INTRODUCTION

In this chapter, we explore the intersection of science and language and the implications for effective science teaching and language development. We identify best practices in language arts instruction that support science learning and examine how learning science content and practices supports language development. The active investigations, science notebooks, FOSS Science Resources readings, and formative assessment activities in FOSS provide rich contexts in which students develop and exercise thinking processes and communication skills. Together, these elements comprise effective instruction in both science and language arts—students experience the natural world around them in real and authentic ways and use language to inquire, process information, and communicate their thinking about scientific phenomena. We refer to the development of language within the context of science as science-centered language development.

Hubert M. Dyasi, “Visions of Inquiry: Science”
Language plays two crucial roles in science learning: (1) it facilitates the communication of conceptual and procedural knowledge, questions, and propositions (external, public), and (2) it mediates thinking, a process necessary for understanding (internal, private). These are also the ways scientists use language: to communicate with one another about their inquiries, procedures, and understandings; to transform their observations into ideas; and to create meaning and new ideas from their work and the work of others. For students, language development is intimately involved in their learning about the natural world. Science provides a real and engaging context for developing literacy, and language arts skills and strategies support conceptual development and scientific practices. For example, the skills and strategies used for reading comprehension, writing expository text, and oral discourse are applied when students are recording their observations, making sense of science content, and communicating their ideas. Students’ use of language improves when they discuss, write, and read about the concepts explored in each investigation.

We begin our exploration of science and language by focusing on language functions and how specific language functions are used in science to facilitate information acquisition and processing (thinking). Then we address issues related to the specific language domains—speaking and listening, writing, and reading. Each section addresses

• how skills in that domain are developed and exercised in FOSS science investigations;
• literacy strategies that are integrated purposefully into the FOSS investigations;
• suggestions for additional literacy strategies that both enhance student learning in science and develop or exercise English-language literacy skills.

Following the domain discussions is a section on science-vocabulary development, with scaffolding strategies for supporting all learners. The last section covers language-development strategies specifically for English learners.

NOTE
The term English learners refers to students who are learning to understand English. This includes students who speak English as a second language and native English speakers who need additional support to use language effectively.
THE ROLE OF LANGUAGE IN SCIENTIFIC AND ENGINEERING PRACTICES

Language functions are the purpose for which speech or writing is used and involve both vocabulary and grammatical structure. Understanding and using language functions appropriately is important in effective communication. Students use numerous language functions in all disciplines to mediate communication and facilitate thinking (e.g., they plan, compare, discuss, apply, design, draw, and provide evidence).

In science, language functions facilitate the enactment of scientific and engineering practices. For example, when students are collecting data, they are using language functions to identify, label, enumerate, compare, estimate, and measure. When students are constructing explanations, they are using language functions to analyze, communicate, discuss, evaluate, and justify.

A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas (National Research Council 2012) provides a “set of essential practices as essential for any education in the sciences and engineering.” Each of these scientific and engineering practices requires the use of multiple language functions. Often, these language functions are part of an internal dialogue weighing the merits of various explanations—what we call thinking. The more language functions with which we are facile, the more effective and creative our thinking can be.

The scientific and engineering practices are listed below, along with a sample of the language functions that are exercised when effectively engaged in that practice. (Practices are bold; language functions are italic.)

**Asking questions and defining problems**
- Ask questions about objects, organisms, systems, and events in the natural world (science) or define a problem (engineering).

**Planning and carrying out investigations; analyzing, and interpreting data**
- Plan and conduct investigations.
- Observe and record data.
- Measure to extend the senses to acquire data.
- Organize observations (data), using numbers, words, images, and graphics.

Examples of Language Functions
- Analyze
- Apply
- Ask questions
- Clarify
- Classify
- Communicate
- Compare
- Conclude
- Construct
- Critique
- Describe
- Design
- Develop
- Discuss
- Distinguish
- Draw
- Enumerate
- Estimate
- Evaluate
- Experiment
- Explain
- Formulate
- Generalize
- Group
- Identify
- Infer
- Interpret
- Justify
- Label
- List
- Make a claim
- Measure
- Model
- Observe
- Organize
- Plan
- Predict
- Provide evidence
- Reason
- Record
- Represent
- Revise
- Sequence
- Solve
- Sort
- Strategize
- Summarize
Science-Centered Language Development

Constructing explanations (science) and designing solutions (engineering); engaging in argument from evidence
- Predict future events, based on evidence and reasonings.
- Use data and logic to construct and communicate reasonable explanations.
- Develop, discuss, evaluate, and justify the merits of explanations.
- Use science-related technologies to apply scientific knowledge and solve problems.

Developing and using models
- Create models to explain natural phenomena and predict future events or outcomes.
- Describe how models represent the natural world.
- Compare models to actual phenomena and identify limitations of the models.

Obtaining, evaluating, and communicating
- Identify key ideas in text, identify supporting evidence, and know how to use various text features.
- Distinguish opinion from evidence.
- Use writing as a tool for clarifying ideas and communicating.

Research supports the claim that when students are intentionally using language functions in thinking about and communicating in science, they improve not only science content knowledge, but also language-arts and mathematics skills (Ostlund 1998; Lieberman and Hoody 1998). Language functions play a central role in science as a key cognitive tool for developing higher-order thinking and problem-solving abilities that, in turn, support academic literacy in all subject areas.
Here is an example of how an experienced teacher can provide an opportunity for students to exercise language functions in FOSS. In the *Soils, Rocks, and Landforms Module*, this is one piece of content we expect students to have acquired by the end of the module.

- The greater the flow of water across Earth’s surface, the greater the rate of erosion and deposition.

The scientific practices the teacher wants the class to focus on are *interpreting data* and *constructing explanations*.

The language functions students will exercise while engaging in these scientific practices are *comparing*, *explaining*, and *providing evidence*. The teacher understands that these language functions are appropriate to the purpose of the science investigation and support the Common Core Standards for writing (students will write explanatory texts to examine a topic and convey ideas and information clearly).

- Students will *compare* observational data (from a stream-table investigation) to *explain* the relationship between the amount of water that runs over a surface and the amount of erosion and deposition that occur.

The teacher can support the use of language functions by providing structures such as sentence frames.

- As _____, then _____.
  *As more water flows over a surface, then more erosion and deposition occur.*

- When I changed _____, then _____ happened.
  *When I changed the amount of water flowing down the stream table, then more erosion and deposition happened.*

- The more/less _____, the _____.
  *The more water that flows across the earth materials, the more erosion and deposition that occur.*

**NOTE**

For more examples of how FOSS teachers address language-arts standards while conducting science investigations with students, go to FOSSweb (www.FOSSweb.com).
SPEAKING AND LISTENING DOMAIN

The FOSS investigations are designed to engage students in productive oral discourse. Talking requires students to process and organize what they are learning. Listening to and evaluating peers’ ideas calls on students to apply their knowledge and to sharpen their reasoning skills. Guiding students in small-group and whole-class discussions is critical to the development of conceptual understanding of the science content and the ability to think and reason scientifically.

FOSS investigations start with a discussion—either a review to activate prior knowledge or presentation of a focus question or a challenge to motivate and engage active thinking. During active investigation, students talk with one another in small groups, share their observations and discoveries, point out connections, ask questions, and start to build explanations. The discussion icon in the sidebar of the Investigations Guide indicates when small-group discussions should take place.

During the activity, the Investigations Guide indicates where it is appropriate to pause for whole-class discussions to guide conceptual understanding. The Investigations Guide provides you with discussion questions to help stimulate student thinking and support sense making. At times, it may be beneficial to use sentence frames or standard prompts to scaffold the use of effective language functions and structures.

At the end of the investigation, there is another opportunity to develop language through speaking and listening in the Wrap-Up/Warm-Up. During this time, students are often asked to discuss their responses to the focus question. All students need to be engaged in this opportunity to use different language functions.

