INTRODUCTION

The Solids and Liquids Module provides experiences that heighten primary students’ awareness, curiosity, and understanding of the physical world and provides opportunities for young students to engage in scientific and engineering practices. Matter with which we interact exists in three fundamental states: solid, liquid, and gas. In this module, students will

- Investigate and sort objects based on their properties.
- Observe, describe, and compare the properties and behaviors of solids and liquids. Record observations with pictures, numbers, and words.
- Recognize the properties of solid materials that make them appropriate for tower construction; build towers.
- Combine and separate solid materials of different particle sizes using tools.
- Observe, describe, and record what happens when solids and water are mixed and when liquids and water are mixed.
- Use knowledge to conduct an investigation on an unknown material (toothpaste).
- Observe and describe changes when solids and liquids are heated and cooled.
<table>
<thead>
<tr>
<th>Module Summary</th>
<th>Focus Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inv. 1: Solids</strong></td>
<td>Students explore solid objects, such as pieces of wood, plastic, and metal. Students observe, describe, and sort the objects according to their properties. They construct towers (and other structures), using the properties inherent in the materials to accomplish the task. Students discover solid objects in the schoolyard environment, and sort the found objects into natural and human-made.</td>
</tr>
<tr>
<td><strong>Inv. 2: Liquids</strong></td>
<td>Students investigate liquids in a variety of settings to become familiar with their properties. They rehearse precise liquids vocabulary, using liquid-properties cards. Students use representational materials to enhance their understanding of the unique behaviors of liquids. Students explore the properties of water puddles in the schoolyard.</td>
</tr>
<tr>
<td><strong>Inv. 3: Bits and Pieces</strong></td>
<td>Students work with beans, rice, and cornmeal to find out how solids behave when the pieces are small. Students shake, rattle, and roll the materials in bottles, pour them from container to container, and separate them by using screens. Students go outdoors to find particulate solid materials. Students observe the particles when poured on a flat surface and compare the particles to water on the same surface.</td>
</tr>
<tr>
<td><strong>Inv. 4: Solids, Liquids, and Water</strong></td>
<td>Students investigate interactions between solids and water and liquids and water. They observe, describe, record, and organize the results. Students test toothpaste to determine if it is a solid or a liquid. They investigate melting and freezing of familiar liquids. Students collect solid materials outdoors and mix them with water. Students look for changes in the color and clarity of the water as evidence that something mixed with the water.</td>
</tr>
<tr>
<td>Content</td>
<td>Reading</td>
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</tbody>
</table>
| Solid is one state or phase of matter. | Science Resources Book  
“Everything Matters”  
“Solid Objects and Materials”  
“Towers” | Embedded Assessment  
Science notebook entries  
Teacher observations  
Scientific practices  
Benchmark Assessment  
Investigation 1 I-Check |
| Objects are described and identified by their properties. |  |  |
| Objects are made of one or more materials. |  |  |
| Natural and human-made objects occur outdoors. |  |  |

<table>
<thead>
<tr>
<th>Content</th>
<th>Reading</th>
<th>Assessment</th>
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</table>
| Liquid is one common state of matter. | Science Resources Book  
“Liquids” | Embedded Assessment  
Science notebook entries  
Teacher observation  
Benchmark Assessment  
Investigation 2 I-Check |
| Liquids move freely in containers. |  |  |
| Liquids have many properties that help identify them. |  |  |
| Liquids take the shape of their containers. |  |  |
| The surfaces of liquids are flat and level. |  |  |
| Liquids pour and flow. |  |  |

<table>
<thead>
<tr>
<th>Content</th>
<th>Reading</th>
<th>Assessment</th>
</tr>
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</table>
| Solid materials can occur as masses of small particles. | Science Resources Book  
“Pouring”  
“Comparing Solids and Liquids” | Embedded Assessment  
Science notebook entries  
Teacher observation  
Scientific practices  
Benchmark Assessment  
Investigation 3 I-Check |
| A mass of particulate matter can form piles and support a denser object on its surface. |  |  |
| Particulate solids can be separated by size (with screens). |  |  |
| Masses of particulate matter can pour. |  |  |
| The surface of a mass of particles is not flat and level. |  |  |
| Particulate matter occurs naturally in the outdoors. |  |  |

