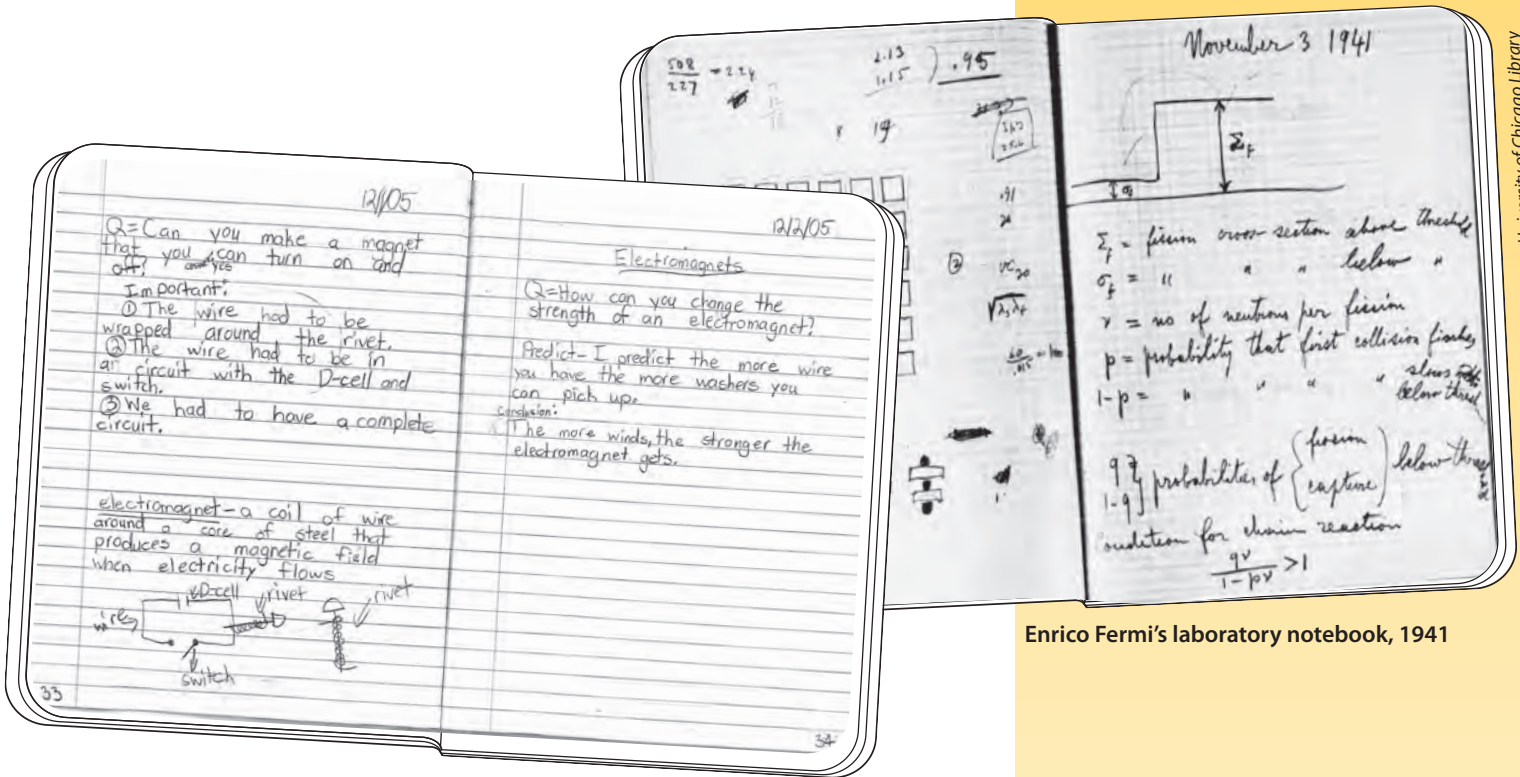


Science Notebooks in Grades 3–6



Enrico Fermi's laboratory notebook, 1941

Student notebook from the Energy and Electromagnetism Module

INTRODUCTION

A scientist's notebook is a detailed record of his or her engagement with natural phenomena. It is a personal representation of experiences, observations, and thinking—an integral part of the process of doing scientific work. A scientist's notebook is a continuously updated history of the development of scientific knowledge and reasoning. FOSS students are young scientists; they incorporate notebooks into their science learning.

This chapter is designed to be a resource for teachers who are incorporating notebooks into their classroom practice. For teachers just beginning to use notebooks, the Getting Started section in this chapter suggests how to set up the notebooks, and the *Investigations Guide* cues you when to engage students with the notebooks during the investigation. For more information on specific types of notebook entries, the subsections in the Notebook Components section include strategies to differentiate instruction for various ability levels.

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Benefits to Students

- Documentation
- Reference document
- Cognitive engagement

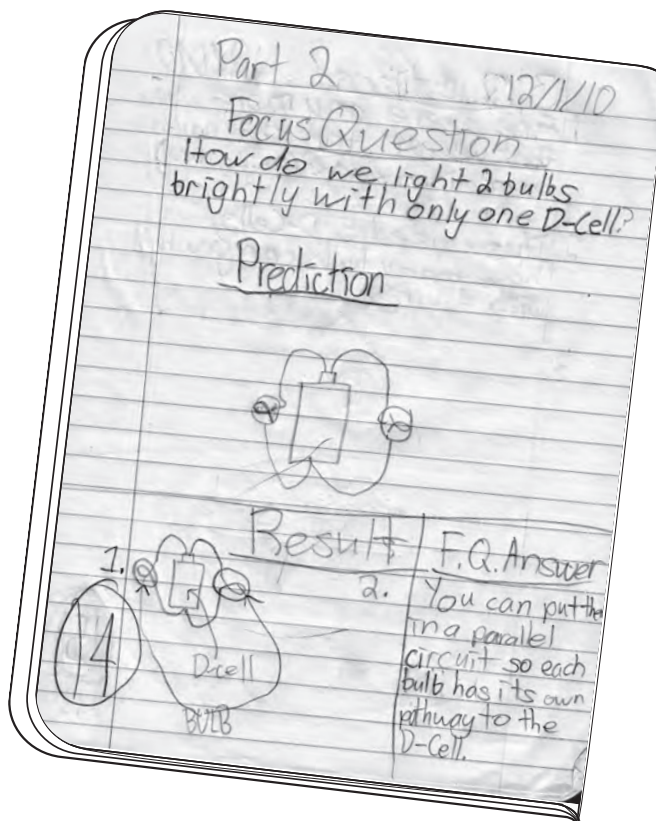
NOTEBOOK BENEFITS

Engaging in active science is one part experience and two parts making sense of the experience. Science notebooks help students with the sense-making part. Science notebooks assist with documentation and cognitive engagement. For teachers, notebooks are tools for gaining insight into students' thinking. Notebooks inform and refine instructional practice.