On the following pages are some suggestions for providing structure to those discussions and for scaffolding productive discourse when needed. Teaching techniques used to generate discussion in language arts and other content areas can also be used effectively during science. Using the protocols that follow will ensure inclusion of all students in discussions.
Partner and Small-Group Discussion Protocols

Whenever possible, give students time to talk with a partner or in a small group before conducting a whole-class discussion. This provides all students with a chance to formulate their thinking, express their ideas, practice using the appropriate science vocabulary, and receive input from peers. Listening to others communicate different ways of thinking about the same information from a variety of perspectives helps students negotiate the difficult path of sense making for themselves.

**Dyads.** Students pair up and take turns either answering a question or expressing an idea. Each student has 1 minute to talk while the other student listens. While student A is talking, student B practices attentive listening. Student B makes eye contact with student A, but cannot respond verbally. After 1 minute, the roles reverse.

Here’s an example from the [Mixtures and Solutions Module](#). Just before students answer the focus question in their notebooks, you ask students to pair up and take turns sharing their answer to the question “How do you know when a chemical reaction has occurred?” The language objective is for students to be able to explain what happens during a chemical reaction and provide evidence (orally and in writing) that it has occurred. These sentence frames can be written on the board to scaffold student thinking and conversation.

* I claim that _______ produces a chemical reaction, because _______.
* Evidence for my claim includes _______.

**Partner parade.** Students form two lines facing each other. Present a question, an idea, an object, or an image as a prompt for students to discuss. Give students 1 minute to greet the person in front of them and discuss the prompt. After 1 minute, call time. Have the first student in one of the lines move to the end of the line, and have the rest of the students in that line shift one step sideways so that everyone has a new partner. (Students in the other line do not move.) Give students a new prompt to discuss for 1 minute with their new partners.

For example, students are just beginning the investigation on landforms, and you want to assess prior knowledge. Give each student a picture of a landform, and have students line up facing each other. For the first round, ask, “What do you know about the image on your card?” For the second round, ask, “How do you think the landform in your picture formed?” For the third round, ask, “What personal experience have you had with this landform?” The language objective is for students to describe their observations, infer how the landform formed,
and reflect upon and relate any experiences they may have had with a similar landform. The following sentence frames can be used to scaffold student discussion.

- I notice _____.
- I think the landform was formed by _____.
- The landform in my picture reminds me of the time when _____.

**Put in your two cents.** For small-group discussions, give each student two pennies or similar objects to use as talking tokens. Each student takes a turn putting a penny in the center of the table and sharing his or her idea. Once all have shared, each student takes a turn putting in the other penny and responding to what others in the group have said. For example,

- I agree (or don’t agree) with ____ because _____.

Here’s an example from the *Sun, Moon, and Planets Module.* Students have been monitoring their shadows throughout the day and are still struggling to make coherent connections between Earth’s rotation and the effect that it has on shadows. The language objective is for students to describe their observations, explain why the direction and length of their shadows change during the day, and provide evidence based on their own observations. You give each student two pennies, and in groups of four, they take turns putting in their two cents. For the first round, each student answers the question “Why do shadows change during the day?” They use the frame

- I think shadows change during the day because _____.
- My evidence is _____.

On the second round, each student states whether he or she agrees or disagrees with someone else in the group and why, using the sentence frame.

**Whole-Class Discussion Supports**

The whole-class discussion is a critical part of sense making. After students have had the active learning experience and have talked with their peers in partners and/or small groups, sharing their observations with the whole class sets the stage for developing conventional explanatory models. Discrepant events, differing results, and other surprises are discussed, analyzed, and resolved. It is important that students realize that science is a process of finding out about the world around them. This is done through asking questions, testing ideas, forming explanations, and subjecting those explanations to logical
Leading students through productive discussion helps them connect their observations and the abstract symbols (words) that represent and explain those observations. Whole-class discussion also provides an opportunity for you to interject an accurate and precise verbal summary statement as a model of the kind of thinking you are seeking. Facilitating effective whole-class discussions takes skill, practice, a shared set of norms, and patience. In the long run, students will have a better grasp of the content and improve their abilities to think independently and communicate effectively.

Norms should be established so that students know what is expected during science discussions.

- Science content and practices are the focus.
- Everyone participates.
- Ideas and experiences are shared, accepted, and valued. Everyone is respectful of one another.
- Claims are supported by evidence.
- Challenges (debate and argument) are part of the quest for complete understanding.

The same discussion techniques used during literacy circles and other whole-class discussions can be used during science instruction (e.g., attentive listening, staying focused on the speaker, asking questions, responding appropriately). In addition, in order for students to develop and practice their reasoning skills, they need to know the language forms and structures and the behaviors used in evidence-based debate and argument (e.g., using data to support claims, disagreeing respectfully, asking probing questions; Winokur and Worth 2006).

Explicitly model and conduct mini-lessons (5 to 10 minutes of focused instruction) on the language structures appropriate for active discussions, and provide time for students to practice them, using the science content.

**Sentence frames.** The following samples can be posted as a scaffold as students learn and practice their reasoning and oral participation skills.

- I think _______, because _______.
- I predict _______, because _______.
- I claim _______; my evidence is _______.
- I agree with _______ that _______.
- My idea is similar/related to _______’s idea.

Let students know that scientists change their minds based on new evidence. It is expected that students will revise their thinking based on evidence presented in discussions.

Encourage science talk. Allow time for students to engage in discussions that build on other students’ observations and reasoning. After an investigation, use a teacher- or student-generated question, and either just listen or facilitate the interaction with questions to encourage expression of ideas among students.
Guiding questions. The Investigations Guide provides questions to help concentrate student thinking on the concepts introduced in the investigation. Guiding questions should be used during the whole-class discussion to facilitate sense making. Here are some other open-ended questions that help guide student thinking and promote discussion.

- What did you notice when _____?
- What do you think will happen if _____?
- How might you explain _____? What is your evidence?
- What connections can you make between _____ and _____?
Whole-Class Discussion Protocols

The following examples of tried-and-true participation protocols can be used to enhance whole-class discussions during science and all other curriculum areas. The purpose of these protocols is to increase meaningful participation by giving all students access to the discussion, allowing students time to think (process), and providing a context for motivation and engagement.

**Think-pair-share.** When asking for a response to a question posed to the class, allow time for students to think silently for a minute. Then, have students pair up with a partner to exchange thoughts before you call on a student to share his or her ideas with the whole class.

**Pick a stick.** Write each student’s name on a craft stick, and keep the sticks handy at the front of the room. When asking for responses, randomly pick a stick, and call on that student to start the discussion. Continue to select sticks as you continue the discussion. Your name can also be on a stick in the cup. You can put the selected sticks in a different location or back into the same cup to be selected again.

**Whip around.** Each student takes a quick turn sharing a thought or reaction. Questions are phrased to elicit quick responses that can be expressed in one to five words (e.g., “Give an example of a stored-energy source.” “What does the word heat make you think of?”).

**Group posters.** Have small groups design and graphically record their investigation data and conclusions on a quickly generated poster to share with the whole class.
WRITING DOMAIN

Information processing is enhanced when students engage in informal writing. When allowed to write expressively without fear of being scorned for incorrect spelling or grammar, students are more apt to organize and express their thoughts in different ways that support sense making. Writing promotes the use of scientific practices, thereby developing a deeper engagement with the science content. It also provides guidance for more formal derivative science writing (Keys 1999).

Science Notebooks

The science notebook is an effective tool for enhancing learning in science and exercising various forms of writing. Science notebooks provide opportunities both for expressive writing (students craft explanatory narratives that make sense of their science experiences) and for practicing informal technical writing (students use organizational structures and writing conventions). Starting as emergent writers in kindergarten, students learn to communicate their thinking in an organized fashion while engaging in the cognitive processes required to develop concepts and build explanations. Having this developmental record of learning also provides an authentic means for assessing students’ progress in both scientific thinking and communication skills.