<table>
<thead>
<tr>
<th>Content</th>
<th>Reading</th>
<th>Assessment</th>
</tr>
</thead>
</table>
| Some solids change when mixed with water; others do not. | Science Resources Book  
“Mix It Up!”  
“Heating and Cooling” | Embedded Assessment  
Science notebook entries  
Teacher observation  
Scientific practices  
Benchmark Assessment  
Investigation 4 I-Check |
| Some solids dissolve in water. |  |  |
| Water can be separated from a mixture through evaporation; evaporation leaves the solid behind. |  |  |
| Some liquids mix with water; others form layers. |  |  |
| Some materials have properties of both solids and liquids. |  |  |
| Melting is the change from solid to liquid. |  |  |
| Freezing is the change from liquid to solid. |  |  |
| Heat causes materials to melt; cold causes them to freeze. |  |  |
FOSS CONCEPTUAL FRAMEWORK

In the last half decade, teaching and learning research has focused on learning progressions. The idea behind a learning progression is that core ideas in science are complex and wide-reaching, requiring years to develop fully—ideas such as the structure of matter or the relationship between the structure and function of organisms. From the age of awareness throughout life, matter and organisms are important to us. There are things we can and should understand about them in our primary school years, and progressively more complex and sophisticated things we should know about them as we gain experience and develop our cognitive abilities. When we can determine those logical progressions, we can develop meaningful and effective curriculum.

FOSS has elaborated learning progressions for core ideas in science for kindergarten through grade 8. Developing a learning progression involves identifying successively more sophisticated ways of thinking about a core idea over multiple years. “If mastery of a core idea in a science discipline is the ultimate educational destination, then well-designed learning progressions provide a map of the routes that can be taken to reach that destination” (National Research Council, A Framework for K–12 Science Education, 2012).

The FOSS modules are organized into three domains: physical science, earth science, and life science. Each domain is divided into two strands, as shown in the table below for the FOSS Elementary Program. Each strand represents a core idea in science and has a conceptual framework.

- matter; energy and change
- dynamic atmosphere; rocks and landforms
- structure and function; complex systems.

The sequence in each strand relates to the core ideas described in the national framework. Modules at the bottom of the table form the foundation in the primary grades. The core ideas develop in complexity as you proceed up the columns.

The FOSS learning progression information is displayed in several places: (1) the module conceptual framework (see page 7) represents the structure of scientific knowledge taught and assessed in a single module, and (2) the content sequence (pages 8–9) is a graphic and narrative description placing the single module into a K–8 strand content or learning progression.
In addition to the science content development, every module provides opportunities for students to engage in and understand the importance of scientific practices, and many modules explore issues related to engineering practices and the use of natural resources.

**Asking questions and defining problems**
- Ask questions about objects, organisms, systems, and events in the natural and human-made world (science).
- Ask questions to define and clarify a problem, determine criteria for solutions, and identify constraints (engineering).

**Planning and carrying out investigations**
- Plan and conduct investigations in the laboratory and in the field to gather appropriate data (describe procedures, determine observations to record, decide which variables to control) or to gather data essential for specifying and testing engineering designs.

**Analyzing and interpreting data**
- Use a range of media (numbers, words, tables, graphs, images, diagrams, equations) to represent and organize observations (data) in order to identify significant features and patterns.

**Developing and using models**
- Use models to help develop explanations, make predictions, and analyze existing systems, and recognize strengths and limitations of proposed solutions to problems.

**Using mathematics and computational thinking**
- Use mathematics and computation to represent physical variables and their relationships and to draw conclusions.

**Constructing explanations and designing solutions**
- Construct logical explanations of phenomena, or propose solutions that incorporate current understanding or a model that represents it and is consistent with available evidence.