Benefits to Students

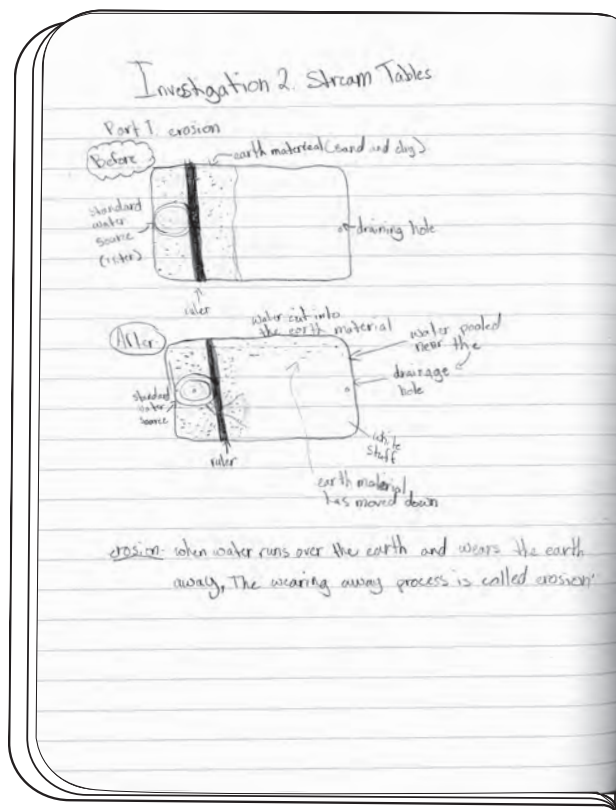
Documentation. Science provides an authentic experience for students to develop their documentation skills. Students are encouraged to keep science notebooks to organize and learn to communicate their thinking. They document their experiences, data, and thinking during each investigation. Students create tables, graphs, charts, drawings, and labeled illustrations as standard means for representing and displaying data. At first, students will look at their science notebooks as little more than a random collection of words and pictures. Each notebook page represents an isolated activity. As students become more accomplished at keeping notebooks, their documentation will become better organized and efficient. In time and with some guidance, students will adopt a deeper understanding of their collections as integrated records of their learning.

Science notebook entry from the Energy and Electromagnetism Module



Reference document. When data are displayed in functional ways, students can think about them more effectively. A well-kept notebook is a useful reference document. When students have forgotten a fact about a rock that they learned earlier in their studies, they can look it up. Learning to trust a personal record of previous discoveries and knowledge structures is important.

A complete and accurate record allows students to reconstruct the sequence of learning events to “relive” the experience. Discussions about science among students; students and teachers; or students, teachers, and families have more meaning when they are supported by authentic documentation in students’ notebooks.



From the Soils, Rocks, and Landforms Module

Science Notebooks in Grades 3–6

Cognitive engagement. Once data are recorded and organized in an efficient manner in science notebooks, students can think about them to draw conclusions about the way the world works. Their data, based on their experiences and observations, are the raw materials that students use to forge concepts and relationships.

Writing stimulates active reasoning. There is a direct relationship between the formation of concepts and the rigors of expressing those thoughts in words. Writing requires students to impose discipline on their thoughts. By writing explanations, students clarify what they know . . . and expose what they don't know.

When students are asked to generate derivative products (such as detailed explanations or posters) as evidence of learning, the process will be much more efficient when they have a coherent, detailed notebook for reference. As students begin to use their notebooks as a personal reference text, they will value their own learning and come to rely on their own work as a source of information about science.

When students use their notebooks as an integral part of their science studies, they are more likely to think critically about their understandings. This reflective thinking can be encouraged by notebook entries that present opportunities for self-assessment. Self-assessment motivates students to rethink and restate their scientific understandings. Revising their notebook entries by using a next-step strategy helps students clarify their understanding of the science concepts under investigation.

► NOTE

For more on derivative products, see the Science-Centered Language Development chapter.

Benefits to Teachers

In FOSS, the unit of instruction is the module—a sequence of conceptually related learning experiences that leads to a set of learning outcomes. A science notebook helps you think about and communicate the conceptual structure of the module you are teaching.

Assessment. From the assessment point of view, a science notebook is a collection of student-generated artifacts that exhibit learning. You can assess student skills, such as using drawings to record data, while students are working with materials. At other times, you collect the notebooks and review them in greater detail. The displays of data and analytical work, such as responses to focus questions, provide a measure of the quality and quantity of student learning. The notebook itself should not be graded. However, the notebook can be considered as one component of a student’s overall performance in science.

Medium for feedback. The science notebook is an excellent medium for providing feedback to individual students regarding their work. Most students will be able to read a teacher comment written on a self-stick note, think about the issue, and respond. Some students may need oral feedback individually or in a small-group situation. This feedback might include modeling to help students make more accurate drawings, revisiting some essential scientific vocabulary, or introducing strategies to better explain their thinking.

Focus for professional discussions. The science notebook acts as a focal point for discussion about students’ learning at several levels. It can be reviewed and discussed during parent conferences. Science notebooks can be the focus of three-way discussions among students, teachers, and principals to ensure that all members of the school science community agree about what kinds of student work are valued and the level of performance to expect. Science notebooks shared among teachers in a study group or other professional-development environment can serve as a reflective tool that informs teachers of students’ ability to demonstrate recording techniques, individual styles, various levels of good-quality work, and so on. Just as students can learn notebook strategies from one another, teachers can learn notebook skills from one another.

Benefits to Teachers

- *Assessment*
- *Medium for feedback*
- *Focus for professional discussions*
- *Refinement of practice*

Refinement of practice. As teachers, we are constantly looking for ways to improve instructional practices to increase students' understanding. Your use of the notebook should change over time. In the beginning, the focus will be on the notebook itself—what it looks like, what goes in it. As you become more comfortable with the notebook, the attention shifts to what students are learning. When this happens, you begin to consider how much scaffolding to provide to different students, how to use evidence of learning to differentiate instruction, and how to modify instruction to refine students' understanding.

GETTING STARTED

A major goal for using notebooks is to establish habits that will enable students to collect data and make sense of them. Use of the notebook must be flexible enough to allow students room to grow and supportive enough for students to be successful from the start. The format should be simple and the information meaningful to students. The notebook includes student drawings; writing in the form of individual words, short phrases, and sentences; and a variety of visual and tactile artifacts. When students thumb through their notebooks, they should be reminded of the objects and organisms they observed and their interactions with them.

Notebook Format

Delta Education sells bound science notebooks that include printed notebook sheets specific for each module. These consumable, preprinted notebooks provide an efficient, supportive approach to notebook keeping.