One way to help students develop the writing skills necessary for productive notebook entries is to focus on the corresponding language functions. The language forms and structures used to perform these language functions in science are used in all curricular areas and, therefore, can be suitably taught in conjunction with existing language-arts instruction. This can be done through mini-lessons on the writing skills that support the various types of notebook entries.

Table 1, at the end of the Writing Domain section, provides examples of how language functions are used to help students develop both their general writing skills and their thinking abilities within the format of the science-notebook entry. The writing objectives for a mini-lesson, along with the particular language forms and structures (vocabulary, syntax, linking words, organization of ideas, and so on), are identified in the table along with the suggested sentence frames for scaffolding.

For example, if students are observing a particular insect’s behavior, the language objective might be “Students describe in detail the behavior of the insect.” A prior mini-lesson on using sensory details to describe observations would provide students with the language forms and structures appropriate for recording their data in their notebooks during the observations. As a scaffold, students could also be provided with sentence frames to help them write detailed narratives.

NOTE
For more information about supporting science-notebook development, see the Science Notebooks chapter.

NOTE
Language forms and structures refer to the internal grammatical structure of words and how those words go together to make sentences.
Developing Derivative Language-Arts Products

Science notebooks provide students with a source of information (content) from which they can draw to create more formal science-centered writing pieces. Derivative products are written pieces that are generated with specific language-arts goals in mind, such as audience and language function. Writing-to-learn methods can enhance science concepts when students engage in different types of writing for different purposes (Hand and Prain 2002). We know that students are more engaged and motivated to write when they have a clear and authentic context for writing.

The language extensions in the Interdisciplinary Extensions section at the end of each investigation suggest writing activities that can be used to help students learn the science content for that particular investigation. The writing activities incorporate language-arts skills appropriate for the grade level. Questions and ideas for future writing activities that surface during the investigations can be recorded in a class list, in science notebooks, or in students’ writing folders. Here are general suggestions for using science content to create products in each of several writing genres.

**Descriptive writing.** Students use descriptive writing to portray an organism, an environment, an object, or a phenomenon in such a way that the reader can almost recapture the writer’s experience. This is done through the use of sensory language; rich, vivid, and lively detail; and figurative language, such as simile, hyperbole, metaphor, and symbolism. You can remind students to show, rather than tell, through the use of active verbs and precise modifiers.

To help them learn the science content, students can use the information in their science notebooks to elaborate on their observations by using descriptive vocabulary, analogies, and drawing.

### Language function | Language objectives for writing in notebooks | Language forms, structures, and scaffolds for writing
---|---|---
**Describe** | Write narratives: use details, sensory observations, and connections to prior knowledge. | I observed __. When I touch the __, I feel __. The __ has __. I noticed __. It feels __. It smells __. It sounds __. It reminds me of __ because __. |

This sample from Table 1 shows how language functions can be developed and applied when writing in science notebooks.

### Derivative Language-Arts Products
- Descriptive writing
- Persuasive writing
- Narrative writing
- Expository writing
- Recursive cycle

**NOTE**
The complete table appears at the end of this Writing Domain section.
For example, kindergartners can draw pictures of isopods, fish, worms, things made of wood, different types of trees and leaves, and so on. Through drawings and words, students describe objects’ properties and compare how those objects are the same and different.

Primary students can make property cards by writing on an index card as many properties as they can that describe an object or organism. Then, students take turns reading the properties to another student to see if the partner can identify the corresponding object.

Students of all ages can expand on their notebook entries in poetry that expresses their interpretation of organisms, objects, and phenomena such as crayfish, seeds, electricity, rivers, weather, and minerals. The use of similes is a good way to engage students in making comparisons. You can use a simple frame, such as: ______ is like ______. (For example, in the Air and Weather Module, students might write “The weather today is like a dragon.”)

Students can share their similes. Other students can explain why they think the simile works.

**Persuasive writing.** The objective of persuasive writing is to convince the reader that a stated opinion or interpretation of data is worthwhile and meaningful. Students learn to support their claims with evidence and to use persuasive techniques, such as logical arguments and calls to action. By using claims and evidence to formulate conclusions in their science notebooks, students develop and apply their thinking and reasoning skills to form the basis of persuasive writing in a variety of formats, such as essays, letters, editorials, advertisements, award nominations, informational pamphlets, and petitions. Animal habitats, energy use, weather patterns, landforms, and water sources are just a few science topics that can generate questions and issues for persuasive writing.

Here is a sample of persuasive writing frames (modified from Gibbons 2002).

Title: _____
The topic of this discussion is _____.
My opinion (position, conclusion) is _____.
There are <number> reasons why I believe this to be true.
First, _____.
Second, _____.
Finally, _____.
On the other hand, some people think _____.
I have also heard people say _____.
However, my claim is that _____. because _____.

Full Option Science System
**Narrative writing.** Science provides a broad landscape of engaging material for stimulating the imagination for the writing of stories, songs, biographies, autobiographies, poems, and plays. Students can use organisms or objects as characters; describe habitats and environments as settings; and write scripts portraying various systems, such as weather patterns, flow of electricity, and water, rock, or life cycles.

**Expository writing.** Students use science content to inform, explain, clarify, define, or instruct through writing letters, definitions, procedures, newspaper and magazine articles, posters, pamphlets, and research reports. Expository writing is characterized by a focus on main topics with supporting facts, details, explanations, and examples and is organized in a clear, coherent, and sequential manner. Expository writing has a clear focus on communicating accurate, complete, and detailed representations of science content and/or observation of natural history or events.

During writing instruction, students can use the information in their science notebooks and in related readings (and other sources, such as video content) to write a more formal and conclusive answer to the focus question. Strategies such as the writing process (plan, draft, edit, revise, and share) and writing frames (modeling and guiding the use of topic sentences, transition and sequencing words, examples, explanations, and conclusions) can be used with the science content to develop proficiency in critical writing skills.

A page from a big book about ecosystems, a derivative product created during language arts

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**NOTE**

Human characteristics should not be given to organisms (anthropomorphism) in science investigations, only in literacy extensions.
Here are three samples of writing frames for science reports for primary and upper-elementary students (modified from Wellington and Osborne 2001).

**Primary** (life cycle appropriate for the Insects and Plants Module)

Title: _____

(Define) A _____ is _____.

(Classify) A _____ is a kind of _____.

(Describe) A _____ is _____.

(Habitat) _____ lives _____.

(Life cycle) _____ started life as _____.

(Change over time) Then it _____.

(Food) A _____ eats _____.

(Evidence) I know that _____ because _____.

**Upper elementary** (living structures appropriate for the Structures of Life Module)

Title: _____

(Identify) The part of the body I am describing is the _____.

(Describe) It consists of _____.

(Explain) The function of these parts is _____.

(Example) This drawing shows _____.

**Upper elementary** (explanation)

Title: _____

I want to explain why (how) _____.

An important reason for why (how) this happens is that _____.

Another reason is that _____.

I know this because _____.

Recursive cycle. An effective method for extending students’ science learning through writing is the recursive cycle of research (Bereiter 2002). This strategy emphasizes writing as a process for learning, similar to the way students learn during the active science investigations.

1. Decide on a problem or question to write about.
2. Formulate an idea or a conjecture about the problem or question.
3. Identify a remedy or an answer, and develop a coherent discussion.
4. Gather information (from science notebooks, FOSS Science Resources, books, FOSSweb interactives, Internet, interviews, videos, experiments, etc.).
5. Reevaluate the problem or question based on what has been learned.
6. Revise the idea or conjecture.
7. Make presentations (reports, posters, electronic presentations, etc.).
8. Identify new needs, and make new plans.