**Engaging in argument from evidence**
- Defend explanations, develop evidence based on data, examine one’s own understanding in light of the evidence offered by others, and challenge peers while searching for explanations.

**Obtaining, evaluating, and communicating information**
- Communicate ideas and the results of inquiry—orally and in writing—with tables, diagrams, graphs, and equations—in collaboration with peers.

*Conceptual Framework*
BACKGROUND FOR THE CONCEPTUAL FRAMEWORK
in Solids and Liquids

Everything that we know of in the universe is either matter or energy. Matter is the stuff from which tangible objects such as people, pencils, mountains, and oceans are made. Energy is the glue and drive that holds things together and moves them around. This module introduces primary students to fundamental ideas about matter.

Matter that we are likely to encounter in a typical day will be in one of three basic states: solid, liquid, or gas. Each state of matter has a precise molecular definition, but we are not interested in that in this module. Descriptive definitions at the macroscopic level serve our purposes much better.

Objects such as bricks, T-shirts, heads of lettuce, coins, baseball caps, and apples are solids. Solid objects have definite shape, and the shape does not change when the object moves from one place to another. When solids move from one container to another, they maintain the same shape they had before they moved.

Liquids, such as water, milk, gasoline, cooking oil, dishwashing detergent, molasses, and paint thinner, flow and pour. Liquids have no shape of their own, but they do have constant volume, so they can be kept in containers, either opened or closed. A liquid poured on a table will spread out to form a shapeless film. Liquids poured into containers take the shape of the container and fill it to a level. The surface of a liquid in a container is flat and parallel to the plane of the surface of Earth.

Gases, such as air, oxygen, helium, carbon dioxide, and methane, have no shape and no constant volume. They expand and contract readily, so they must be kept in closed containers. Gases expand to fill all the space in a container. Primary students will explore gases in more depth in the Air and Weather Module.

Solid materials composed of very small particles, such as sand, cornmeal, rice, sugar, and salt, have some of the characteristics of liquids. Granular or powdered materials pour and spill, and they appear to fill containers to a level. Unlike liquids, however, powders do not form flat surfaces, and they can be made into piles and pushed into shapes.

Some materials, such as peanut butter, hair-styling mousse, toothpaste, and jelly, are composed of solids and liquids. These materials can be perplexing to students because the materials have some of the properties of solids and some of the properties of liquids. Students sometimes solve this quandary by describing a new state of matter—gel.
Interactions between solids, between liquids, and between solids and liquids produce a variety of results. Solids often don’t interact in any more provocative way than to make mixtures and layers. Mixtures of solids can be separated into their components, although separating them is sometimes a challenge.

Mixtures of liquids are often interesting. Liquids might intermix completely, producing diluted solutions, or they might react to produce new products, such as solids, gases, or a product with a color change. Liquids that don’t mix, such as oil and water, form layers.

When solids and liquids interact, all the results mentioned above are possible, plus others. Solids might float or sink in the liquid. The solid might soak up the liquid. The solid, or part of the solid, might dissolve in the liquid. Each new observation gives students something to think about and a new piece of information about the organization and behavior of the objects in their world.

When conditions are right, a sample of matter can change state. A substance can change state from solid to liquid, liquid to gas, solid to gas, or change in the other direction. When a substance changes from solid to liquid, we say it melted, or liquefied. When a substance changes from liquid to solid, we say it froze, or solidified. When a substance changes from liquid to gas, we say it evaporated, or vaporized. When a substance changes from gas to liquid, we say it condenses.

Melting ice, butter, or chocolate is pretty easy—you just heat the substance, and it changes from solid to liquid. That’s a change of state, and it is accomplished with heat. Transfer of heat is the key to all state changes. The composition of the materials is the same; they are just in a different molecular arrangement.