The *Teacher Resources* component of the FOSS *Teacher Toolkit* includes duplication masters for the same notebook sheets that are bound into the consumable notebooks. You can use these sheets to prepare an analogous notebook or to have students design a customized version in a composition book.

In an autonomous approach, students create their entire science notebooks from blank pages in bound composition books. Experienced students determine when to use their notebooks, how to organize space, what methods of documentation to use, and how to flag important information. This level of notebook use will not be realized quickly; it will likely require systematic development by an entire teaching staff over several years.

You might choose to have a separate notebook for each module or one notebook for the entire year. (See the sidebar for the advantages of each.) Students will need about 30 pages (60 sides) for a typical module.

Advantages of One Notebook per Module

- *Easy to replace if lost*
- *Lower cost*
- *Fewer pages*

Advantages of One Notebook per Year

- *Easy to refer to prior activities*
- *Easy to see growth over time*

Science Notebooks in Grades 3–6

Table of contents	
Unit 1.1.1	Make a Mixture P.6
	Separate a mixture P.8
1.2	Separate a salt water solution into its parts P.12
1.3	Observing salt water Crystals P.16
1.4	Separating a dry mixture P.18

A sample table of contents

Organization of Notebooks

Four organizational components of the notebook should be planned right from the outset: a table of contents, page numbering, documentation, and an index. The consumable FOSS science notebook has these features already in place. No setup is required beyond pointing out where these features are in the notebook.

Table of contents. Students should reserve the first two pages of their notebooks for a table of contents. They will add to it systematically as they proceed through the module. The table of contents can be based on the names of the investigations in the module, the specific activities undertaken, the concepts learned, or some other schema that makes sense to everyone. You could have students make their own titles for the table of contents. This is best done at the end of the investigation part so that students can come up with meaningful titles.

Page numbering. Each page should have a number. These can be applied to the pages and referenced in the table of contents as the notebook progresses, or small blocks of pages can be prenumbered (pages 1–15 initially, pages 16–30 later, and so on) at appropriate times in the module.

Date, title, and other conditions. Each time students make a new entry, they should record certain information. At the very minimum, they should record the date and a title. More complete documentation might include the time; day of the week; team members; and, if appropriate, weather conditions.

Some classes start each new entry at the top of the next available page. Others simply leave a modest space and apply the documentation information right before the new entry.

When introducing a new condition to students, such as weather conditions, it is important to discuss why students are recording the information so that they understand its relevancy.

Index. Scientific academic language is important. FOSS strives to have students use precise, accurate vocabulary at all times in their writing and conversations. To assist with acquisition of the scientific vocabulary, students should set up an index at the end of their notebooks. It is not usually possible to enter the words in alphabetical order, since they will be acquired as the module advances. Instead, assign a block of letters to each of several index pages (A–E, F–K, etc.) where students can enter key words. As an alternative, students could use a single page blocked out in 24 squares and assign one or more letters to each square. (See the sample illustration.) Students write the new vocabulary word or phrase in the appropriate square and tag it with the number of the page on which the word is defined in the notebook.

Notebook Entries

As students engage in scientific exploration, they will make entries in their notebooks. They may use a prepared notebook sheet or create a more free-form entry. Students frequently respond to a focus question with a drawing or a simple narrative entry. For example, in the **Soils, Rocks, and Landforms Module**, students may explain their thinking about factors that affect erosion and include a drawing to show how the earth materials move when the land is steep. These notebook entries allow students to relive and describe their science experiences as they turn the pages in their notebooks.

Typically, the rules of grammar and spelling are relaxed when making notebook entries so as not to inhibit the flow of creative expression. Encourage students to use many means of recording and communicating besides writing, including charts, graphs, drawings, graphics, color codes, numbers, and images attached to the notebook pages. By exploring many options for making notebook entries, each student will find his or her most efficient, expressive way to capture and organize information for later retrieval.

NOTE

Templates for indexes can be found online at www.FOSSweb.com.



A sample index

NOTE

More information about vocabulary appears in the Science-Centered Language Development chapter.

Supporting Students

Elementary classrooms contain students with a range of abilities, which need to be considered when planning strategies for implementing science notebooks. Students need to have successful early experiences with notebooks. A blank notebook may be intimidating for some students, and they will look to you for guidance. FOSS teachers have had success using different supportive structures to help transform the blank notebook into a valuable reference tool. These supports and scaffolds can be used with the whole class, a small group, or an individual and should be adjusted to meet students' needs.

Class notebook. You can create a class notebook to document the investigation as a way to model the various notebook components. The class notebook should be accessible at all times for students to reference. You can use a chart-paper tablet, a paper notebook displayed under a document camera, or a computer. You could use the class notebook to introduce strategies such as a T-table, or write a summary statement in it after all students have answered the focus question. While individual notebooks will look similar to the class notebook, it is not the intent that students' notebooks be identical to the class notebook.

Scaffolds. Supports and scaffolds differ in one way. Supports are always available for students to access, such as allowing students access to a class notebook. Scaffolds are available just when the student needs them and will vary from student to student and from investigation to investigation. Scaffolds are meant to provide structure to a notebook entry and allow students to insert their observations or thinking. As the year progresses, the scaffolds change to allow for more student independence. Scaffolds include

- **Sentence starters** or **drawing starters** provide a beginning point for a notebook entry. Here's an example: "I noticed the crayfish had _____."
- **Frames** provide more support but leave specific gaps for students to complete. Here's an example: "Magnets attract when _____. Magnets repel when _____."
- The suggested **notebook sheets** can guide students to collect data with a table, graph, or list of questions. The notebook sheets also guide thinking.

TEACHING NOTE

Use of the class notebook should be thoughtfully timed. Doing a class-notebook entry at the end of an activity is helpful to teach the components of a notebook, yet allows you to see what students do on their own. If you want to model a specific notebook strategy, use the class notebook during the activity.

Think-alouds. Think-alouds help explain the decision-making process practiced by a savvy notebook user. They verbalize the thoughts used to create a particular notebook entry. For example, if students have recorded observations about how one variable affects erosion and deposition and are going to observe a second variable, you might say,


I am going to observe how another variable affects erosion and deposition. I am going to look back to see how I recorded the information before. I see that I made a detailed drawing. I used a T-table to describe what happened to the earth materials over time. So now I'm going to make similar observations and use a T-table and then make a drawing. One way I can get ideas about how to organize my observations is to look back at observations I wrote before.

Providing time to record. When students are engaged in active science, their efforts are focused on the materials, not the notebook. Students need this time to explore and initially might not open their notebooks and record observations until prompted. Students may need separate time to record observations that fully document their discoveries. Some teachers have found it easier to leave the materials on the table and have students bring their notebooks to a common writing area. Then the teacher revisits the focus question or task and provides a few minutes for students to record in their notebooks.