This process can continue for as long as new ideas and questions occur, or students can present a final product in any of the suggested formats.
Table 1. Examples of how language functions are exercised in science notebook writing and examples of sentence frames and language structures students may use

<table>
<thead>
<tr>
<th>Language function</th>
<th>Language objectives for writing in notebooks</th>
<th>Language forms, structures, and scaffolds for writing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Organizational setup</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organize</td>
<td>Set up and organize notebook: table of contents, glossary or index, page numbers, date, turning to the next blank page.</td>
<td>Use structures such as rows, columns, blocks, numbers, location, alphabetizing.</td>
</tr>
<tr>
<td><strong>Notebook component—planning the investigation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design</td>
<td>Write a narrative plan: communicate ideas on an approach to answer the focus question or challenge posed in the investigation.</td>
<td>Use adverbs such as first, second, next, then, finally. Brainstorming ideas: First I will _____ and then I will ____. I will need to _____ to _____.</td>
</tr>
<tr>
<td>Strategize</td>
<td></td>
<td></td>
</tr>
<tr>
<td>List</td>
<td>Write ordered lists: materials, variables, vocabulary words, bullets</td>
<td>We need _____, _____, and _____ to _____.</td>
</tr>
<tr>
<td>Record</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sequence</td>
<td>Record step-by-step procedures: explain exactly what to do, number steps in a sequence, specifics for measurement, how controls will be established, how variables will be measured (tools/units).</td>
<td>1. _____________. 2. _____________. 3. _____________. I will change ____. I will not change ____. I will measure ____. I will not measure _____.</td>
</tr>
<tr>
<td><strong>Notebook component—data acquisition</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Describe</td>
<td>Write narratives: use details, sensory observations, connections to prior knowledge.</td>
<td>I observed ____. When I touch the ____, I feel ____. The ____ has ____. I noticed ____. It feels ____. It smells ____. It sounds ____. It reminds me of ____, because ____.</td>
</tr>
</tbody>
</table>
### Notebook component—data acquisition (continued)

<table>
<thead>
<tr>
<th>Language function</th>
<th>Language objectives for writing in notebooks</th>
<th>Language forms, structures, and scaffolds for writing</th>
</tr>
</thead>
</table>
| Draw               | Make technical drawings: draw large, accurate, and detailed representations; identify parts of a system. | Label drawing, using science vocabulary. Recognize shapes, form, location, color, size, and scale. My drawing shows ____.
| Label              |                                            |                                                      |
| Identify           |                                            |                                                      |
| Organize           | Make charts and tables: use a T-table or chart for recording and displaying data. | Set up rows, columns, headings. My T-table compares ____.
| Compare            |                                            |                                                      |
| Classify           |                                            |                                                      |
| Sequence           | Record changes: use language structures to communicate change over time, cause and effect. | At first, ____ but now _____. We saw that first ____ then ____ and finally _____. When I ____ it ____. After I ____ it _____. |
| Compare            |                                            |                                                      |
| Sequence           |                                            |                                                      |

### Notebook component—data organization

<table>
<thead>
<tr>
<th>Enumerate</th>
<th>Plot graphs: decide when and how to use bar graphs, line plots, and two-coordinate graphs to organize data.</th>
<th>Define x- and y-axes; provide axis labels, title, units, coordinates; use equal intervals, set origin = (0, 0).</th>
</tr>
</thead>
</table>
| Compare            | Use graphic organizers and narratives to express similarities and differences, to assign an object or action to the category or type to which it belongs, and to show sequencing and order. | This ____ is the same as ____ because ____. This ____ is different than ____ because ____. All these are ____ because ____. ____ ____ and ____ all have/are ____.
| Classify           |                                            |                                                      |
| Sequence           |                                            |                                                      |
| Analyze            | Use graphic organizers, narratives or concept maps to identify part/whole or cause-and-effect relationships. | Use relationship verbs such as contain, consist of. As ____ then ____ When I changed ____ then ____ happened. The more/less ____ then ____ |
Table 1 (continued)

<table>
<thead>
<tr>
<th>Language function</th>
<th>Language objectives for writing in notebooks</th>
<th>Language forms, structures, and scaffolds for writing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Notebook component—making sense of data</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infer, Explain</td>
<td>Provide claims and evidence: write assertions about what was learned from the investigation, use the data as evidence to support those claims.</td>
<td>Use inferential logical connectors such as although, while, thus, therefore. I claim that ____. I know this because _____.</td>
</tr>
<tr>
<td>Provide evidence</td>
<td>Use qualitative and quantitative data from the investigation as evidence to support claims.</td>
<td>Use qualitative descriptors such as more/less, longer/shorter, brighter/dimmer. Use quantitative expressions using standard metric units of measurement such as cm, mL, °C. My data show _____.</td>
</tr>
<tr>
<td>Summarize, Predict, Generalize</td>
<td>Write a summary narrative to communicate what was learned; ask questions and make predictions based on the newly acquired knowledge.</td>
<td>Answer the focus question by rewriting it as a statement and providing evidence from data. Make a concluding statement. I learned _____. Therefore, I think _____. I predict _____. because _____. A new question I have is _____.</td>
</tr>
<tr>
<td><strong>Notebook component—next-step strategies</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Critique, Evaluate</td>
<td>Reflect on experience: review notebook entries and revise, using line of learning or 3 Cs (correct in red, confirm in green, and complete in blue).</td>
<td>I used to think _____. but now I think _____. I have changed my thinking about _____. I am confused about _____. because _____. I wonder _____.</td>
</tr>
</tbody>
</table>
READING DOMAIN

Reading is an integral part of science learning. Just as scientists spend a significant amount of their time reading one another’s published works, students need to learn to read scientific text—to read effectively for understanding with a critical focus on the ideas being presented.

The articles in FOSS Science Resources help facilitate sense making as students make connections to the science concepts introduced and explored during the active investigations. Concept development is most effective when students are allowed to experience organisms, objects, and phenomena firsthand before engaging the concepts in text. The text and illustrations help students make connections between what they have experienced concretely and the abstract ideas that explain their observations.

FOSS Science Resources supports developing literacy skills by providing reading material that corresponds exactly to the concrete, personal experience provided in the active investigations. Students read with enthusiasm when they recognize familiar materials, organisms, and activities and are eager to tackle the reading to confirm their prior knowledge and discover more about the topic. In addition to making connections, once engaged, students naturally use other reading-comprehension strategies, such as asking questions, visualizing, inferring, and synthesizing, to help them understand the reading. As students apply these strategies, they are, in effect, using some of the same scientific thinking processes that promote critical thinking and problem solving.

Reading in the Primary Grades

In the kindergarten modules, you can enhance science learning by using trade books and other read-aloud resources to engage students and provide topics for lively discussions. Reading aloud helps primary students understand the science content and lets you model reading-comprehension strategies, such as asking yourself questions (thinking aloud) and summarizing a paragraph just read. The Reading in FOSS Science Resources sections (in every part that has a reading) usually offer suggestions for activating prior knowledge before reading, indicate places to pause and discuss key points during the reading, and describe activities to deepen understanding after the reading. As students develop their reading skills, you might try these different ways to read from FOSS Science Resources.
• Read aloud from the big book while students follow along in their own books.
• Lead students in small guided reading groups.
• Have students read aloud with a partner.
• Have students read silently on their own.

The same strategies used in language arts can be applied to reading in science. Begin with reading the article aloud so that students can hear the content read fluently and listen for meaning and coherence. Go back and review the questions within the article. Use think-pair-share or other discussion protocols to allow students to think first, share with a partner, and then respond to the group. Emphasize blending phonemes as you read the text again, and model tracking, connecting spoken words with written words, and helping students identify sight words. Model reading-comprehension strategies by using think-alouds (as you think aloud, you explain the process that you are using in order to understand the text while reading). The expository text structure also provides the opportunity for primary students to learn how to extract information from a table of contents, a glossary, an index, and other text conventions such as headings, subheads, boldface and italic print, labeled graphics, and captions.

