across grades, making sure students are thinking rather than merely copying from a class notebook, helping students develop ownership of their individual science notebooks; making sure students know how to use their science notebooks as a resource; and not treating science notebook activity as a test.

Science Notebooks is an excellent account of best practice in teaching and learning inquiry-based science at the elementary school level. Its pedagogical approach is firmly rooted in widely recognized research findings about how people learn: It calls for building on the knowledge children bring to school, and for teaching children to engage in scientific reasoning and argument using evidence from their investigations, to use their current conceptual knowledge to build new knowledge, and to continually monitor their own learning. The teacher's roles portrayed in the book are completely in line with the highly acclaimed science teaching standards of the National Science Education Standards and with the Next Generation Science Standards. The authors also show how using science notebooks directly contributes to the development of knowledge and skills described in the Common Core State Standards for English Language Arts: talking, listening, writing, and reading are critical aspects of the science notebook.

Fulton and Campbell devote a chapter to professional scientists and engineers discussing the science (or engineering) notebooks in their professional lives. They make remarkably powerful statements showing how pervasive and pivotal the science notebook is and how true scientific inquiry or engineering design work can be achieved with the use of notebooks. The book's vivid images of the science class invoke parallels with a science or engineering research community in all its attributes of exploration. It demonstrates how to implement authentic science activity in elementary school classrooms.

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Introduction

What is the purpose of this book?

The main emphasis of this book is to begin teachers on a journey in developing the use of science notebooks in their elementary classrooms. For those already on this journey, the purpose is to aid in the overall development of notebooks. This book is not designed as a step-by-step guide, but as a resource to develop strategies and methods to make notebooks more meaningful.

Who is the audience of this book?

This book is primarily written for elementary classroom teachers using hands-on, inquiry-based science, which allows for more opportunities to utilize the information presented. However, preservice teachers, middle school science and literacy teachers, administrators, literacy specialists, and English language learner facilitators would benefit from various sections as well.

Why a second edition?

Since the first edition was published in 2003, there have been changes to the standards addressing science and literacy. In science, *A Framework for K–12 Science Education* (National Research Council 2012) and the Next Generation Science Standards (Achieve 2013) were published. In literacy, the Common Core State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects (National Governors Association Center for Best Practices, Council of Chief State School Officers 2010) was published in 2010. Science notebooks can play an important role in helping students acquire the ideas, practices, and capacities addressed in all of these documents. These ideas are fully developed in Chapters 5 and 6.

In addition to addressing the new standards, we have added new material to each chapter. In Chapter 1, strategies to support or scaffold science notebook instruction have been added. In Chapters 2, 3, and 5, we examine the role science notebooks play in the development of explanations and arguments. In Chapter 3, we have also added strategies for collecting and analyzing science notebooks for formative purposes. We've added new interviews with a scientist and two engineers to Chapter 4, and we've brought in more than twenty new pieces of student work throughout the book.

What are science notebooks?

Science notebooks are a natural complement to kit-based programs in which students are actively engaged with materials, involved in small- and whole-group discussions, and using expository text as a reference to confirm or extend ideas after investigations. In the elementary school classroom, science notebooks are a record of students' findings, questions, thoughts, procedures, data, explanations, and wonderings that may or may not retell the journey of their science experience.

Science notebooks are

- tools for students to use during science;
- tattered—a sign of regular use—with water stains and bent corners;
- always near children, tucked under their arms or close at hand, so they can record a moment in time as they work with the materials;
- personal to the owners and might make sense only to them;
- places to record data, observations, illustrations, understandings, questions, reflections, and ideas while working;
- reference tools students use as they continue their work or talk with others in small- or whole-group discussions.

What can be used as a science notebook?

- a composition book
- a spiral notebook
- a three-ring binder
- a three-prong paper folder
- folded paper

What is the difference among science journals, logs, and notebooks?

As science notebooks gain in popularity, more and more people are using some sort of recording device in their classrooms. Teachers often refer to them as *science journals* or *logs*, as well as *notebooks*. Although teachers may use these words interchangeably, the differences among them have led many people to question how others are using these recording devices.

Being familiar with journals in other subject areas, some teachers ask their students to keep journals in science as well. Journals often serve as reflections of students' learning. In science, journals are kept in the desk during the investigation and used only after the work is done and the materials are put away. Most entries usually begin with "Today in science I. . . ." In this sense, journals contain reflections of students' work and not necessarily the data from their investigations.

When teachers refer to *logs*, they often mean books where students keep data over time. In science, logs are used during investigations but are not used during discussions. Students might look back at the data but do not reflect on their understandings or synthesize the data within the log itself.

Notebooks are meant to be tools for students to record both their data and thinking as they work with materials. Students use them prior to the investigation to record their thinking or planning; during the investigation to record words, pictures, photos, or numbers, possibly getting the notebooks wet and messy in the process; and after the investigation to help clarify their thinking and data to share them with others.

Science notebooks are more than a collection of notes about science. Science notebooks replicate, to a certain degree, the notebooks that scientists keep. They contain plans, questions, quantitative and qualitative data, thoughts, explanations, analysis, and more. The development of content through scientific practices drives the science notebook for students. Language strategies support the content development; for example, the teacher might use a Venn diagram as a way to help students compare and contrast the structures of two different organisms. The teacher facilitates the use of the skills of comparing and contrasting within the science notebook as a way to develop a better conceptual understanding of structures of organisms.

We use the general term *scientific practices* to refer to the work of both scientists and engineers throughout this book.

What are the goals of a science notebook?

There are three goals for using science notebooks with students. The primary goal is to build and reveal students' thinking about science content. Whether in a school focused on meeting the Next Generation Science Standards or in an informal after-school setting, students should be thinking deeply about science content as they use their science notebooks. The notebook serves as a space for students to communicate that thinking. The second goal of notebooks is to replicate the work of scientists. Scientists plan investigations, collect data, interpret those data, and construct explanations as they work. They document this work in their science notebooks and report their findings to the scientific community. Their notebooks are an important tool in their work. The last goal is to serve as a tool to develop and exercise literacy skills. The science notebook provides a vehicle in which students write and organize information and thoughts. The notebook is used as a resource when speaking to their peers and as a reference to be read to access prior experiences and connect thinking across months of work.

What is in this book?

This book is designed as a reference for the classroom teacher. The first three chapters focus on classroom implementation, and the last three chapters provide rationale for using notebooks. These sections should be read as needed to help teachers meet their goals in developing science notebooks in the classroom. Within certain sections are vignettes (short stories). These vignettes are based upon the authors' experiences when working with children in a variety of settings utilizing science notebooks. Thinking points are presented throughout the chapters and are designed to help link the ideas presented in this book to the classroom and philosophical beliefs. The thinking points should be revisited from time to time as your thinking changes as you gain experience with notebooks.