Ownership

A student's science notebook can be personal or public. If the notebook is personal, the student decides how accessible his or her work is to other students. If ownership falls at the opposite extreme, everything is public, and anyone can look at the contents of anyone else's notebook at any time. In practice, most classroom cultures establish a middle ground in which a student's notebook is substantially personal, but the teacher claims free access to the students' work and can request that students share notebooks with one another and with the whole class from time to time.

TEACHING NOTE



Consider having students who need extra assistance with writing or formulating their ideas dictate specific information to an adult. The adult writes the information in the notebook for the student. Or the adult could write the sentence, using a highlighter, and the student could trace the words, using a pencil.

Notebook Components

- *Planning the investigation*
- *Data acquisition and organization*
- *Making sense of data*
- *Next-step strategies*

NOTEBOOK COMPONENTS

A few components give the science notebook conceptual shape, coherence, and direction. These components don't prescribe a step-by-step procedure for how to prepare the notebook, but they do provide some overall guidance.

The general arc of an investigation starts with a question or challenge, and then proceeds with an activity, data acquisition, sense making, and next steps. The science notebook should record important observations and thoughts along the way. It may be useful to keep these four components in mind as you systematically guide students through their notebook entries.

Planning the Investigation

Typically at the start of a new activity, the first notebook entry is a focus question, which students transcribe into their notebooks. The focus question establishes the direction and conceptual challenge for the investigation.

Focus question. Each part of each investigation starts with a focus question or challenge. Write or project it on the board for students to transcribe into their notebooks, or give them photocopied strips of the focus question to tape or glue into their notebooks. Some teachers look ahead, write all the focus questions on one sheet of paper, copy the sheet, and cut the questions apart with a paper cutter. A list of the focus questions for each module is also available as a PDF on FOSSweb.

2. Focus question: What's in our schoolyard soils?

Write or project the focus question on the board, and say it aloud.

➤ *What's in our schoolyard soils?*

Students may develop their own questions to investigate as well.

The focus question determines the kinds of data to be collected and the procedures that will yield those data. The procedures may be a narrative plan consisting of a few sentences or a more detailed step-by-step procedure, depending on the requirements of the investigation.

Narrative plans. After posing a focus question, we often ask students for their ideas about how they will engage the question. For instance, the focus question that sets up a free exploration of crayfish might be

► *What do crayfish do when they are removed from water for a short time?*

Students think about this question and formulate a plan, perhaps writing a short narrative description of their general approach.

We are going to take the crayfish out and put it on the table for 3 minutes. We are going to see if the swimmerets move the same way they do in the water.

The narrative helps students consider the options available to them. It also reminds them of the limits and considerations when working with living organisms.

As with all notebook entries, some students need little more than a nudge in the right direction. Other students may need more support. One option is to prompt them with sentence starters. Good sentence starters provide a start but still leave the intellectual responsibility with students. Here are some examples.

- *The first thing we are going to do is _____.*
- *The next thing we will do is _____.*
- *We have to be careful about _____.*
- *Finally, we are going to _____.*

Lists. Science notebooks often include lists of things to think about, materials to get, or words to remember. A materials list is a good organizer, helping students anticipate actions they will take. A list of variables to be controlled clarifies the purpose of an experiment. Simple lists of dates for making observations, or of the people responsible for completing a task keep information readily available.

TEACHING NOTE

Supports such as sentence starters and frames should be monitored and adjusted as your expectation of students' responsibility for notebooks changes over the year.

Science Notebooks in Grades 3–6

TEACHING NOTE

Be selective when engaging students in making step-by-step procedures as the process will require additional time. To save time when using a class-generated procedure, provide each student with a typed copy.

TEACHING NOTE

It is important for students to understand that in order to do accurate work, scientists need to do multiple trials and present their work so that it can be replicated.

Step-by-step procedures. Some work with materials requires structured planning. Students start an investigation in the **Soils, Rocks, and Landforms Module** with the focus question

➤ *What's in our schoolyard soils?*

Students need to recall what they know about soil and develop a strategy for adding water to help isolate the different components. An appropriate convention for recording a sequential procedure is a numbered, step-by-step plan. Here is an example.

1. Collect 1 spoon of soil.
2. Record where it came from.
3. Put it in a vial.
4. Add 20 mL of water.
5. Cap the vial and shake.
6. Let it settle overnight.
7. Observe layers.

One way to introduce students to this type of entry is to provide a notebook sheet as a model. Both you and students can refer to the notebook sheet as they work through the hands-on investigation. During the next investigation, students can look back at the model notebook sheet when they write their own step-by-step procedures. To check the procedures for errors or omissions, students can trade notebooks and attempt to follow other students' instructions to complete the task.

Predictions. Depending on the content and the focus question, students may be able to make a prediction. When they make predictions, they are attempting to relate prior experiences to the question posed. Providing students with a frame can help them explain the rationale behind their predictions. A frame to help with stating a prediction is “I think that _____ because _____.”

Data Acquisition and Organization

Data are the bits of information (observations) from which scientists construct ideas about the structure and behaviors of the natural world. Because observation is the starting point for answering the focus question, data records should be

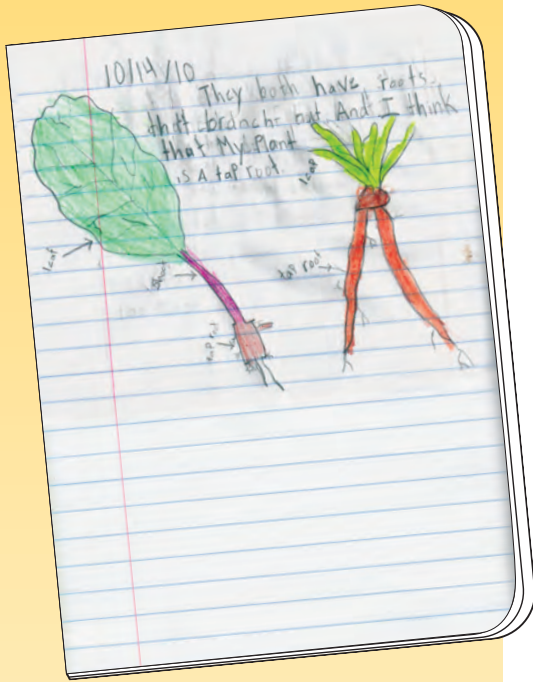
- clearly related to the focus question;
- accurate and precise, including units with measurements;
- organized for efficient reference.