We are all familiar with water in its three states—ice, liquid water, water vapor—because those states exist in a temperature range we commonly experience (from 0°C to 100°C). Melting and freezing of water happen at the same temperature—0°C. The direction of energy transfer (from the environment to the water or away from the water to the environment) determines what we call the process. Some substances melt and freeze at lower temperatures (salt water, isopropyl alcohol, mercury), and some melt and freeze at higher temperatures (aluminum, copper, iron).
Matter Content Sequence
This table shows the five FOSS modules and courses that address the matter-content sequence for grades K–8. Running through the sequence are the two progressions—matter has structure, and matter interacts. The supporting elements in each module (somewhat abbreviated) are listed. The elements for the Solids and Liquids Module are expanded to show how they fit into the sequence.

<table>
<thead>
<tr>
<th>Module or course</th>
<th>Matter has structure</th>
<th>Matter interacts</th>
</tr>
</thead>
</table>
| Chemical Interactions | Matter is made of atoms.  
| | Substances are defined by chemical formulas.  
| | Elements are defined by unique atoms.  
| | The properties of matter are determined by the kinds and behaviors of its atoms.  
| | Atomic theory explains the conservation of matter.  
| | Solid matter can break into pieces too small to see.  
| | Mass is conserved (not created or lost) during changes.  
| | Properties can be used to identify substances (e.g., solubility).  
| | Relative density can be used to seriate solutions of different concentrations.  
| | During chemical reactions, particles in reactants rearrange to form new products.  
| | Energy transfer to/from the particles in a substance can result in phase change.  
| | During dissolving, one substance is reduced to particles (solute), that are distributed uniformly throughout the particles of the other substance (solvent).  
| | A mixture is two or more intermingled substances.  
| | Dissolving occurs when one substance disappears in a second substance.  
| | A chemical reaction occurs when substances mix, and new products result.  
| | Melting is an interaction between one substance and heat.  
| | Different substances change state (e.g., melt or freeze) at different temperatures.  
| | Mass is conserved when objects or materials are mixed.  

Solids and Liquids
- Wood, paper, rock, and fabric are examples of solid materials.  
- Solid objects are made of solid materials.  
- Solid objects have properties.  
- The whole (object) can be broken down into smaller pieces.  
- Wood, paper, and fabric can be changed by sanding, coloring, tearing, etc.  
- Common materials can be changed into new materials (paper making, weaving, etc.).  
- Water can change to ice in a freezer, and ice can change to water in a room.
The Solids and Liquids Module aligns with the NRC Framework. The module addresses these K–2 grade band endpoints described for core ideas from the national framework for physical sciences and for engineering, technology, and the application of science.

**Physical Sciences**

Core idea PS1: Matter and Its Interactions—How can one explain the structure, properties, and interactions of matter?

- **PS1.A:** How do particles combine to form the variety of matter one observes? [Different kinds of matter exist (e.g., wood, metal, water), and many of them can be either solid or liquid, depending on temperature. Matter can be described and classified by its observable properties, by its uses, and by whether it occurs naturally or is manufactured. Different properties are suited to different purposes. A great variety of objects can be built up from a small set of pieces. Objects or samples of a substance can be weighed, and their size can be described and measured. (Boundary: Volume is introduced only for liquid measure.)]

- **PS1.B:** How do substances combine or change (react) to make new substances? How does one characterize and explain these reactions and make predictions about them? [Heating or cooling a substance may cause changes that can be observed. Sometimes these changes are reversible (e.g., melting and freezing) and sometimes they are not (e.g., baking a cake, burning fuel).]
FOSS COMPONENTS

Teacher Toolkit

The Teacher Toolkit is the most important part of the FOSS Program. It is here that all the wisdom and experience contributed by hundreds of educators has been assembled. Everything we know about the content of the module, how to teach the subject, and the resources that will assist the effort are presented here. Each toolkit has three parts.

Investigations Guide. This spiral-bound document contains these chapters.

- Overview
- Materials
- Investigations (four in this module)

Teacher Resources. This three-ring binder contains these chapters.