What does the teacher do?

Chapter 1 focuses on the role of the teacher in implementing science notebooks, sharing ideas of how to establish goals for notebook use, getting authentic notebooks started, and developing them further without infringing upon the notebook's authenticity. The chapter also examines ways to purposefully use strategies to develop notebooks to help all children, including English language learners.

What is in a science notebook?

Chapter 2 explores the elements of science notebooks and closely examines what notebooks might look like. We share some ideas for helping students record and organize their data using both words and drawings, and we examine the importance of questioning. The chapter also explores how to take students beyond simply recording data to developing explanations containing claims, evidence, and reasoning, as well as synthesizing their thoughts before, during, and after an investigation.

What are signs of students' progress?

Chapter 3 examines how students progress as they utilize science notebooks. It opens by considering the role of formative assessment and ways in which teachers can collect information on student progress. Next, the chapter shifts to how students progress from beginning to more advanced stages in their representation related to the scientific practices as well as their conceptual understandings.

What does the scientific community have to say about science notebooks?

Chapter 4 shares conversations with scientists and engineers. Because notebooks are an important component of the scientific world, this chapter discusses what scientists consider to be important elements of a notebook and examines how scientists use notebooks in their line of work.

How do notebooks support implementation of the Next Generation Science Standards?

Chapter 5 examines how notebooks can foster the development of scientific practices, crosscutting concepts, and core ideas and discusses the implications on students' learning. Connections to the Next Generation Science Standards are shared.

How do science notebooks promote literacy development?

Chapter 6 discusses the use of science notebooks as a context for literacy development, looking at connections between science notebooks and the development of speaking and listening, reading, writing, and the use of vocabulary as identified in the Common Core State Standards for English Language Arts.

1

The Role of the Teacher

As with any practice within the classroom, the teacher's role is crucial to success with science notebooks. Getting students to use science notebooks to their fullest extent allows students to develop and reveal their thinking about scientific concepts, replicate the work of scientists and engineers, and develop and exercise language skills. The teacher needs to carefully plan how to manage time, materials, and students as notebooks are used and to consider carefully the type of notebook used, what is recorded, and what tools and strategies benefit students' content and language development.

Planning

Where to begin?

There are certain decisions to make before beginning to use science notebooks in the classroom. Grade level and student ability should be considered in these decisions, as they factor into initial student use of the science notebook. These decisions include such things as:

- What type of notebook should be used?
- What should be included with every notebook entry?
- What will students write about in their notebooks?
- What organizational tools will students need?
- What role will students' language abilities play?
- Which experience will provide students with a meaningful starting point?

What type of notebook should be used?

To begin, the teacher must decide the physical structure of the science notebook. There are a variety of options, including composition books, spiral notebooks, three-ring binders, two-pocket folders with prongs, or pieces of folded paper stapled with or without a cover. Preference on the type of notebook varies; however, many have found the composition book allows students to keep a running record of the work and thinking they do throughout the year and represents growth over time. Using a composition book provides ample flexibility for first-time use. If using instructional materials that will require students to glue or tape sheets into their notebooks, the notebook should be large enough so students have ample room to attach those sheets. Samples that appear in this book come from students who used composition books.

THINKING POINT: What type of notebook will you use?

What should be included with every notebook entry?

Another decision the teacher must consider is what information will be recorded within each entry. Scientists often record the date, time, and weather. These items might not seem important in elementary science; however, by including this information in every entry, students are establishing habits of scientific documentation. Younger students can start with a date initially and add additional information as they are able. Many teachers find it helpful for themselves and their students to include a subject or title with each entry. This becomes a quick reference to locate information as students flip through their notebooks during discussion.

THINKING POINT: What information will you expect students to include in all entries?

What will students write about in their notebooks?

Chapter 2, "Elements of a Science Notebook," offers a variety of ideas for recording.

Notebooks provide a medium in which students document scientific investigations. Students will approach the process of documentation from different perspectives and the teacher should take this into consideration. For example, it might be more realistic to initially expect drawings from first graders than the use of Venn diagrams.

It takes time before students begin to use many of the elements of a notebook, so it is important to have reasonable expectations. Beginning entries might appear discouraging, but from there you can determine where students are starting and how much scaffolding might be needed. Some entries will contain only observations and others will offer interpretations or inferences of those observations. Some students might draw smiley faces on animals and write that their insect likes them. This should be expected, as students are most familiar and comfortable with that form of writing and drawing. Students will progress as they continue to work with notebooks and use them in their discussions with others. The more students use their notebooks, the more scientific their representations become. Students develop at different rates and their notebooks are no exception. Some students take to their notebooks right away, recording in great detail, while other students require extensive scaffolding to become proficient. Figures 1–1 and 1–2 show beginning entries from students at two different grade levels. What do you notice about these two entries?

Chapter 3 describes how students progress and how teachers can use formative assessment to guide this development.

THINKING POINT: What are realistic expectations for your students' writing?

What organizational tools will students need?

In the beginning you will need to talk with students about the overall organization of their notebooks. One technique that might help with organization is the use of colored tabs. For example, a red tab could mark the section on organisms and a yellow tab might signify the solids and liquids section. It might also be helpful to talk with students about using the next blank page rather than skipping around in their notebooks or using an entire page to record information rather than putting only one piece of information on a page. Although these might sound like simple ideas, some students struggle with organizational skills, and such techniques might require direction in the form of guiding questions, minilessons, or modeling from both teachers and students.