Data handling can have two phases: data acquisition and data display. Data acquisition is making observations and recording data. The data record can be composed of words, phrases, numbers, and/or drawings. Data display is reorganizing the data in a logical way to facilitate thinking. The display can take the form of narratives, drawings, artifacts, charts, tables, images, graphs, Venn diagrams, calendars, or other graphic organizers. Early in a student's experience with notebooks, the record may be disorganized and incomplete, and the display may need guidance. With practice, however, students will become skilled at determining what form of recording to use in various situations and how best to display the data for analysis.

Narratives. The most intuitive approach to recording data for most students is narrative—using words, sentence fragments, and numbers in a more or less sequential manner. As students make a new observation, they record it right after the previous entry, followed by the next observation, and so on. Some observations, such as a record of the movements and interactions of a crayfish over time or the changes observed in an environment, are appropriately recorded in narrative form.

Sentence frames can help students record their narratives initially. Another option is to have students read their narratives to a partner from a different group. This allows them to refine their language and gain insight into another student's observation.

Science Notebooks in Grades 3–6



A drawing from the Structures of Life Module

Drawings. When students observe the shape and distribution of crystals after evaporation, or observe and identify the parts of a system, a labeled illustration is the most efficient way to record data. A picture is worth a thousand words, and a labeled picture is even more useful.

Students' initial drawings may need refinement to accurately capture their observations. It can be helpful to suggest an acronym for making useful drawings. Accurate, big, colorful, and detailed (ABCD) drawings can explain systems, identify structures of an organism, or capture observations of landforms. As the need arises, introduce specific drawing techniques, such as the use of scale, magnified view, and appropriate use of color.

Tables. With experience, students will recognize when a table is appropriate for recording data. When students make similar observations about a series of objects, such as a set of minerals or powdered substances, a table with columns is an efficient recording method. The two-dimensional table makes it easy to compare the properties of all the objects under investigation. Similarly, when students conduct an experiment, they can record data directly into a T-table. With little effort, they can transform the table, presented in ordered pairs, into a graph.

Notebook sheets are a good way to scaffold the use of tables. Students can quickly enter the information on the sheets. As they take on more independence in their notebooks, discussions about the column headings or the purpose of the tables shift the focus from filling in the table, to the purpose the table serves, and, eventually, to how to make a table to record this information.

Other things that stick to a magnet

yes	no
whiteboard	Paper
desk legs	marker
Choir legs	pencil
pencil sharpener	marker counter
basket handle	sink
file cabinet	paper towels
ring	whiteboard
desk handle	book rack
door handle	

A table from the Energy and Electromagnetism Module

Graphs, charts, and graphics. Reorganizing data into a logical, easy-to-use graphic is the first phase of data analysis. Graphs allow easy comparison (bar graphs), quick statistical analysis of numerical data (line plots), and visual confirmation of a relationship between variables (two-coordinate graphs). Additional graphic tools, such as Venn diagrams, pie charts, concept maps, food chains, and life cycles, help students perceive patterns in their data.

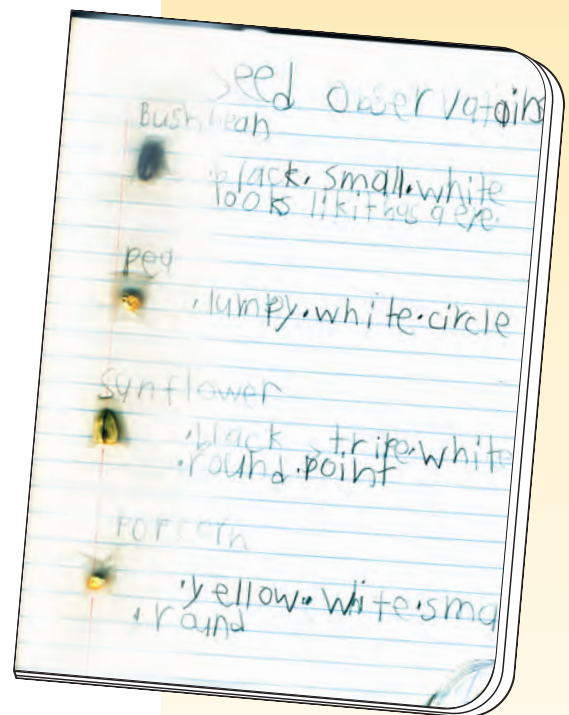
As students progress in making graphs and graphics, so should their understanding of when and why to use them. Taking a little time to have students discuss which graph to use before distributing a notebook sheet will go a long way to reinforce the idea that different graphs serve different purposes.

Artifacts. Occasionally, the results of an investigation produce three-dimensional products that students can tape or glue directly into their science notebooks. Sand, minerals, seeds, and so on can become a permanent part of the record of learning.

Images. Digital photos of plants, rocks, and the results of investigations can be great additions to the science notebook. Digital photos should be used to enhance students' observations and drawings, not to replace them.

	time	pennies	release point	length	predic	# of swings
1. stand	15 sec.	1	0°	38cm	15	11
2. release point	15 sec.	1	45°	38cm	11	11
3. mass	15 sec.	2	0°	38cm	10	12
4. length of string	15 sec.	1	0°	50cm	11	11

A table from the Motion, Force, and Models Module



Artifacts can be placed inside the notebook.

Making Sense of Data

Most of the sense making takes place during whole-group discussions when students share and discuss the observations they made while investigating. Questions are asked to help students interpret and analyze data in order to build conceptual understanding. Encourage students to use new vocabulary when they are sharing and making sense of their data. These words should be accessible to all students on the word wall. When students have limited written language skills, this oral discussion is important. This sharing is essential and is described in detail in the *Investigations Guide*. After sharing observations, the class revisits the focus question. Students flip back in their notebooks and use their data to discuss their answers to the question. You scaffold the discussion, and use appropriate language-development strategies.

The student's most important job is to think about the data and the focus question together to craft an answer to the question. Many investigations give students time to discuss and think with fellow students prior to writing an answer.

14. Discuss the relative amounts of materials in soils

Have students look at other groups' vials and the vials of soils you saved from Part 1 in order to compare the contents.

- *Do all vials contain the same amount of soil?* [Approximately.]
- *Do all vials have the same number of layers?* [Possibly, but not necessarily.]
- *Are the layers the same thickness for each type of earth material?* [Probably not.]
- *Can you identify each layer?* [Each soil should include some sand, a significant layer of silt and clay, and some humus.]
- *How are our schoolyard soils alike and different from the mountain, desert, river delta, and forest soils?*

After the sense-making discussion, students might review relevant vocabulary. They answer the focus question in their notebooks, expressing their current understanding. Some students will naturally use scientific vocabulary in their explanations, while others may need additional experiences before they include scientific vocabulary in their writing. In many instances, you can use supports to guide the development of a coherent and complete response to the question.