At the end of articles, use the questions provided to guide understanding and to assess comprehension and vocabulary acquisition. Choose one or two questions for students to answer in their notebooks. Emphasize the importance of science vocabulary and the appropriate language forms and structures. Here are some ways students can enhance reading comprehension.

• Have students predict the sequence of events or content.
• Have students write or dictate questions about the text and illustrations.
• Use visualization with students to “see, touch, feel, smell, hear” in their minds the content presented in the article.
• Ask students to make connections to information in the article and their observations during the active investigation.
Reading in the Upper-Elementary Grades

As students progress from learning to read to reading to learn, they apply the strategies and skills of reading comprehension to learning about science in FOSS Science Resources and other texts. Writing becomes increasingly important in helping students make sense of the readings as well as the active investigations. Use the suggested questions in the Investigations Guide to support comprehension as students read from FOSS Science Resources. For most of the investigation parts, the articles are designed to follow the active investigation and are interspersed throughout the flow of the module. This allows students to acquire the necessary background knowledge through active experience before tackling the wider-ranging content and relationships presented in the text. Additional strategies for reading are derived from the seven essential strategies that readers use to help them understand what they read (Keene and Zimmermann 2007).

- Monitor for meaning: Discover when you know and when you don’t know.
- Use and create schemata: Make connections between the novel and the known; activate and apply background knowledge.
- Ask questions: Generate questions before, during, and after reading that reach for deeper engagement with the text.
- Determine importance: Decide what matters most, what is worth remembering.
- Infer: Combine background knowledge with information from the text to predict, conclude, make judgments, and interpret.
- Use sensory and emotional images: Create mental images to deepen and stretch meaning.
- Synthesize: Create an evolution of meaning by combining understanding with knowledge from other texts/sources.

Following are some strategies that enhance the reading of expository texts in general and have proven to be particularly helpful in science.

**Build on background knowledge.** Activating prior knowledge is critical for helping students make connections between what they already know and new information. Reading comprehension improves when students have the opportunity to think, discuss, and write about what they know about a topic before reading. Review what students learned from the active investigation, provide prompts for making connections, and ask questions to help students recall past experiences and previous exposure to concepts related to the reading.

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**Strategies for Reading in Upper-Elementary Grades**

- Build on background knowledge
- Create an anticipation guide
- Draw attention to vocabulary
- Preview the text
- Turn and talk
- Jigsaw text reading
- Note making
- Interactive reading aloud
- Summarize and synthesize
- 3-2-1
- Write reflections
- Preview and predict
- SQ3R
Create an anticipation guide. Create true-or-false statements related to the key ideas in the reading selection. Ask students to indicate if they agree or disagree with each statement before reading, then have them read the text, looking for the information that supports their true-or-false claims. Anticipation guides connect students to prior knowledge, engage them with the topic, and encourage them to explore their own thinking.

Draw attention to vocabulary. Check the article for bold words to determine if there are words students may not know. Review the science words that have already been listed on the word wall and in students’ notebooks. For new science and nonscience vocabulary words that appear in the reading, have students predict their meanings before reading. During the reading, have students use strategies such as context clues and word structure to see if their predictions were correct. This strategy activates prior knowledge and engages students by encouraging analytical participation with the text.

Preview the text. Give students time to skim through the selection, noting subheads, before reading thoroughly. Point out the particular structure of the text and what discourse markers to look for. For example, most FOSS Science Resources articles are written as cause and effect, problem and solution, question and answer, comparison and contrast, description, and sequence. Students will have an easier time making sense of the text if they know what to look for in terms of text structure. Model and have students practice analyzing these different types of expository text structures by looking for examples, patterns, and the discourse markers.

Point out how FOSS Science Resources text is organized (titles, headings, subheadings, questions, and summaries) and how to use the table of contents, glossary, and index. Explain how to scan for formatting features that provide key information (such as bold type and italics, captions, and framed text) and graphic features (such as tables, graphs, photographs, maps, diagrams, charts, and illustrations) that help clarify, elaborate, and explain important information in the reading.

While students preview the article, have them focus on the questions that appear in the text, as well as questions at the end of the article. Encourage students to write down questions they have that they think the reading will answer.

**NOTE**

Discourse markers are words or phrases that relate one idea to another. Examples are “however,” “on the other hand,” and “second.”
**Turn and talk.** When reading as a whole class, stop at key points and have students share their thinking about the selection with the student sitting next to them or in their collaborative group. This strategy helps students process the information and allows everyone to participate in the discussion. When reading in pairs, encourage students to stop and discuss with their partners. One way to encourage engagement and understanding during paired reading is to have students take turns reading aloud a paragraph or section on a certain topic. The one who is listening then summarizes the meaning conveyed in the passage.

**Jigsaw text reading.** Students work together in small groups (expert teams) to develop a collective understanding of a text. Each expert team is responsible for one portion of the assigned text. The teams read and discuss their portions to gain a solid understanding of the key concepts. They might use graphic organizers to refine and organize the information. Each expert team then presents its piece to the rest of the class. Or new, small jigsaw groups can be formed that consist of at least one representative from each expert team. Each student shares with the jigsaw group what their team learned from their particular portion of the text. Together, the participants in the jigsaw group fit their individual pieces together to create a complete picture of the content in the article.

**Note making.** The more interactive that students make a reading, the better for their understanding. Encourage students to become active readers by asking them to make notes as they read. Studies have shown that note making—especially paraphrasing and summarizing—is one of the most effective means for understanding text (Graham and Herbert 2010; Applebee 1984).

Students can annotate the text by writing thoughts and questions on self-stick notes. Using symbols or codes can help facilitate comprehension monitoring. Here are some possible symbols (Harvey 1998).

- * interesting
- BK background knowledge
- ? question
- C confusing
- I important
- L learning something new
- W wondering
- S surprising
Science-Centered Language Development

Students can use a set of symbols while making notes about connections. The readings in FOSS Science Resources incorporate the active learning that students gain from the investigations so that they can make authentic text-to-self (T-S) connections. In other words, what they read reminds them of firsthand experiences, making the article more engaging and easier to understand. Text-to-text (T-T) connections are notes students make when they discover a new idea that reminds them of something they’ve read previously in another text. Text-to-world (T-W) connections involve the text and more global everyday connections to students’ lives.

You can model note-making strategies by displaying a selection of text, using a projection system, a document camera, or an interactive whiteboard. As you read the text aloud, model how to write comments on self-stick notes, and use a graphic organizer in a notebook to enhance understanding.

Graphic organizers help students focus on extracting the important information from the reading and analyzing relationships between concepts. This can be done by simply having students make columns in their notebooks to record information and their thinking (Harvey and Goudvis 2007). Here are two examples of graphic organizers.
Interactive reading aloud. Reading aloud is an effective strategy for enhancing text comprehension. It offers opportunities to model specific reading-comprehension strategies and allows students to concentrate on making sense of the content. When modeling, share the thinking processes used to understand the reading (questioning, visualizing, comparing, inferring, summarizing, etc.), then have students share what they observed you thinking about as an active reader.

Summarize and synthesize. Model how to pick out the important parts of the reading selection. Paraphrasing is one way to summarize. Have students record summaries of the reading, using their own words. To scaffold the learning, use graphic organizers to compare and contrast, group, sequence, and show cause and effect. Another method is to have students make two columns in their notebooks. In one column, they record what is important, and in the other they record their personal responses (what the reading makes them think about). When writing summaries, tell students,

- Pick out the important ideas.
- Restate the main ideas in your own words.
- Keep it brief.

3-2-1. This strategy gives students the opportunity to synthesize information and formulate questions they still have regarding the concepts covered in an article. In their notebooks, students write three new things they learned, two interesting things worth remembering and sharing, and one question that occurred to them while reading the article. Other options might include three facts, two interesting ideas, and one insight about themselves as learners; three key words, two new ideas, and one thing to think about (modified from Black Hills Special Service Cooperative 2006).