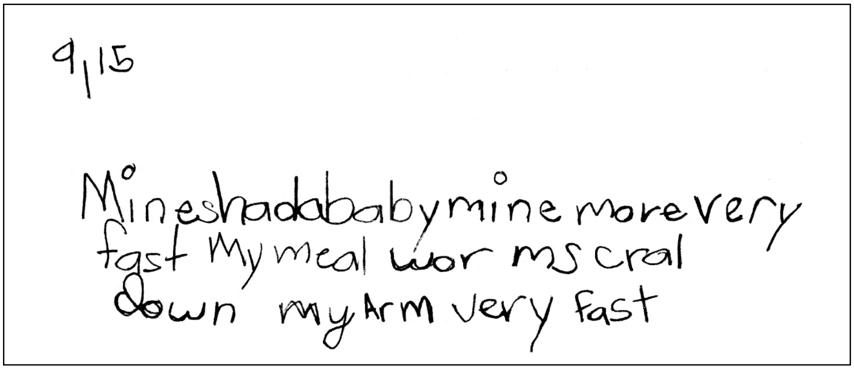
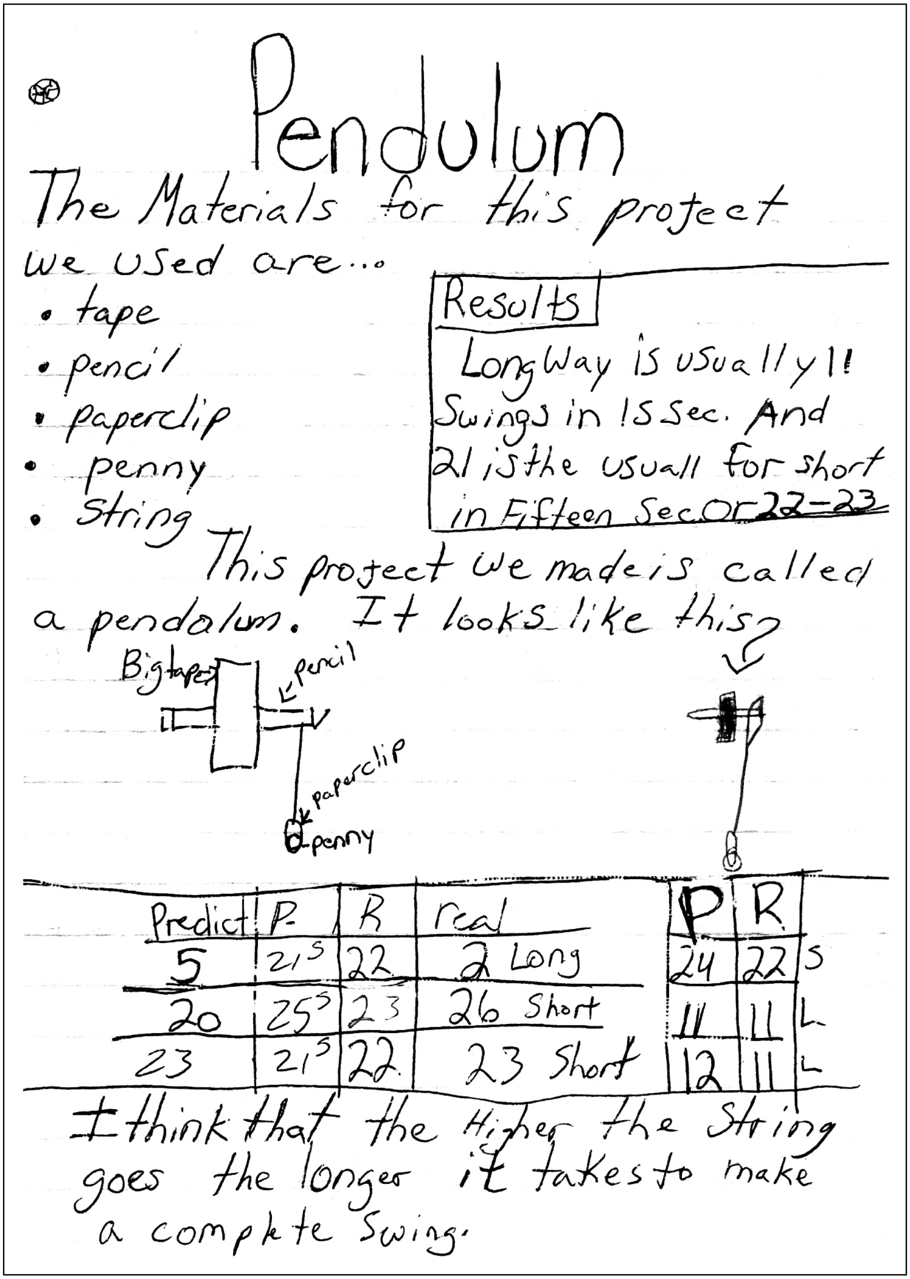


Figure 1–1. Beginning notebook entry of a second grader describing how fast a mealworm crawls



Pendulum

The Materials for this project we used are...

- tape
- pencil
- paperclip
- penny
- String

Results

LongWay is usually 11 Swings in 15 Sec. And 21 is the usuall for short in Fifteen Sec Or 22–23

This project we made is called a pendolum. It looks like this

Predict	P	R	real	P	R	
5	21 S	22	2 Long	24	22	S
20	25 S	23	26 Short	11	11	L
23	21 S	22	23 Short	12	11	L

I think that the Higher the String goes the longer it takes to make a complete Swing.

Figure 1–2. Beginning notebook entry of a fifth grader

The teacher's own organizational habits, whether they be sequential or random, often impact the outcome of students' notebooks. A word of caution about teaching only one style of organization: some students might have a difficult time following a certain line of thinking, causing frustration for both students and teacher. Yet it is important to establish some sense of organization initially; notebooks that are too random might not be useful tools. Providing too much structure will also limit the ability to determine what students are able to do independently. By allowing students choice in their organization, such as where they put the date or whether they use a drawing or words to capture their thinking, the teacher is helping them build an important skill. In time and with feedback and appropriate guidance, students will find an organizational technique that works for them.

THINKING POINT: What organizational tools do your students need?

What role will students' language abilities play in notebook development?

Teachers with young students or students who have limited experiences with English will need to consider what additional scaffolding and strategies might be needed to support science notebook development. Some might be surprised to find that even their articulate students have limited experience with the language of science, as the procedural and conceptual language of science is often new to all students. There is usually a range of language abilities within the classroom, and different scaffolds and strategies are effective for different students. Some teachers prefer to provide a high level of support initially and modify the strategies as the year progresses. Other teachers start with a moderate amount of support and then modify. Both approaches have benefits and limitations. With more support, the students might feel more successful, but it is difficult to determine what students can do independently. Alternatively, with less support, students might struggle more initially but the teacher can better gauge what students are able to do independently. Specific strategies for scaffolding are shared later in this chapter.

THINKING POINT: How will you support students' language needs and development?

What experience will provide students with a meaningful starting point?

One of the most important things to consider in the beginning is what kind of investigation will provide a solid foundation for the development of good scientific practices and appropriate content. Students in younger grades have fewer experiences with scientific practices than older students and will need guidance on how to make observations or follow procedures. The first experience should offer students the opportunity to record using various techniques. Observations that require more than one sense often work well. Having students observe familiar materials, such as the properties of a specific fruit or leaf or a section of the school grounds, would serve as an appropriate beginning activity. Because this investigation will set the stage for future recordings, it is important that it is engaging, promotes scientific conversation, and is developmentally appropriate.

THINKING POINT: What will you use as your initial investigation?

After considering ideas on

- the type of notebook,
- information to be included in all entries,
- realistic expectations,
- organizational tools,
- language abilities, and
- the initial investigation,

the teacher is ready to implement science notebooks.

Initial Implementation of Science Notebooks

After considering all these initial issues, the next step is to implement notebooks in the classroom. As you begin to put notebooks into practice, there are new considerations:

- What goals will science notebooks address?
- What will the first week actually look like?

What goals will science notebooks address?

One element of teaching involves setting goals for students' learning. When using science notebooks, teachers need to thoughtfully plan specific goals related to

1. content,
2. scientific practices and crosscutting concepts, and
3. language and communication skills.