Frames and prompts. When providing frames or prompts, you are helping students organize their thinking. The frame provides a communication structure that allows students to focus their attention on thinking about the science involved. Here are some general frames.

- *I used to think _____, but now I think _____.*
- *The most important thing to remember about evaporation is _____.*
- *One thing I learned about _____.*

When using frames, you need to provide just the right amount of scaffolding to allow students to communicate their understanding. Too much scaffolding limits the opportunity for students' communication skills to progress. Too little scaffolding may not allow the student to accurately represent his or her understanding.

For example, in the **Energy and Electromagnetism Module**, students are asked,

- ▶ *What is the relationship between the distance between two magnets and the force of attraction between them?*

You can provide different frames to students, depending on ability. Each frame has merit when used appropriately. The four different frames below give students progressively less support.

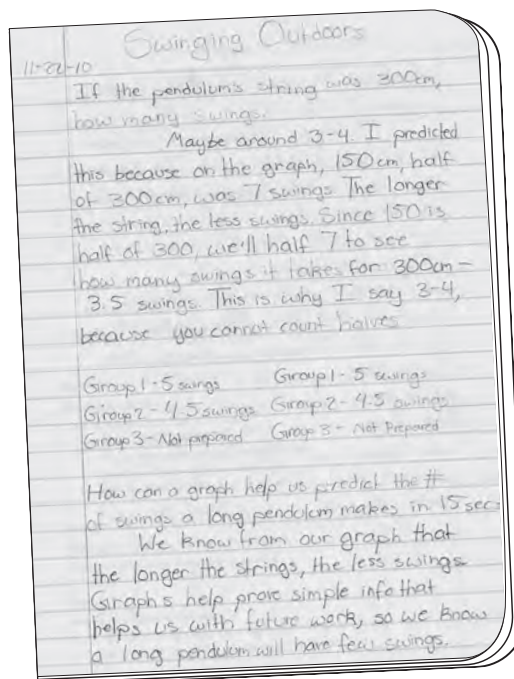
- *As the distance between the two magnets increases, the force of attraction _____ . I know this because when I tested a distance of 6 spacers, the force broke with _____ washers. When I tested a distance of 1 spacer, the force broke with _____ washers.*
- *As the distance between the two magnets _____, the force of attraction _____ . I know this because when I tested a distance of _____ spacers, the force broke with _____ washers. When I tested a distance of _____ spacer, the force broke with _____ washers.*
- *As the _____, the _____ . I know this because _____ .*
- *Make a claim about the force of attraction between magnets, and provide evidence to support your claim.*

TEACHING NOTE

Frames and prompts are designed to support students to either communicate or think more about the content. The important point is that students are doing the thinking and not merely responding to the prompt.

Claims and evidence. A claim is an assertion about how the natural world works. A student might claim, for instance, that metals stick to magnets. For the claim to be valid and accurate, it must be supported by evidence—statements that are directly correlated with data. The evidence should refer to specific observations, relationships that are displayed in graphs, tables of data that show trends or patterns, dates, measurements, and so on. Many teachers will provide a frame to help students include both their claims and evidence in their responses. A claims-and-evidence construction is a sophisticated, rich display of student learning and thinking.

Conclusions and predictions. At the end of an investigation (major conceptual sequence), it may be appropriate for students to generate a summarizing narrative to succinctly communicate what they have learned. When appropriate, students can make predictions based on their understanding of a principle or relationship. For instance, after completing the investigation on evaporation, a student might predict the order in which the water will completely evaporate from various containers, based on surface area exposed to air. Or a student might predict how long to make a pendulum that swings 15 times in 15 seconds. Predictions will frequently indicate the degree to which a student can apply the new knowledge to real-world situations. A prediction can be the springboard for further inquiry by the class or by individual students.



A prediction can show understanding of a relationship.

I wonder. Does the investigation connect to a student’s personal interests? Or does the outcome suggest a question or pique a student’s curiosity? Providing time for students to write “I wonder” statements or questions supports the idea that the pursuit of scientific knowledge does not end with the day’s investigation. The notebook is an excellent place to capture students’ musings and for students to record thoughts that might otherwise be lost.

Wrap-up/warm-up. At the end of each investigation part or at the beginning of the next part, students will engage in a wrap-up or warm-up. This is another opportunity for students to revisit the content of the investigation. As partners discuss their responses to the focus question, they may choose to add information to their responses. This should be encouraged.

► **NOTE**

More information about partner and small-group discussion protocols that can be used during the Wrap-Up/Warm-Up session appears in the Science-Centered Language Development chapter.

21. Share notebook entries

Conclude Part 1 or start Part 2 by having students share notebook entries. Ask students to open their science notebooks to the most recent entry. Read the focus question together.

► *What is soil?*

Ask students to pair up with a partner to

- share their answers to the focus question;
- discuss the different kinds of materials that were found in the four different soils;
- share their ideas about which soil came from which location—desert, river delta, mountain, forest.

TEACHING NOTE

Students' learning can be assessed only at the level in which it was done. If students worked in groups to answer the focus question, it is difficult to assess individual understanding. Similarly, providing a frame to guide a student response provides evidence on what students can do at a supported level, not at an independent level.

Next-Step Strategies

- *Teacher feedback*
- *Line of learning*
- *Review and critique*
- *Key points*
- *Revision with color*
- *Class debate*
- *Mini-lessons*

Next-Step Strategies

In each investigation, the *Investigations Guide* indicates an assessment opportunity and what to look for when examining students' work. The purpose of looking at students' work at intermediate junctures is for embedded (formative) assessment, *not* for grading. Look for patterns in students' understanding by collecting and sorting the notebooks. If the patterns indicate that students need additional help with communication or with content, you might want to select a corrective next-step strategy before going on to the next part. This process of looking critically at students' work is described in more detail in the Assessment chapter.

A next-step strategy is a brief instructional activity that takes place before the start of the next investigation part. Select a strategy based on students' needs to communicate their thinking more efficiently or accurately, use scientific vocabulary effectively, or think about the concept in a different way.

During each next step, students are engaged in reflection and self-assessment. Scientists constantly refine and clarify their ideas about how the natural world works. They read scientific articles, consult with other scientists, and attend conferences. They incorporate new information into their thinking about the subject they are investigating. This reflective process can result in deeper understanding or even a complete revision in thinking.

Likewise, when students receive additional instruction or information after writing a conclusion, response sheet, or answer to a focus question, give them time to reflect on how their ideas might have changed. In the self-assessment that follows, they review their original written work, judge its accuracy and completeness, and write a revised explanation.

What follows here is a collection of next-step strategies that teachers have used successfully with groups of students to address areas of need. The strategies are flexible enough to use in different groupings and can be modified to meet your students' needs.