Write reflections. After reading, ask students to review their notes in their notebooks to make any additions, revisions, or corrections to what they recorded during the reading. This review can be facilitated by using a line of learning. Students draw a line under their original conclusion or under their answer to a question posed at the end of an article. They then add any new information as a new narrative entry. The line of learning indicates that what follows represents a change of thinking.
**Preview and predict.** Instruct students to independently preview the article, directing attention to the illustrations, photos, boldfaced words, captions, and anything else that draws their attention. Working with a partner, students discuss and write three things they think they will learn from the article. Have partners verbally share their list with another pair of students. The group of four can collaborate to generate one list. Teams report their ideas, and together you create a class list on chart paper.

Read the article aloud, or have students read with a partner aloud or silently. Referring to the preview/prediction list, discuss what students learned. Have them record the most important thing they learned from the reading for comparison with the predictions.

**SQ3R.** Survey! Question! Read! Recite! Review! provides an overall structure for before, during, and after reading. Students begin by previewing the text, looking for features that will help them make predictions about content. Based on their surveys, students develop questions to answer as they read. Students then read the selection. They recite by telling a partner what they’ve learned (their partner listens carefully to their recitation, making sure they haven’t missed any important concepts) and answering any questions their partner might have. Finally, they review their questions and answers. There is value in asking students to make their entire SQ3R process explicit.

Use this script as an outline, using appropriate wording where necessary.

**Survey! Question!**

a. Before you read, survey (preview) the reading selection.

b. As you survey, think of questions that the reading might answer while you read the title, headings, and subheadings.

c. Read the questions at the end of the article.

d. Ask yourself, “What did my teacher say about this selection when it was assigned?”

e. Ask yourself, “What do I already know about this subject from experiments or discussions we’ve had in class?”
Read!

a. While reading, look for answers to the questions you raised.
b. Think about answers for the questions at the end of the article.
c. Study graphics, such as pictures, graphs, and tables.
d. Reread captions associated with pictures, graphs, and tables.
e. Note all italicized and boldfaced words or phrases.
f. Reduce your reading speed for difficult passages.
g. Stop and reread parts that are not clear.
h. Read only a section at a time, and recite after each section.

Recite!

a. After you’ve read a section, make notes in your science notebook by writing information in your own words.
b. Underline or highlight important notes in your science notebook.
c. Use the method of recitation that best suits your particular learning style. Remember that the more senses you use, the more likely you are to remember what you read. Seeing, saying, hearing, and writing will all enhance learning.
d. Ask questions aloud about what you just read, and summarize aloud, in your own words, what you read.
e. Listen attentively as your partner recites.

Review!

Reviewing should be ongoing. With the whole class, review the entire process, calling on groups to talk to the class about what they’ve learned.

Struggling Readers

For students reading below grade level, the strategies listed above can be modified to support reading comprehension by integrating strategies from the Reading in the Primary Grades section, such as read-alouds and guided reading. Students can also follow along with the audio stories on FOSSweb. Breaking the reading down into smaller chunks, providing graphic organizers, and modeling reading-comprehension strategies can also help students who may be struggling with the text. For additional strategies for English learners, see the supported-reading strategy in the English-Language Development section of this chapter.
Words play two critically important functions in science. First and most important, we play with ideas in our minds, using words. We present ourselves with propositions—possibilities, questions, potential relationships, implications for action, and so on. The process of sorting out these thoughts involves a lot of internal conversation, internal argument, weighing of options, and complex linguistic decisions. Once our minds are made up, communicating that decision, conclusion, or explanation in writing or through verbal discourse requires the same command of the vocabulary. Words represent intelligence; acquiring the precise vocabulary and the associated meanings is key to successful scientific thinking and communication.

The words introduced in FOSS investigations represent or relate to fundamental science concepts and should be taught in the context of the investigation. Many of the terms are abstract and are critical to developing science content knowledge and scientific and engineering practices. The goal is for students to use science vocabulary in ways that demonstrate understanding of the concepts the words represent—not to merely recite scripted definitions. The most effective science-vocabulary development strategies help students make connections to what they already know. These strategies focus on giving new words conceptual meaning through experience; distinguishing between informal, everyday language and academic language; and using the words in meaningful contexts.

**Building Conceptual Meaning through Experience**

In most instances, students should be presented with new words in the context of the active experience at the need-to-know point in the investigation. Words such as flexible, magnetic, viscous, silt, erode, and electricity are conceptually loaded and significantly abstract. Students will have a much better chance of understanding, assimilating, and remembering the new word (or new meaning) if they can connect it with a concrete experience.
The new-word icon appears in the sidebar when you introduce a word that is critical to understanding the concepts or scientific practices students will be learning and applying in the investigation. When you introduce a new word, students should

- Hear it: Students listen as you model the correct contextual use and pronunciation of the word.

- See it: Students see the new word written out. Add a visual reference (an illustration or a sample) next to the word if possible.

- Say it: Have primary-grade students repeat the word chorally and clap out the syllables.

- Write it: You write the word on the board, chart paper, sentence strip, or card. Students use the new words in context when they write in their notebooks.

- Act it: Demonstrate action words such as separate, compare, and observe (using total physical response).

Bridging Informal Language to Science Vocabulary

Students bring a wealth of language experience to the classroom. FOSS investigations are designed to tap into students’ inquisitive natures and their excitement of discovery in order to encourage lively discussions as they explore materials in creative ways. There should be a lot of talking during science time! Your role is to help students connect informal language to the vocabulary used to express specific science concepts. As you circulate during active investigation, you continually model the use of science vocabulary. For example, when a student holds up a bottle of water and says, “I can see through it!” you might respond, “Yes, I see what you mean; the liquid in the bottle is transparent.” Following are some strategies for validating students’ conversational language while developing their familiarity with and appreciation for science vocabulary.

**Word bubbles.** Choose a word from the word wall that is widely used by students and that is a synonym for a science vocabulary word. Draw a circle on the board or chart paper, and write the word in the center. Draw lines out from the circled word, and make more circles. Ask students to call out more synonyms for the word, and write them in the outer circles. Introduce the target vocabulary word as yet one more synonym for the target word, a word that is used in science. Highlight the word, and model its correct usage and pronunciation. Encourage students to use it in their discussions and in their notebook entries. Introduce the science word that is its opposite, when appropriate.
**Word sorts.** Make a set of word cards from words on the word wall. Ask students to help you group the words that are synonyms or that have conceptual connections. Add the new science words to the card set. Repeat the process with a new set of words. For upper-elementary students, make sets of vocabulary cards for students to sort in small groups.

**Semantic webs.** Select a vocabulary word, and write it in the center of a piece of paper (or on the board if doing this with the whole class). Brainstorm a list of words or ideas that are related to the first word. Group the words and concepts into several categories, and attach them to the central word with lines, forming a web (modified from Hamilton 2002).

**Concept maps.** Select six to ten related science words. Have students write them on self-stick notes or cards. Have small groups discuss how the words/concepts are related. Students organize words in groups and glue them down or copy them onto a sheet of paper. Students draw lines between the related words. On the lines, they write words describing or explaining how the concept words are related.

**Cognitive content dictionaries.** There are many variations of frameworks to help students record new words. This example can be used with the whole class with primary students or individually with upper-elementary students to introduce a few key vocabulary words used in an investigation. Have students write the word, predict its meaning, write the final meaning after class discussion (using primary language or an illustration when appropriate), and then use the word in a sentence. The word can then be used as a signal word to call for attention.