The first goal focuses on building scientific concepts. Students use their science notebooks to record their findings and ideas about a content goal, such as the effects of environmental changes on organisms. Such goals come from national and state standards and are addressed in quality science curricula that not only identify these content goals but also sequence them in a logical progression to build toward understanding core ideas in science. The content goal may lead to a focus question meant to guide the instruction and reveal students' understanding of the content, such as "How does an increase in rain affect plant life?" Students communicate their thinking as they answer this question in their notebooks. (The focus of this book is on using science notebooks as learning tools to develop these ideas rather than the development and selection of such content goals or focus questions.)

The second goal emphasizes the advancement of scientific practices and crosscutting concepts, such as analyzing and interpreting data and determining patterns. The science notebook provides an authentic means for students to engage with these practices and concepts in much the same way that scientists engage with them.

Finally, the third goal focuses on the development of students' language and communication skills, such as supporting claims with evidence. The science notebook provides students with a venue to develop these skills in a meaningful context related to their firsthand experiences.

With clear learning goals in mind, it is easier for the teacher to facilitate students' experiences with science notebooks and guide students toward the desired understandings. Begin by looking at the identified content goals within the curriculum you use. For example, a curriculum might suggest "Water can change the shape of the land" as a content goal. This content factors into instructional decisions for the science notebook. (If your curriculum does not provide these stated goals, it will be up to you to determine them based on your standards and required topics.) As students work toward this content goal within their notebooks, you might notice that students need to further develop their observation skills and plan to focus on a goal related to that scientific practice by modeling a technical drawing to address the skill. Later, you might introduce sentence frames to scaffold students' explanations about the ways in which water can change the shape of the land, supporting a goal related to students' ability to communicate a scientific explanation.

As you read the following vignette (from a second-grade classroom after a few months of using science notebooks), notice the goals the teacher is setting for the students.

> At the beginning of each investigation, I looked at what the students would be doing and considered: (1) What were the content goals for this activity? For example, were students investigating the physical characteristics of an insect or determining what affected the pitch of an instrument? (2) What were the main scientific practices being used? For example, were students obtaining, communicating, or evaluating information? In most science activities, there were several scientific practices occurring over time and it was difficult to focus on all of them; however, I tried to select one on which to focus. (3) What different ways did students represent information? Because I consider notebooks to be tools for the students, I focused on different ways the students recorded the information, not necessarily the way I would do it. In addition, I also considered what language supports my students might need to help them effectively represent their ideas. For example, I made sure vocabulary was easily accessible for students to use as they wrote. Once I determined the focus of the lesson in terms of content, practice, and representation, I was able to focus on facilitating the interactions between the students and their notebooks.

In this vignette, the teacher established three goals—a content goal, a scientific practice goal, and a goal on how to communicate that information in the notebook.

As with any good teaching, the goals of the lesson will shift over time according to students' needs and teacher comfort level. In the beginning, notebook instruction might only focus on a single content goal, a scientific practice, or language skills. As the year progresses, the teacher begins to focus on multiple goals including a goal for content, a goal for particular scientific practices or concepts, and a third goal on the use of language within the notebook.

What will the first week actually look like?

Because science notebooks might be new to students, it is important to thoroughly plan the first few days of use. A thorough plan allows you to think through all aspects and prepare for the unexpected. Although the scientific concept might differ from lesson to lesson, the process of learning to use notebooks is quite similar in all lessons. In the following example, the teacher begins by having students observe apples to provide a common experience with a familiar material. This allows students to focus on their notebooks and develop observation skills. The teacher can also choose to focus more on specific concepts, such as variation of the apples or structure and function of parts of the apple, during the discussion. After the initial introductory lesson, the teacher introduces new materials that students will study more in depth, developing additional skill as well as content. Since these lessons address both science and language, they could take place during both science and language arts instructional time.

DAY ONE

Objective: Students will record observations of an apple.

Materials: apples, hand lenses, notebooks

Procedure (50+ minutes):

1. Introduce the lesson: discuss with students that they will be observing an apple and recording what they notice. (2 minutes)
2. Introduce notebooks as tools to help students keep track of their observations. Discuss the essential components of every entry (date and subject) with students. (5 minutes)
3. Have students observe the apple and record their findings. (10 minutes)

4. Ask students to sit in a circle on the floor and share recorded observations of their apple with a partner. (3 minutes)
5. Ask students to share observations as a whole group using their science notebooks. Record observations on the board. (10 minutes)
6. Have students share how they recorded their information (words, sentences, pictures). Ask students to discuss the benefits of various recording methods. (5 minutes)
7. Introduce the hand lens and how to use it. (2 minutes)
8. Pose a question, such as "What do apples look like?" (grades K–2) or "How do apples vary in appearance?" (grades 3–5). Have students record the question in their notebook and provide time for students to partner with another student to continue observing their apples, making comparisons and adding to their recordings. (10 minutes)
9. Have students return to the floor and share their observations with each other, focusing on the similarities and differences in their apples. (3 minutes)
10. Return to the question posed earlier. Have students discuss their thinking with a new partner and record their answer in their notebook. Provide a sentence starter, such as "Some apples have. . . ." (grades K–2) or "Some ways apples are different from each other are. . . ." (grades 3–5). (5–10 minutes)

DAY TWO

Objective: Students will record observations of plant structures. Patterns of discussion will be established.

Materials: plants, notebooks

Procedure (50 minutes):

1. Gather students on the floor to read the responses to the question they recorded on day one. Invite students to share their observations with the whole group by asking questions about the color and shape of the apples. Ask students to provide their evidence if applicable. (5 minutes)
2. Ask students to look at how they recorded the information in their notebooks. Have students discuss how the method they used to record was effective. (5 minutes)
3. Introduce the plant(s): share with students that they will work with partners to observe and record information about their plant. Ask

students, "What can you observe about your plant?" to guide their entries. (15 minutes)

4. Have students return to the floor and share their findings with a different partner. (5 minutes)
5. Ask students to share their observations with the whole group. After one student shares his observations, provide time for other students to ask questions or make comments regarding what was shared. (10 minutes)
6. After the discussion, give students time to record any additional information they would like to add to their notebooks. (5 minutes)
7. Have students return to the plants to make further observations. (5 minutes)

DAY THREE

Objective: Students will record observations of plant structures. Students will be introduced to relevant vocabulary. Students will discuss methods of recording.