- FOSS Introduction
- Assessment
- Science Notebooks in Grades K–2
- Science-Centered Language Development
- Taking FOSS Outdoors
- FOSSweb and Technology
- Science Notebook Masters
- Teacher Masters
- Assessment Masters

The chapters contained in the Teacher Resources and the Spanish duplication masters can also be found on FOSSweb (www.FOSSweb.com).

Science Resources book. This is a copy of the student book of readings that are integrated into the instruction.

Equipment Kit

The FOSS Program provides the materials needed for the investigations, including metric measuring tools, in sturdy, front-opening drawer-and-sleeve cabinets. Inside, you will find high-quality materials packaged for a class of 32 students. Consumable materials are supplied for two uses before you need to resupply. Teachers may be asked to supply small quantities of common classroom items.
**FOSS Science Resources Books**

*FOSS Science Resources: Solids and Liquids* is a book of original readings developed to accompany this module. The readings are referred to as articles in the *Investigations Guide*. Students read the articles in the book as they progress through the module. The articles cover a specific concept usually after that concept has been introduced in an active investigation.

The articles in *Science Resources* and the discussion questions provided in the *Investigations Guide* help 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 make connections between what students experience concretely and the ideas that explain their observations.

**FOSSweb and Technology**

The FOSS website opens new horizons for educators, students, and families, in the classroom or at home. Each module has an interactive site where students and families can find instructional activities, interactive simulations and virtual investigations, and other additional resources. FOSSweb provides resources for materials management, general teaching tools for FOSS, purchasing links, contact information for the FOSS Project, and technical support. You do not need an account to view this general FOSS Program information. In addition to the general information, FOSSweb provides digital access to PDF versions of the *Teacher Resources* component of the *Teacher Toolkit* and digital-only resources that supplement the print and kit materials.

Additional resources are available to support FOSS teachers. With an educator account, you can customize your homepage, set up easy access to the digital components of the modules you teach, and create class pages for your students with access to tutorials and online assessments.

**Ongoing Professional Development**

The Lawrence Hall of Science and Delta Education are committed to supporting science educators with unrivaled teacher support, high-quality implementation, and continuous staff-development opportunities and resources. FOSS has a strong network of consultants who have rich and experienced backgrounds in diverse educational settings using FOSS. Find out about professional-development opportunities on FOSSweb.

*Solids and Liquids Module*
FOSS INSTRUCTIONAL DESIGN

Each FOSS investigation follows a similar design to provide multiple exposures to science concepts. The design includes these pedagogies.

- Active investigation, including outdoor experiences
- Recording in science notebooks to answer the focus question
- Reading in FOSS Science Resources
- Assessment to monitor progress and motivate student reflection on learning

In practice, these components are seamlessly integrated into a continuum designed to maximize every student’s opportunity to learn. An instructional sequence may move from one pedagogy to another and back again to ensure adequate coverage of a concept.

FOSS Investigation Organization

Modules are subdivided into investigations (four in this module). Investigations are further subdivided into 3–5 parts. Each part of each investigation is driven by a focus question. The focus question, usually presented as the part begins, signals the challenge to be met, mystery to be solved, or principle to be uncovered. The focus question guides students’ actions and thinking and makes the learning goal of each part explicit for teachers. Each part concludes with students recording an answer to the focus question in their notebooks.

Investigation-specific scientific background information for the teacher is presented in each investigation. The content discussion is divided into sections, each of which relates directly to one of the focus questions. This section ends with information about teaching and learning and a conceptual-flow diagram for the content.

The Getting Ready and Guiding the Investigation sections have several features that are flagged or presented in the sidebars. These include several icons to remind you when a particular pedagogical method is suggested, as well as concise bits of information in several categories.

Teaching notes appear in blue boxes in the sidebars. These notes comprise a second voice in the curriculum—an educative element. The first (traditional) voice is the message you deliver to students. It supports your work teaching students at all levels, from management to inquiry. The second educative voice, shared as a teaching note, is designed to help you understand the science content and pedagogical rationale at work behind the instructional scene.
The **safety** icon alerts you to a potential safety issue. It could relate to the use of a chemical substance, such as salt, requiring safety goggles, or the possibility of a student allergic reaction when latex, legumes, or wheat are in use.