<table>
<thead>
<tr>
<th>Cognitive Content Dictionary</th>
</tr>
</thead>
<tbody>
<tr>
<td>New word</td>
</tr>
<tr>
<td>Prediction (clues)</td>
</tr>
<tr>
<td>Final meaning (e.g., primary language, pictures)</td>
</tr>
<tr>
<td>How I would use it (sentence)</td>
</tr>
</tbody>
</table>

**Word associations.** In this brainstorming activity, you say a word, and students respond by writing the first word that comes to mind. Then students share their words with the class. This activity builds connections to students’ prior frames of reference.
Using Science Vocabulary in Context

In order for a new vocabulary word to become part of a student’s functional vocabulary, he or she must have ample opportunities to hear and use it. The use of vocabulary terms is embedded in the activities through teacher talk, whole-class and small-group discussions during investigations, writing in science notebooks, readings, assessments, and games. In addition, other methods used during language-arts instruction can be used to reinforce important vocabulary words and phrases.

Word wall/word cards. Use chart paper or a pocket chart to record both science content and procedural words. Record the words as they come up during and after the investigations. Then copy key words on sentence strips or cards, and put them in a pocket chart. With a pocket chart, words can be sorted and moved around easily. For example, you could ask students to find words that are synonyms, antonyms, nouns, or verbs. Word cards should be available to each group during the investigation. This allows students to retrieve a word quickly when they are labeling diagrams and objects used during the investigation.

Drawings and diagrams. For English learners and visual learners, a diagram can be used to review and explain abstract content. Ahead of time, draw an illustration lightly, almost invisibly, with pencil on chart paper. When it’s time for the investigation, trace the illustration with markers as you introduce the words and phrases to students. Students will be amazed by your artistic ability.

Cloze activities. Structure a sentence for students to complete, leaving out the vocabulary word, and crafting the sentence so that the missing vocabulary word is the last word in the sentence. You can do this chorally with primary students or in writing on the board or chart paper for upper-elementary students. Here’s an example from the Solids and Liquids Module.

Teacher: Liquids that are clear and that you can see through are ______.

Students: Transparent.

Science Vocabulary Strategies

- Word wall/word cards
- Drawings and diagrams
- Cloze activities
- Word wizard
- Word analysis/word parts
- Breaking apart words
- Possible sentences
- Reading
- Highlighting the vocabulary
- Index
- Poems, chants, and songs
- Games
**Word wizard.** Tell students that you are going to lead a word activity. You will be thinking of a science vocabulary word from the word wall. The goal is to figure out the word. Provide hints that have to do with parts of a definition, root word, prefix, suffix, and other relevant components. Students work in teams of two to four. Provide one hint, and give teams 1 minute to discuss. One team member writes the word on a piece of paper or on the whiteboard, using dark marking pens. Each team holds up its word for only you to see. After the third clue, reveal the word, and move on to the next word.

1. This word is part of a plant.
2. It is usually not green.
3. It brings water and nutrients into the plant.

   It is the root.

**Word analysis/word parts.** Learning clusters of words that share a common origin can help students understand content-area texts and connect new words to familiar ones. This type of contextualized teaching meets the immediate need of understanding an unknown word while building generative knowledge that supports students in figuring out difficult words for future reading.

- geology
- geologist
- geological
- geography
- geometry
- geophysical

**Breaking apart words.** Have teams of two to four students break the word into prefix, root word, and suffix. Give each team different words, and have each team share the parsed elements of the word with the whole class.

- **electromagnetism**
  - electro: having to do with electricity
  - magnet: having polar properties; attraction and repulsion of opposite and similar poles
  - ism: relating to a theory of how things behave
Possible sentences. Here is a simple strategy for teaching word meanings and generating class discussion.

1. Choose six to eight key concept words from the text of an article in FOSS Science Resources.
2. Choose four to six additional words that students are more likely to know something about.
3. Put the list of 10–14 words on the board or project it. Provide brief definitions as needed.
4. Ask students to devise sentences that include two or more words from the list.
5. On chart paper, write all sentences that students generate, both coherent and otherwise.
6. Have students read the article from which the words were extracted.
7. Revisit students’ sentences, and discuss whether the sentences are sensible based on the passage or how they could be modified to be more coherent.

Reading. After the active investigation, students continue to develop their understanding of the vocabulary words and the concepts those words represent by listening to you read aloud, reading with a partner, or reading independently. Use strategies discussed in the Reading Domain section to encourage students to articulate their thoughts and practice the new vocabulary.

Highlighting the vocabulary. Emphasize the vocabulary words students should be using when they answer the focus question in their science notebooks. Distribute copies of the vocabulary/glossary for the investigation (available on FOSSweb) for students to glue into their notebooks. As you introduce the words in the investigation, students highlight them.

Index. Have students create an index at the back of their notebooks. There, they can record new vocabulary words and the notebook page where they defined and used the new words for the first time in the context of the investigation.

Poems, chants, and songs. Vocabulary words and phrases can be reinforced using content-rich poems, rhymes, chants, and songs.

Games. The informal activities included in the investigations are designed to reinforce important vocabulary words. Once students learn them, the words can be integrated into any type of independent work time, such as centers, workshops, and early-finisher tasks.

Science-Centered Language Development
Active investigations, together with ample opportunities to develop and use language, provide an optimal learning environment for English learners. This section highlights the English-language development (ELD) opportunities inherent in FOSS investigations and suggests other best practices for facilitating both the learning of new science concepts and the development of academic vocabulary and language structures that enhance literacy. For example, the hands–on structure of FOSS investigations is essential for the conceptual development of science content knowledge and the habits of mind that guide and define scientific practices. Students are engaged in concrete experiences that are meaningful and that provide a shared context for developing understanding—critical components for ELD instruction.

To further address the needs of English learners, the Investigations Guide includes EL Notes at points in the investigations where students at beginning levels of English proficiency may need additional support. When getting ready for an investigation, review the EL Notes, and determine the points where English learners may require scaffolds and where the whole class might benefit from additional language-development supports. One way to plan for ELD integration in science is to keep in mind four key areas: prior knowledge, comprehensible input, academic language development, and oral practice. The ELD chart below lists examples of universal strategies for each of these components that work particularly well in teaching science.

<table>
<thead>
<tr>
<th>English-Language Development (ELD) Quadrants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activating prior knowledge</td>
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<tr>
<td>• Inquiry chart</td>
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<tr>
<td>• Circle map</td>
</tr>
<tr>
<td>• Observation poster</td>
</tr>
<tr>
<td>• Quick write</td>
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<tr>
<td>• Kit inventory</td>
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<tr>
<td>Using comprehensible input</td>
</tr>
<tr>
<td>• Content objectives</td>
</tr>
<tr>
<td>• Multiple exposures</td>
</tr>
<tr>
<td>• Visual aids</td>
</tr>
<tr>
<td>• Supported reading</td>
</tr>
<tr>
<td>• Procedural vocabulary</td>
</tr>
<tr>
<td>Developing academic language</td>
</tr>
<tr>
<td>• Language objectives</td>
</tr>
<tr>
<td>• Sentence frames</td>
</tr>
<tr>
<td>• Word wall, word cards, drawings</td>
</tr>
<tr>
<td>• Concept maps</td>
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<tr>
<td>• Cognitive content dictionaries</td>
</tr>
<tr>
<td>Providing oral practice</td>
</tr>
<tr>
<td>• Small-group discussions</td>
</tr>
<tr>
<td>• Science talk</td>
</tr>
<tr>
<td>• Oral presentations</td>
</tr>
<tr>
<td>• Poems, chants, and songs</td>
</tr>
<tr>
<td>• Teacher feedback</td>
</tr>
</tbody>
</table>

**NOTE**

English-language development refers to the advancement of students’ ability to read, write, and speak English.

**EL NOTE**

Look for EL Notes in the investigations at points where students at beginning levels of English proficiency may need additional support.
**Activating Prior Knowledge**

When an investigation engages a new concept, first students recall and discuss familiar situations, objects, or experiences that relate to and establish a foundation for building new knowledge and conceptual understanding. Eliciting prior knowledge also supports learning by motivating interest, acknowledging culture and values, and checking for misconceptions and prerequisite knowledge. This is usually done in the first steps of Guiding the Investigation in the form of an oral discussion, presentation of new materials, or a written response to a prompt. The tools outlined below can also be used before beginning an investigation to establish a familiar context for launching into new material.