Materials: plants, hand lenses, notebooks

Procedure (45+ minutes):

1. Ask students to sit on the floor and individually review their notebook entries from the previous day prior to discussing their observations with a new partner. (5 minutes)
2. Have individuals share observations with the whole group. Continue to provide time for questions and comments for each student. (5 minutes)
3. Discuss with students that they will be looking at the same plants as before, but this time a hand lens will be available. (2 minutes)
4. Prior to returning to the plants, ask students to think about what they are going to observe. Allow time for students to discuss ideas with others. Once they have a focus in mind, ask the students how they plan to record their observations. Have students share how they are going to record (pictures, labels, sentences, etc.). (5 minutes)
5. Have students return to the plants and make further observations. (15 minutes)
6. Ask students to return to the floor and share observations. As students share their observations, listen for the terminology they use to describe the plant structures. Connect students' informal language to formal vocabulary, such as *stems* or *veins*. (10 minutes)

By providing a hand lens, students can discuss the scale of their drawings when recording their observations.

These words can be added to the word wall after being introduced.

7. Prior to cleaning up, provide students with time to add to their observations. Students might or might not naturally incorporate new words that were introduced during the discussion. Encourage students to use the words if they find them helpful in describing their observations. (3 minutes)

DAY FOUR

Objective: Students will draw and label plant structures.

Materials: plants, hand lenses, notebooks, colored pencils

Procedure (52 minutes):

1. Gather students on the floor and review their recordings from the previous days. (2 minutes)
2. In groups of three or four, ask students to discuss different ways they recorded their information. As students share out, ask them to explain how they recorded their information. (5 minutes)
3. After all groups have shared how they recorded their information, focus on drawings of the plants. Discuss what information might be shown in a drawing. Guide students to notice that the plant structures can be recorded quite easily using a drawing. Ask students what else might help them record plant structures along with the drawings. Guide students to use labels along with their drawings to show the various parts of the plant. Older students might suggest different techniques to represent observations made using the hand lens. (10 minutes)
4. Before students continue with their observations, have them discuss with a partner what they might draw and label while observing their plants. (2 minutes)
5. Introduce the colored pencils as tools that they may use to more accurately record their plant observations. (2 minutes)
6. Ask students to observe their plants and record their observations. (15 minutes)
7. Have students return to the floor and share their observations with a different partner. (5 minutes)
8. Focus the whole-group discussion on how observations were recorded. Are students drawing their plants and labeling the structures? Have students share their techniques for recording with the class. (6 minutes)

9. Have students discuss with a partner how they might improve their recording the next time they look at plants. They might need some suggestions, such as using correct colors, labeling the structures, or labeling only the important things rather than everything. (5 minutes)

DAY FIVE

Objective: Students will compare and contrast different plants and variation of structures. Students will develop strategies to record information on two different objects.

Materials: colored pencils, hand lenses, notebooks, different plants

Procedure (60 minutes):

1. Have students review their previous observations. Revisit how students might improve their recording. (5 minutes)
2. Introduce the new plant. Discuss with the students that they will be looking at a new type of plant today. Students might wish to revisit the first plant to compare it with the new plant. Have students think about how they are going to record the information on their new plant. Have a few students share their recording strategies. (10 minutes)
3. Have students observe and record information about their new plant with a partner. Students might revisit the first plant and add information to their notebooks. (10 minutes)
4. Gather students on the floor to share their findings with each other. (3 minutes)
5. Ask students to share their findings with the whole group. Students will need to clarify which plant they are discussing. (10 minutes)
6. After the students have shared, have them look at their notebooks and discuss how they might organize the information about the two separate plants to see how they are similar and different. Share strategies with the whole group. (5 minutes)
7. Before returning to their plants, have students think about how they will organize their information. Let them know that it is okay to try new ways to find one that works best for them. (2 minutes)
8. Have students return to their plants to make more observations and organize their information to make it easier to determine how the two plants are similar and different. (10 minutes)

9. Ask students to return to the floor. Pose the question, "How do plant structures vary?" Have students discuss their thinking and provide evidence to support their thinking. Students can record their thinking using a sentence frame, such as "I think . . . because. . . ." (5 minutes)

This schedule is one way to introduce science notebooks. Teachers might make adjustments to accommodate student readiness. As in any subject area, the teacher needs to constantly assess where students are and adjust the plan accordingly. The next section looks more closely at the role science notebooks play in informing instructional practice.

Formative Assessment

An assessment functions formatively to the extent that evidence about student achievement is elicited, interpreted, and used by teachers, learners, or their peers to make decisions about the next steps in instruction that are likely to be better, or better founded, than the decisions they would have made in the absence of that evidence. (Wiliam 2011, 43)

What role do science notebooks play in formative assessment?

As students use their notebooks, the notebooks become formative assessment tools for both the teacher and the students, serving as an aid in terms of making learning decisions. They are not used by the teacher for summative assessment, nor are they a graded product. Rather, notebooks are tools for informing the teacher if students are meeting predetermined goals or if more instruction needs to be given. Even in the beginning stages of notebook use, it is important to consider students' progress. Following are some questions you might ask regarding students' science notebooks. These might be helpful in determining where students are and what next steps might be appropriate. Other sections of this book provide further information on next steps using the information gathered.

- Do students' drawings enhance their entries?
- How often are students using drawings and how much time are they spending on them?

- How comfortable are students in using labels with their drawings?
- How do labels enhance or detract from the drawings students create?
- Is the use of color enhancing or impeding the students' drawings?
- What types of questions are students asking and recording in their notebooks?
- How much of the students' recording is fact and how much is fiction?
- What types of recording strategies are students using?
- What organizational strategies would make notebooks more useful for students?
- When observing live organisms, how do students represent the behaviors and structures of the organisms?
- What evidence do students show of their thinking and understanding?
- To what extent are students providing evidence and reasoning when answering questions?
- How do students make use of their notebooks in small- and whole-group discussions?
- When do students choose to record information in their notebooks?
- When do students choose to use information in their notebooks?

These questions serve as an initial guide for teachers in determining future goals related to scientific practices or language, such as focusing on students providing evidence to support claims or on students communicating information from their notebooks to their peers.

THINKING POINT: How will I gather data to formatively assess my students?

Developing Science Notebooks

How can student use of the notebook be supported?

One of your most important roles is to support and scaffold students' use of notebooks. To be used in a scientific manner, notebooks need to be available during an investigation and then used in discussions with others. This does not occur naturally for many students and requires assistance from the teacher to become habit. In the beginning, it might seem as though a great deal of time is being invested; consider it as time spent building a solid foundation for scientific thinking.

As students develop science content, they work through several experiences with the materials, notebooks, and class discussions. The following section introduces a general process called the "Cycle of Notebook Interaction." The cycle describes the roles of the students and the teacher throughout an investigation. It is important to note that this cycle might take place over the course of several days. Depending on the goals of the lesson, aspects of the cycle might be in a different order as well. The vignettes throughout the following sections describe how a teacher worked with a fourth-grade class throughout the cycle.