The small-group **discussion** icon asks you to pause while students discuss data or construct explanations in their groups. Often, a Reporter shares the group’s conclusions with the class.

The **new-word** icon alerts you to a new vocabulary word or phrase that should be introduced thoughtfully. The new vocabulary should also be entered onto the word wall (or pocket chart). A complete list of the scientific vocabulary used in each investigation appears in the sidebar on the last page of the Background for the Teacher section.

The **vocabulary** icon indicates where students should review recently introduced vocabulary, often just before they will be answering the focus question or preparing for benchmark assessment.

The **recording** icon points out where students should make a science-notebook entry. Students record on prepared notebook sheets or, increasingly, on pages in their science notebooks.

The **reading** icon signals when the class should read a specific article in the *FOSS Science Resources* book, preferably during a reading period.

The **assessment** icon appears when there is an opportunity to assess student progress by using embedded or benchmark assessments. Some of the embedded-assessment methods for grades 1–2 include observation of students engaged in scientific practices, review of a notebook entry (drawing or text), or a teacher observation.

The **outdoor** icon signals when to move the science learning experience into the schoolyard. It also helps you plan for selecting and preparing an outdoor site for a student activity.

The **engineering** icon indicates opportunities for addressing engineering practices—applying and using scientific knowledge. These opportunities include developing a solution to a problem, constructing and evaluating models, and using systems thinking.

The **EL Note** in the sidebar provides a specific strategy to use to assist English learners in developing science concepts. A discussion of strategies is in the Science-Centered Language Development chapter.

To help with pacing, you will see icons for **breakpoints**. Some breakpoints are essential, and others are optional.
Active Investigation

Active investigation is a master pedagogy. Embedded within active learning are a number of pedagogical elements and practices that keep active investigation vigorous and productive. The enterprise of active investigation includes

- context: questioning and planning;
- activity: doing and observing;
- data management: recording/organizing/processing;
- analysis: discussing and writing explanations.

**Context: questioning and planning.** Active investigation requires focus. The context of an inquiry can be established with a focus question or challenge from you or, in some cases, from students. (How can solid objects be described?) At other times, students are asked to plan a method for investigation. This might start with a teacher demonstration or presentation. Then, you challenge students to plan an investigation, such as to find what happens when solid objects are placed in water. In either case, the field available for thought and interaction is limited. This clarification of context and purpose results in a more productive investigation.

**Activity: doing and observing.** In the practice of science, scientists put things together and take things apart, observe systems and interactions, and conduct experiments. This is the core of science—active, firsthand experience with objects, organisms, materials, and systems in the natural world. In FOSS, students engage in the same processes. Students often conduct investigations in collaborative groups of four, with each student taking a role to contribute to the effort.

The active investigations in FOSS are cohesive, and build on each other and the readings to lead students to a comprehensive understanding of concepts. Through the investigations, students gather meaningful data.

**Data management: recording/organizing/processing.** Data accrue from observation, both direct (through the senses) and indirect (mediated by instrumentation). Data are the raw material from which scientific knowledge and meaning are synthesized. During and after work with materials, students record data in their science notebooks. Data recording is the first of several kinds of student writing.

Students then organize data so that they will be easier to think about. Tables allow efficient comparison. Organizing data in a sequence (time) or series (size) can reveal patterns. Students process some data into graphs, providing visual display of numerical data. They also organize data and process them in the science notebook.
Analysis: discussing and writing explanations. The most important part of an active investigation is extracting its meaning. This constructive process involves logic, discourse, and existing knowledge. Students share their explanations for phenomena, using evidence generated during the investigation to support their ideas. Students conclude the active investigation by writing a summary in their science notebooks of their learning as well as questions raised during the activity.