By engaging in any of these next-step strategies, students have to think actively about every aspect of their understanding of the concept and organize their thoughts into coherent, logical narratives. The learning that takes place during this reflection process is powerful. The relationships between the several elements of the concept become unified and clarified.

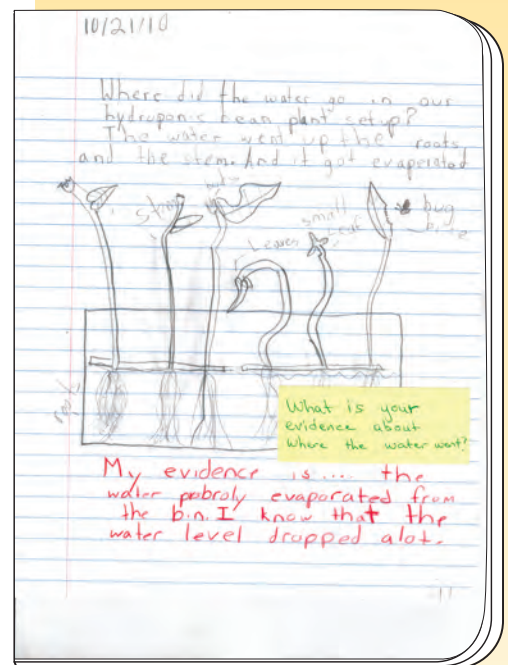
Teacher feedback. Students’ writing often exposes weaknesses in students’ understanding—or so it appears. It is important to check whether the flaw results from poor understanding of the science or from imprecise communication. You can use the notebook to provide feedback, asking for clarification or additional information. Attach a self-stick note, which can be removed after the student has taken appropriate action. The most effective forms of feedback relate to the content of the work. Nonspecific feedback (such as stars, smiley faces, and “good job!”) and ambiguous critiques (such as “try again,” “put more thought into this,” and “not enough”) are less effective. Here are a couple of examples.

- You claim that water condensed on the glass of ice water. Where did the water come from?
- Tell me why you think Lightbulb A will light. Hint: Check the contact points on the two illustrations.

Feedback that guides students to think about the content of their work and gives suggestions for how to improve are productive instructional strategies. Here are some examples of useful generic feedback.

- Use the science vocabulary in your answer.
- Include an example to support your ideas.
- Include more detail about _____.
- Check your data to make sure this is right.
- Include units with your measurements.

When students return to their notebooks and respond to the feedback, you will have additional information to help you discriminate between knowledge and communication difficulties.



Students can respond to feedback using a different-color pencil.

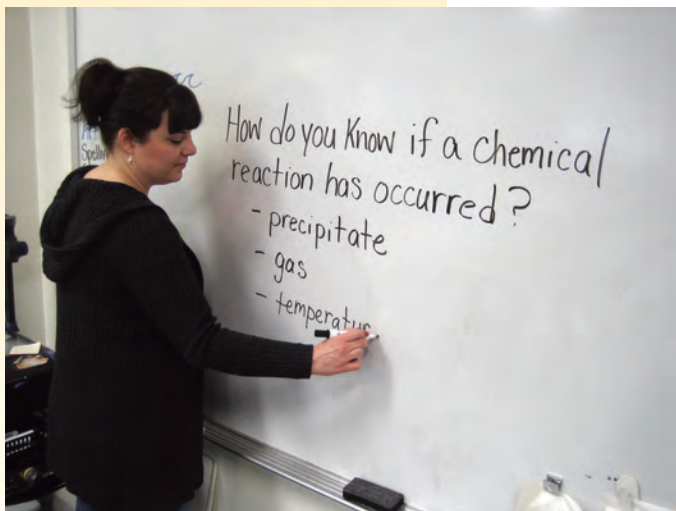
Science Notebooks in Grades 3–6

Line of learning. One technique many teachers find useful in the reflective process is the line of learning. After students enter their initial explanation, followed by discussion, assessment, reading, and/or teacher feedback, they draw and date a line under their original work. Then they make a new entry under the line of learning, adding to or revising their original thinking. If the concept is elusive or complex, a second line of learning, followed by more processing and revising, may be appropriate.

The line of learning is a reminder to students that learning is an ongoing process, and that the products of the process are imperfect. The line of learning marks places in that process where a student made a stride toward full understanding. The psychological security provided by the line of learning reminds students that they can always draw another line of learning and revise their thinking once again. The ability to look back in the science notebook and see concrete evidence of learning gives students confidence and helps them become critical observers of their own learning.

Review and critique anonymous student work. Presenting work from other students can be a valuable learning tool for refining and improving responses for content and literacy. Depending upon the culture of the class, you might present actual or simulated student work from a focus question or response sheet, selected to represent a common misconception, error, or exemplary work. Present it to the whole class, and then have students work in groups to discuss the merits of the response and make recommendations for improvement. In this process, students discuss what information is needed in a quality response. After critiquing other students' responses, students look at their own responses, draw a line of learning, and refine their own thinking.

Key points. As students advance in years, so does the level of questions they are asked to answer. Some questions require students to address several points for a complete response. If students discuss only one point well, it may be that they are unaware of the other points or need assistance in how to address multiple points in an answer. Using key points, you pose the question to the group and, through discussion, elicit the key ideas or points that would be included in a complete answer to the question. On the board, record only words or brief phrases. Once the class has agreed on the key points, students review their responses and add information to answer the question completely. The list of words and phrases provides the support for revision, but not the language.



Revision with color. Suppose a student response of several sentences has some accurate information, some information that needs refinement, and a critical gap. Instead of crossing out the original response completely and starting anew, students can use color to revise their responses. After discussing the question with a partner or in a group, or even during key points, students grab three different-color pens or pencils and refine their responses by using the three Cs (confirm, correct, and complete). To confirm information as accurate, they underline it in green. If they need to correct a misconception, they do so in red. If they need to complete their responses by adding more information, they do it in blue. In doing so, students learn that their initial responses are works in progress, and, like scientists, students may revisit and modify their responses based on new information.

Class debate. If students have differing points of view on a response, you could have students engage in a healthy class debate. After establishing rules to foster a respectful and helpful class environment, volunteers read their answers, and classmates can agree or disagree. Students can present supporting evidence or counterarguments. An important part of the debate is that students may change their minds once they have additional evidence. Students return to their notebooks and can modify their responses by using any other next-step strategy.

Mini-lessons. Sometimes the data from sorting notebook entries reveal that students need some additional information or specific guidance on a skill. A mini-lesson is a brief interaction with a group of students, targeting the area of need. You might have a group of students observe a stream table more closely in order to observe landforms or give a writing prompt to a small group of students and ask them to explain their thinking more clearly.