- Materials: Exploration
- Discussion: Setting the Stage
- Materials: Recording Strategies
- Discussion: Recording Strategies
- Materials: Content
- Discussion: Content
- Notebooks: Content and Reflection

MATERIALS: EXPLORATION Whenever students are introduced to something new, it is important that they have time to explore the materials and concepts freely. This allows them to formulate ideas related to the content goal and is very beneficial for students with limited experiences. A general question or challenge can be posed to the students to guide this exploration, such as "What are the properties of these liquids?" or "How can these materials make a system to launch a ball?" Students might or might not record during this initial exploration—that is okay.

DISCUSSION: SETTING THE STAGE This second phase of the cycle takes place only after students have manipulated the materials and allows students to share initial ideas about the content goal, accessing prior knowledge and experiences. The teacher might collect some of the students' initial ideas in a class notebook, planning to revisit these ideas later in the cycle. Additionally, this discussion and the use of the class notebook provides students with the support or scaffolds they might need for documenting scientific practices, such as writing a procedure, asking questions, or collecting data. During this discussion, focus first on setting the stage for the content goal and, if applicable, second on documentation of the scientific practice goal. Exactly how much time for each varies depending on the goals and the students.

> Many times throughout the investigation I gathered the students to a discussion area (an area away from their work space where we could go over directions and discuss the activity). I revisited the question I posed earlier, "What do you notice about the way water flows?" They began by sharing their thoughts with someone sitting near them before sharing with the group; this provided everyone the opportunity to share something in a nonthreatening environment. It also allowed students who might not have an idea or be able to verbalize their idea clearly to receive help from others. A few students shared their thinking about the way water flows with the whole group. I did not confirm or reject any ideas at this point, but I took mental note of points to revisit later. I shifted the discussion to get students thinking about how they might record the information. I asked leading questions. For example, "How might you organize the information you are collecting about the way water flows?" We shared our thoughts about recording as a class, and then I asked the group for questions they had about the recording strategies the students shared. Before ending the discussion, I asked students to talk with a partner about what recording strategy they planned to use when they returned to the materials.

After this type of discussion, students have developed initial ideas about the content and discussed a variety of strategies they can use to record their observations and thinking. This provides a level of support for students and focuses their learning for the investigation.

MATERIALS: RECORDING STRATEGIES Once students are focused on how to record, they return to the materials. Although this exploration looks similar to the initial one, there are differences. This time, the teacher collects some data to formatively assess students' thinking about the content goal and their progress on the scientific practice goal. Although these data are collected informally, they can help the teacher determine the focus of the next discussion.

> I frequently walked around during the activity to observe students' communication about the flow of water, the content goal, and their progress on recording their observations, the scientific practice goal. I only interacted with the students to clarify directions or redirect their attention to the activity. They needed this time with the materials to continue formulating their ideas; if I jumped in too quickly, it would likely interrupt their learning. Students needed time to work uninterrupted to develop their thought processes and questions, allowing them to truly internalize the science concepts. During this time, I noted if students were struggling with organizing the data or labeling.

In this vignette, the attention of the teacher is focused on collecting formative assessment data on students' representations in the notebook. The purpose is to allow the teacher to make instructional decisions based on one of the goals for the lesson, in this case, the recording of observations. Depending on the data, the teacher might use these data during the next discussion to guide students or might plan to meet with a small group later.

DISCUSSION: RECORDING STRATEGIES This discussion period becomes a pivotal point in students' recording. Based on data gathered during the last interaction with the materials and the recording strategies used, the teacher chooses a focus for discussion. This discussion can focus on the documentation of a scientific practice (discussed more in Chapter 2), such as technical drawing or building explanations. Through careful questioning, the teacher guides the students to develop various techniques related to the scientific practice goal.

> After a brief fifteen- to twenty-minute period working with the materials, I called the students back for a discussion using their notebooks. I began by asking students what type of recording strategy they used, such as drawings or

tables. Then I asked them to focus on one particular aspect of the investigation, directing their discussion toward how they recorded observations of how water flows. I gave them a couple of minutes to look over their notes and make additions before they shared their thoughts. I asked them to discuss with a friend, using their notebooks, what they observed, how they recorded their observations, and what questions they still had. Then I asked the students to share as a class, again allowing the students time to question each other.

I never skipped sharing with a friend because that is a powerful part of the activity. Sharing is valuable for students because they are working, making progress, and sharing that progress with each other. It holds everyone in the class accountable to each other, as speaking and listening are part of our language arts skills.

Occasionally, if there was a recording convention that was difficult, such as a complex table, I provided some guidance. I modeled this convention in the class notebook and used a think-aloud so students gained insight on when and how to use the new strategy. I intentionally put off most of the content discussion until students had more time with the materials. The last thing we talked about before returning to the investigation was next steps the students would take as they continued to record in their notebooks. Again, the students discussed their next steps with each other before sharing as a class.

In this vignette, the teacher focuses the students' attention on documenting the observations that relate to the content goal, how water flows. A thorough record of their observations is necessary for students to determine the patterns in the data in order to better understand the content. Additionally, this is an opportunity for the teacher to provide some support for the students through a minilesson, peer modeling, or other instructional strategy.

MATERIALS: CONTENT Once students have started to use strategies for recording information, the focus is now on understanding of the content goal.

As students continue to work with the materials, the teacher assesses their understanding and determines next steps to take in terms of the content goal.

> When students returned to the investigation, I observed how they were recording, but this time I was more focused on the content. I interacted more with the students and asked them questions, such as "What are you finding? What are your thoughts? What evidence do you have to support your thinking?" Sometimes I asked why they were recording the information the way they were. I determined how the whole class was progressing. Did they need more time with this experience or did they need more experiences to understand the content?

The teacher encourages informal discussion of the content and recording of those inferences, reasons, and observations within the notebook. These records serve as a precursor to the formal discussion of the content.

DISCUSSION: CONTENT The primary goal of science notebooks is to serve as tools to aid students in building and representing scientific content. Once students have had experience with the concept and have formulated initial ideas, small- and whole-group discussions take place to help students solidify conceptual understandings. The teacher poses questions to help students analyze and interpret data to extract meaning from those data recorded in their notebooks. The focus question is revisited and students discuss their thinking with their peers.

> After students had time to focus on the content, I called them back to the floor. I provided a few minutes for them to write down any thoughts they had not yet recorded, and then I asked them to share with a partner. The purpose of this discussion was to communicate their thinking. Keeping this in mind, I often began the group discussion with a question, such as "What did you discover?" Again, the students discussed this with each other before sharing ideas with the whole group. I asked follow-up questions, such as

"Look at the observations you recorded in your notebook; what patterns do you notice about how water flows?" and "What evidence do you have to support your claim?" This discussion served as an opportunity for students to examine the purpose of their work as well as build speaking and listening skills.