**Circle maps.** Draw two concentric circles on chart paper. In the middle circle, write the topic to be explored. In the second circle, record what students already know about the subject. Ask students to think about how they know or learned what they already know about the topic. Record the responses outside the circles. Students can also do this independently in their science notebooks.

An example of a circle map

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**Strategies for Activating Prior Knowledge**

- Circle maps
- Observation posters
- Quick writes
- Kit inventories
**Observation posters.** Make observation posters by gluing or taping pictures and artifacts relevant to the module or a particular investigation onto pieces of blank chart paper or poster paper. Hang them on the walls in the classroom, and have students rotate in small groups to each poster. At each station, students discuss their observations with their partners or small groups and then record (write, draw, or dictate) an observation, a question, a prediction, or an inference about the pictures as a contribution to the commentary on the poster.

![An observation poster](image)

**Quick writes.** Ask students what they think they know about the topic of the investigation. Responses can be recorded independently as a quick write in science notebooks and then shared collaboratively. You should not correct misconceptions initially. Periodically revisit the quick-write ideas as a whole class, or have students review their notebook entries to correct, confirm, or complete their original thoughts as new information is acquired (possibly using a line of learning). At the conclusion of the investigation, students should be able to express mastery of the new conceptual material.

**Kit inventories.** Introduce each item from the FOSS kit used in the investigation, and ask students questions to get them thinking about what each item is and where they may have seen it before. Have them describe the objects and make predictions about how they will be used in the investigation. Tape samples of the items on chart paper, or print and display the equipment photo cards (download from FOSSweb) along with the name and a description, to serve as an interactive word wall.
Comprehensible Input

In order to initiate their own sense-making process, students must be able to access the information presented to them. We refer to this ability as comprehensible input. Students must understand the essence of new ideas and concepts before beginning the process of constructing new scientific meaning. The strategies for comprehensible input used in FOSS ensure that the delivery of instruction is understandable while providing students with the opportunity to grapple with new ideas and the critically important relationships between concepts. Additional tools such as repetition, visual aids, emphasis on procedural vocabulary, and auditory reinforcement can also be used to enhance comprehensible input for English learners.

Content objectives. The focus question for each investigation part frames the activity objectives—what students should know or be able to do at the end of the part. Making the learning objectives clear and explicit helps English learners prepare to process the delivery of new information, and helps you maintain the focus of the investigation. Write the focus question on the board, have students read it aloud and transcribe it into their science notebooks, and have students answer the focus question at the end of the investigation part. You then check their responses for understanding.

A kit inventory script from the Solids and Liquids Module

<table>
<thead>
<tr>
<th>Item</th>
<th>Teacher</th>
<th>Student</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bottle</td>
<td>What is this?</td>
<td>A bottle.</td>
</tr>
<tr>
<td></td>
<td>What is it made of?</td>
<td>Plastic.</td>
</tr>
<tr>
<td></td>
<td>What is it used for?</td>
<td>To hold liquids.</td>
</tr>
<tr>
<td>Scoop</td>
<td>What is this?</td>
<td>It looks like a spoon.</td>
</tr>
<tr>
<td></td>
<td>It’s like a spoon. It’s called a scoop.</td>
<td>Like an ice-cream scoop!</td>
</tr>
<tr>
<td></td>
<td>What do you think we will be using it for in science?</td>
<td>To scoop things up.</td>
</tr>
<tr>
<td>Funnel</td>
<td>Have you seen this before?</td>
<td>My mom uses that for the car.</td>
</tr>
<tr>
<td></td>
<td>It’s called a funnel. Where else have you seen this?</td>
<td>In the kitchen. My uncle uses it sometimes to pour things.</td>
</tr>
<tr>
<td></td>
<td>Can you describe it?</td>
<td>It’s round on the ends. It’s bigger on one end, and it’s hollow.</td>
</tr>
<tr>
<td>Beaker</td>
<td>Have you seen this before?</td>
<td>We used it for science last year to measure and pour water.</td>
</tr>
<tr>
<td></td>
<td>It’s called a beaker. Where else have you seen this?</td>
<td></td>
</tr>
<tr>
<td>Vial</td>
<td>This is a vial. What do you think we will be using it for in science?</td>
<td>To hold small things.</td>
</tr>
</tbody>
</table>

Strategies for Comprehensible Input

- Content objectives
- Multiple exposures
- Visual aids
- Supported reading
- Procedural vocabulary
Multiple exposures. Repeat the activity as a class, at a center during independent work time, or in an analogous but slightly different context, ideally one that incorporates elements that are culturally relevant to students.

Visual aids. On the board or chart paper, write out the steps for conducting the investigation. This will provide a visual reference. Include illustrations if necessary. Use graphic representations (illustrations drawn and labeled in front of students) to review the concepts explored in the active investigations. In addition to the concrete objects included in the kit, use realia to augment the activity to help English learners build understanding and make cultural connections. Graphic organizers (webs, Venn diagrams, T-tables, flowcharts, etc.) aid comprehension by helping students see how ideas (concepts) are related.

Supported reading. In addition to the reading comprehension strategies suggested in the Reading Domain section of this chapter, English learners can also benefit from methods such as front-loading key words, phrases, and complex text structures before reading; using preview–review (main ideas are previewed in the primary language, read in English, and reviewed in the primary language); and having students use sentence frames specifically tailored to record key information and/or graphic organizers that make the content and the relationship between concepts visually explicit from the text as they read.

Procedural vocabulary. Make sure students understand the meaning of the words used in the directions describing what they should be doing during the investigation. These may or may not be science-specific words. Use techniques such as modeling, demonstrating, and body language (gestures) to explain procedural meaning in the context of the investigation. The words students will encounter in FOSS include those listed in the sidebar. To build academic literacy, English learners need to learn the multiple meanings of these words and their specific meanings in the context of science.

Developing Academic Language
As students learn the nuances of the English language, it is critical that they build proficiency in academic language in order to participate fully in the cognitive demands of school. Academic language refers to the more abstract, complex, and specific aspects of language, such as the words, grammatical structure, and discourse markers that are needed for higher cognitive learning. FOSS investigations introduce and provide opportunities for students to practice using the academic vocabulary needed to access and meaningfully engage with science ideas.
**Language objectives.** Consider the language needs of English learners and incorporate specific language-development objectives that will support learning the science content of the investigation, such as a specific word knowledge skill (a way to expand use of vocabulary by looking at root words, prefixes, and suffixes), a linguistic pattern or structure for oral discussion and writing, or a reading-comprehension strategy. Recording in students’ science notebooks is a productive place to optimize science learning and language objectives. For example, in the *Pebbles, Sand, and Silt Module*, one language objective might be “Students will describe what happened when they rubbed their rocks together (think-pair-share) and answer the focus question in their notebooks, using a cause–and–effect sentence frame.”

**Vocabulary development.** The Science-Vocabulary Development section in this chapter describes the ways science vocabulary is introduced and developed in the context of an active investigation and suggests methods and strategies that can be used to support vocabulary development during instruction in English language arts and ELD. In addition to science vocabulary, students also need to learn the nonspecific-content words that facilitate deeper understanding and communication skills. Words such as *release, convert, beneficial, produce, receive, source*, and *reflect* are words used in the investigations and *FOSS Science Resources* and are frequently used in other content areas. Learning these academic vocabulary words gives students a more precise and complex way of practicing and communicating productive thinking. Consider using the strategies described in the Science-Vocabulary Development section to explicitly teach targeted, high-leverage words that can be used in multiple ways and that can help students make connections to other words and concepts. Sentence frames, word wall, concept maps, and cognitive content dictionary are strategies that have been found to be effective with academic-vocabulary development.
REFERENCES