WRITING OUTDOORS

Every time you go outdoors with students, you will have a slightly different experience. Naturally, the activity or task will be different, but other variables may change as well. The temperature, cloud cover, precipitation, moisture on the ground; other activities unexpectedly happening outside; students' comfort levels related to learning outdoors; and time of the school year are all aspects that could affect the activity and will certainly determine how you incorporate the use of notebooks. Most students are completely capable of staying on task with the outdoor experience when they are doing science, but writing outdoors can be a bit trickier. The following techniques are tried-and-true ways to help students learn how to write outdoors and to give them all the supplies they need to support their writing.

Create “Desks”

Students need a firm writing surface. Students who write in composition notebooks with firm covers can simply fold them open to the pages they are writing on, rest them in the crook of their nonwriting arms, and hold them steady with their nonwriting hands—they can stand, sit, kneel, or lean against a wall to write. At the beginning of the school year, take a minute to model how to do this.

Many students feel most comfortable sitting down to write. Curbs, steps, wooden stumps or logs, rocks, and grass are places to sit while writing. Select a writing location that suits your students' comfort levels. Some students will not be comfortable sitting on the grass or ground. They will need to sit on something such as a curb, stair, boulder, or stump at the start of the year, but will eventually feel more comfortable with all aspects of the outdoor setting as the year moves along.

If students are using individual notebook sheets or notebooks with flimsy covers, you will likely want to buy or make clipboards. If you do not have clipboards, use a box cutter to cut cardboard to the proper size. Clamp a binder clip at the top to make a lightweight yet sturdy clipboard. If it gets ruined, no tears will be shed. If you're in the market for new clipboards, get the kind that are stackable and do not have a bulky clip. Ideally, all the clipboards will fit in one bag for portability and easy distribution.



If using a notebook sheet, simply put the sheet on the clipboard before going outdoors, and have students glue the sheet into their notebooks when you are back in the classroom. If you are using three-ring binders, do not bring them outdoors. Take the paper out, put it on a clipboard, and return it to the binder when back in the classroom. Don't take the risk of the rings opening and everything blowing away.

Elastic bands around the bottom of the clipboard, or around a stiffer composition notebook, will help keep the paper from flapping around and becoming too weathered.

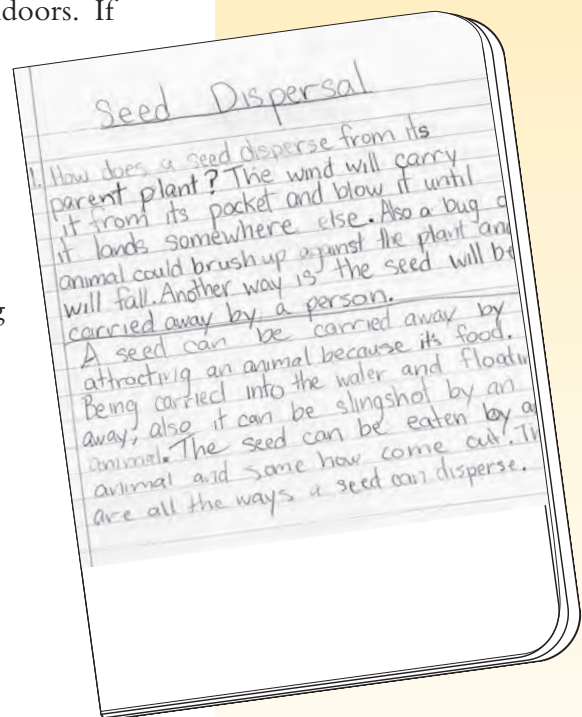
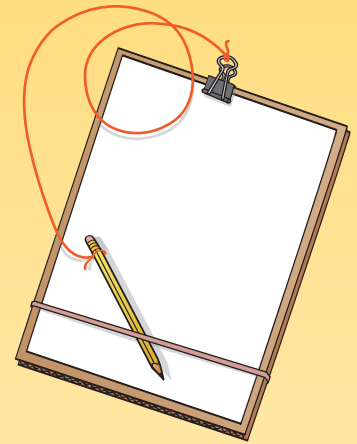
Bring Writing Tools Outdoors

You can bring chart paper outdoors. Roll up a blank piece of chart paper, grab some blue painter's tape, and stick the piece of paper to the school wall. You'll need to tape all four corners. Or set up a chart inside, and clip it to a chain-link fence with binder clips or clothespins when you go outdoors.

Take along extra pencils, as pencil points will break. Some teachers find it helpful to tie pencils onto clipboards. Pencils should be tucked between the clip and the notebook sheet so that students don't poke themselves or, more likely, accidentally break the pencil points.

Decide When to Write Outdoors

In general, notebook entries will be more detailed and more insightful if students can stay outdoors where the scientific exploration occurred. Sometimes, you will want to complete notebook entries indoors. If you are teaching the module early in the year when students are building up the routines for using the schoolyard, or if the weather is not ideal (a little chilly, raining, too hot, too windy), then you may want students to make notebook entries after returning to the classroom. If students are totally focused and in the moment, they can stay outdoors while they answer the focus question. If other students are outdoors playing, you may need to bring the class indoors to complete the written work. Only you will be able to determine what is best at the time.



CLOSING THOUGHTS

Engaging students in active science with notebooks provides a rich experience. Doing this successfully requires thoughtful interactions among students, materials, and natural phenomena. Initially, adding notebooks to your science teaching will require you to focus students' attention on how to set up the notebook, what types of entries students should make, and when students should be using their notebooks. You will establish conventions about where to record the date and title, where to keep notebooks, how to glue notebook sheets into notebooks, and when to record observations and thinking.

Once you are past these perfunctory issues, you can shift your focus to the amount of scaffolding to provide to students or to encouraging students to create their own notebook entries. During this time, you and your students are developing skills to improve the quality of notebook entries. These skills may include asking better questions to focus students' attention on a specific part of an organism or using color to enhance a drawing. Students begin to make entries with less prompting. They give more thought to supporting their responses to the focus question. When asked to make a derivative product, students thumb through their notebooks to find the needed information. The notebook becomes a tool for students to help recall their learning.

As students begin to document their thinking about focus questions and other queries, you may begin to wonder, "Should I be doing something with their notebooks?" This is when your focus shifts from the notebook as just something students use during science learning to the notebook as an assessment tool. Once everyone is comfortable recording the focus question and collecting data, you can take the next step of collecting notebooks and reading students' responses as a measure of not just how individual students are learning, but what the pervasive needs of students are. You choose next-step strategies that address students' needs before proceeding to the next investigation. The notebooks act as an assessment tool that lets you modify your science instruction.

This process will take time, discussions with colleagues, revisiting different sections of this chapter, and critical scrutiny of students' work before both you and your students are using notebooks to their full potential.

► NOTE

For more on derivative products, see the Science-Centered Language Development chapter.