In this vignette, the teacher guides the discussion to build understanding of the content goal. The questions ask students to refer to the information recorded in their notebooks to determine patterns or cause and effect. The notebook is a very valuable tool in this discussion as the teacher prompts for specific pieces of evidence. Additionally, the teacher might ask students to engage in argumentation during this discussion time to deepen or clarify the content. In the vignette above, the teacher could have made the claim "Water flows to the side" or "Water flows when there is a path," providing evidence to support the claim, to encourage students to provide counterclaims supported by evidence from their notebooks.

NOTEBOOKS: CONTENT AND REFLECTION Students benefit from writing in science, as it allows them a means to process their thinking. Generally, this is when students respond to the focus question and write claims or explanations as independently as possible. By giving them time to write purposefully on their understanding of the science concept, the teacher is asking them to make sense of their learning. The teacher can scaffold this communication by providing a language frame for students; however, it is important to ensure that the students are doing the thinking about the content rather than copying from the class notebook or board, as such written communication can serve as a window into their true understanding.

As discussed in Chapter 3, this writing serves as a valuable formative assessment.

I asked students to answer the focus question, "How does water flow?" in their notebooks. I provided a frame for making an explanation of "I think . . . because I observed . . . I think this happens because. . . ." (see Figure 1–3). As students finished recording, I walked around the room and encouraged them to record any additional thoughts or questions that might help them later. I have found that the students who were actively engaged with the materials benefit from this time; it allows them time to process their thoughts without distraction. There were times when we were at the end of the day and students would be so engaged in recording their thoughts that they stayed after the bell rang.

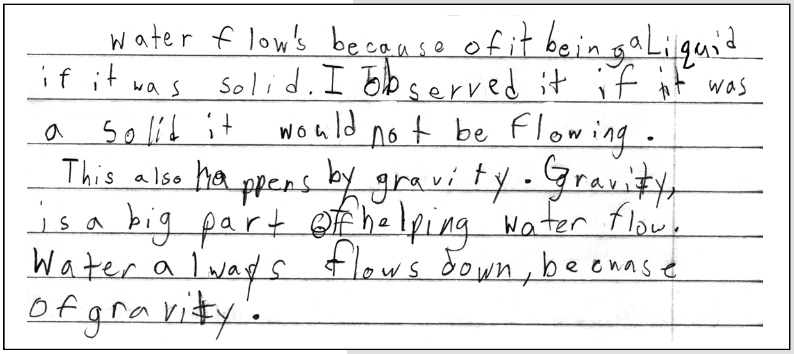

water flow's because of it being a Liquid if it was solid. I observed it if it was a solid it would not be flowing. This also happens by gravity. Gravity, is a big part of helping water flow. Water always flows down, becuase of gravity.

Figure 1–3. An example of a student explanation using provided sentence frames

This vignette examined what happened after the content discussion, as the focus shifted to the language goal, which was for students to provide reasons supported by evidence. Other language goals, such as making an oral presentation on a topic, might happen after the Cycle of Notebook Interaction during a language arts time using the science notebook as a resource.

By allowing students time to work without interruption on writing an explanation, the teacher is helping them internalize the science concepts and make them their own. Students need time to explore their own thought processes and questions. It is the teacher's responsibility to pull the students' thoughts together and begin to help students make connections between their thoughts and the concept being explored. These connections are formalized when students are asked to communicate them in writing.

What instructional practices support the development of science notebooks?

Although establishing goals and using the Cycle of Notebook Interaction help establish a focus and a general pattern for notebook use, some students will need additional instruction, supports, or scaffolds to develop their notebooks. Following are strategies that provide general guidance for the notebook. The teacher will need to consider how and when to use these scaffolds and how these change over the course of the year. Looking first at what students are able to do independently allows the teacher to determine how much guidance to provide.

Some strategies to develop notebooks include:

Strategies to develop specific skills within the notebook are provided in Chapter 2.

THINK-ALOUDS: The teacher verbalizes his or her thinking when making a notebook entry. Think-alouds can be done any time during the Cycle of Notebook Interaction to model the thinking process, such as making a prediction or explanation. Think-alouds are also helpful to model the process of recording, why we draw something larger than it is, why we label, or why we organize information in a certain way.

CLASS NOTEBOOK: A class notebook (see Figure 1–4) can be used for several purposes, including modeling how to make a technical drawing, how to lay out physical space on a page, or how to collect class data. Students make entries in the class notebook, serving as models for their peers. These can be kept in a composition book and displayed with a document camera, kept on chart paper, or kept electronically, but students should always have access to them.

PEER MODELING: To develop a repertoire of strategies, students might find it helpful to see models of various methods. Students can explain how they recorded data, answered a focus question, or recorded new questions. Students are less likely to become dependent upon teacher guidance when they are encouraged to share their work with one another rather than learning from teacher-generated models. This allows the teacher to focus first on what students know and what they can learn from each other.

STUDENT-GENERATED CHECKLIST: When students begin to use the notebook, the teacher can guide students in the creation of a checklist for what should be recorded. Although the teacher has predetermined which elements are necessary, having students generate their own list allows them to take greater ownership of their work and serves as a formative assessment opportunity for the teacher.

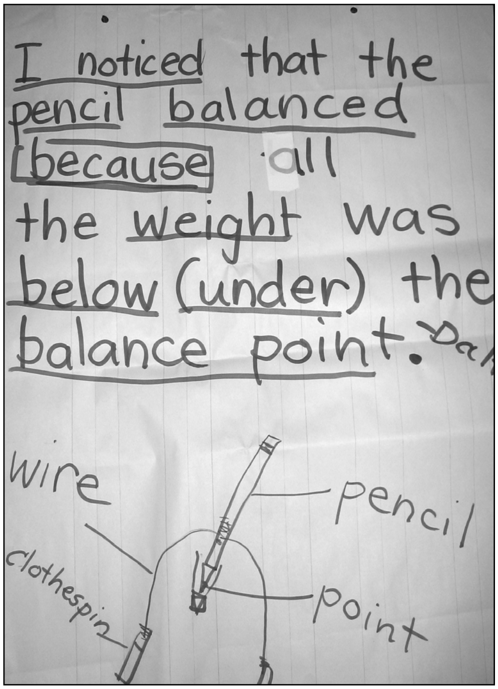


Figure 1–4. An example of a class notebook describing balancing an object

EXAMPLES/NONEXAMPLES: Students need to see quality examples of notebook entries. Provide an example of a quality notebook entry to compare to a nonexample and ask students to discuss what works or is helpful and what needs to be improved in the entry. The idea is for students to determine the characteristics of a good entry. This can be done with any of the elements discussed in Chapter 2.

THINKING POINT: What scaffolds are appropriate for your students?

What instructional practices support English language learners in the development of science notebooks?

For some students, the language of science is further complicated by the fact that English is not their first language. It is helpful to have basic supports available, such as a word wall or vocabulary cards attached to visual pictures depicting the concept or a real object. In addition, further scaffolding can be provided in the form of sentence starters/frames, blackline drawings, and oral rehearsal to support the development of students' understanding of the content and representation of the idea within the science notebooks.

SENTENCE STARTERS/FRAMES: Basic sentence starters or frames can be displayed in the room to provide students with a starting point. Starters such as "I notice . . ." or "I wonder . . ." provide students with a beginning point from which to write in their notebook. These can be expanded upon to include various starters for claims, evidence, and reasoning, or a frame that helps students construct a full explanation. Eventually, frames that help students focus their evidence and reasoning on specific conceptual ideas can replace the generic starters. As with all scaffolds, it is important to change these out over time to promote student independence.

DRAWING STARTER FOR EXPLANATIONS: Although drawings can help convey a student's understanding, they can also be time-consuming and take time away from a written explanation. At times, it might be helpful to provide a blackline master of a system with which students have been working, such as a closed system that contains air, as represented in Figure 1–5. They can use this master to help communicate where air is in the system and then explain in writing what evidence they have to support this idea.

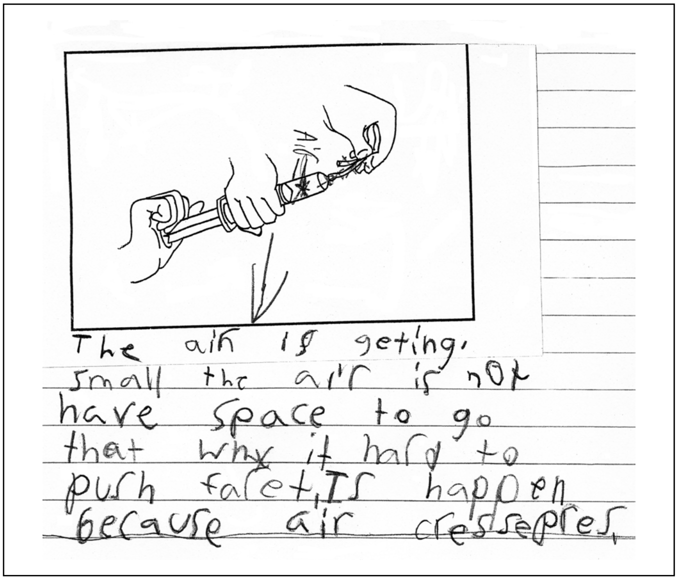


Figure 1–5. An example containing a drawing starter followed by a written explanation

ORAL PRACTICE OF OBSERVATIONS/EXPLANATIONS: Some students might be able to explain their thinking in conversation but struggle to convey this in writing due to the time it takes them to physically write. Allow them to capture their idea into an audio-recording device and then listen as they write in their science notebooks. By rehearsing or recording an answer to a focus question first, students can focus on the mechanical aspects of writing it down without forgetting the bigger scientific ideas they are trying to convey.

Creating a Purpose for Notebooks

Why create a purpose?

Notebooks are an important component of scientists' work, and they should be important components of students' investigations. If students do not have a purpose for them, notebooks simply become a busy activity. Students also need a reason to record while they work; otherwise the materials can be too alluring and recording does not take place. Students gain a better appreciation of the notebooks' value if they use them in an authentic manner.

How is an authentic purpose for science notebooks created?

Scientists use their notebooks on a daily basis in the work they do and in conversations with others, similar to the way students use their notebooks. Additionally, scientists make formal presentations on their work to their colleagues. By having students use science notebooks to create a presentation of scientific findings to share with their peers, the teacher establishes an authentic purpose and has a product that can be summatively assessed. These scientific presentations might take the form of oral sharing, an expository text, a report, a slide show presentation, or a poster. Students use their notebooks to reference their questions, procedures, results, explanations, and any new questions they might have while creating their presentations. The following vignette shows how fifth graders shared their understandings of environments. As you read, think about how students used their notebooks as they developed their presentations and how those presentations helped establish a purpose for the notebooks.

> My class had been studying different types of environments and how changes would impact plant growth. My content goal was for students to recognize that several environmental factors influence plant growth. Groups of students had planned and begun working on investigations based on questions they generated. A few days into their work, I announced that they would be sharing their investigations and results in the form of a slide show using a familiar computer program. The notebooks served as tools for students to recall their plans, data, thinking, results, and questions as they began to work on their slide shows. Students who recorded a great deal in their notebooks found them very helpful, and those who did not, relied upon others. Following the presentations of their investigations, there was a noticeable change in the documentation of work.

In this vignette, the students were asked to create a formal product based on their work. The data the students needed to access were collected over several days, making the notebook a valuable tool in providing evidence, such as the height of a certain plant at a certain period of time. The teacher provided an experience to help students answer the often asked question, "Why do we have to write all of this down?" on their own.

What is the vision for science notebooks?

Your vision of what notebooks will look like and how they will be used will evolve over time. The following vignette examines one teacher's vision over the first three years of notebook use.

> Notebook development for me went from being very structured and teacher-centered to very student-centered over the course of three years. In my first year of implementing notebooks, my goal was student mastery of recording strategies. I wanted to show them all the different recording strategies I knew. I set up the structure for them, told them what to record, and showed them how to record it. Most of the notebooks looked similar, and many students met the goals. Reflecting back, I wonder if students really understood the strategies they used or if they were just following my directions.
>
> The following year, I wanted my students to take more ownership of their notebooks. My goal was for students to select appropriate recording techniques. I introduced them to various recording strategies but left the decisions of what and how to record up to the students. When I looked at their notebooks, I focused on when and how they used the strategies. Over the course of the year, I began to realize that my students were using strategies I introduced to them, but they were not using any other strategies. As students represented their understanding of the content, they used various recording strategies, but the data represented looked similar. At the end of the year, I wondered if the students really understood those strategies or if they used them only because they thought that was the expectation.
>
> In the third year, I gave control of the notebooks over to the students. My goal was for students to use notebooks in a way that made sense to them. At the beginning of the year, students brainstormed ideas for recording strategies, which were posted in the room for reference throughout

the year. My mantra for the year became "Record in a way that will make sense to you later." As the year progressed, I provided time for students to share the new strategies they were developing. There were times when I needed to introduce new strategies as well, and I did this through minilessons and modeling. I decided the notebooks belonged to the students, not me, and stopped looking in them to verify everyone was using the same strategies. Instead, I looked at them for their understanding of the science content. The notebooks provided me with evidence of student learning of the scientific content, which I used to inform the decisions I made about instruction.

THINKING POINT: What benefits and limitations are there to various amounts of structure?

Here are two final thinking points for you to consider as you implement science notebooks. These two questions are crucial to understanding your own vision for notebook use in your class.

THINKING POINTS: Where are your students starting? What do you expect to accomplish with science notebooks?