Science Notebooks

Research and best practice have led FOSS to place more emphasis on the student science notebook. Keeping a notebook helps students organize their observations and data, process their data, and maintain a record of their learning for future reference. The process of writing about their science experiences and communicating their thinking is a powerful learning device for students. The science-notebook entries stand as credible and useful expressions of learning. The artifacts in the notebooks form one of the core elements of the assessment system.

You will find the duplication masters for grades 1–6 presented in notebook format. They are reduced in size (two copies to a standard sheet) for placement (glue or tape) into a bound composition book. Full-size duplication masters are also available on FOSSweb. Student work is entered partly in spaces provided on the notebook sheets and partly on adjacent blank sheets.
Reading in FOSS Science Resources

The FOSS Science Resources books emphasize expository articles and biographical sketches. FOSS suggests that the reading be completed during language-arts time. When language-arts skills and methods are embedded in content material that relates to the authentic experience students have had during the FOSS active learning sessions, students are interested, and they get more meaning from the text material.

Assessing Progress

The FOSS assessment system includes both formative and summative assessments. Formative assessment monitors learning during the process of instruction. It measures progress, provides information about learning, and is generally diagnostic. Summative assessment looks at the learning after instruction is completed, and it measures achievement.

Formative assessment in FOSS, called embedded assessment, occurs on a daily basis. You observe action during class or review notebooks after class. Embedded assessment provides continuous monitoring of students’ learning and helps you make decisions about whether to review, extend, or move on to the next idea to be covered.

Benchmark assessments are short summative assessments given after each investigation. These I-Checks are actually hybrid tools: they provide summative information about students’ achievement, and because they occur soon after teaching each investigation, they can be used diagnostically as well. Reviewing a specific item on an I-Check with the class provides another opportunity for students to clarify their thinking.

The embedded assessments are based on authentic work produced by students during the course of participating in the FOSS activities. Students do their science, and you look at their notebook entries. Within the instructional sequence, you will see the heading What to Look For in red letters. Under that, you will see bullet points telling you specifically what students should know and be able to communicate.
If student work is incorrect or incomplete, you know that there has been a breakdown in the learning/communicating process. The assessment system then provides a menu of next-step strategies to resolve the situation. Embedded assessment is assessment for learning, not assessment of learning.

Assessment of learning is the domain of the benchmark assessments. Benchmark assessments are delivered after each investigation. The assessment items do not simply identify whether or not a student knows a piece of science content. The items identify the depth to which students understand science concepts and principles and the extent to which they can apply that understanding. Since the output from the benchmark assessments is descriptive and complex, it can be used for assessment formatively as well as summatively.

Completely incorporating the assessment system into your teaching practice involves realigning your perception of the interplay between good teaching and good learning, and usually leads to a considerably different social order in the classroom with redefined student-student and teacher-student relationships.

14. Assess progress: notebook entry
Observe as students work on this first notebook page.

What to Look For
- Students write “properties” or “by their properties” under the focus question.
- Students draw a solid object.
- Students list two or more properties.
Taking FOSS Outdoors

FOSS throws open the classroom door and proclaims the entire school campus to be the science classroom. The true value of science knowledge is its usefulness in the real world and not just in the classroom. Taking regular excursions into the immediate outdoor environment has many benefits. First of all, it provides opportunities for students to apply things they learned in the classroom to novel situations. When students are able to transfer knowledge of scientific principles to natural systems, they experience a sense of accomplishment.

In addition to transfer and application, students can learn things outdoors that they are not able to learn indoors. The most important object of inquiry outdoors is the outdoors itself. To today’s youth, the outdoors is something to pass through as quickly as possible to get to the next human-managed place. For many, engagement with the outdoors and natural systems must be intentional, at least at first. With repeated visits to familiar outdoor learning environments, students may first develop comfort in the outdoors, and then a desire to embrace and understand natural systems.

The last part of most investigations is an outdoor experience. Venturing out will require courage the first time or two you mount an outdoor expedition. It will confuse students as they struggle to find the right behavior that is a compromise between classroom rigor and diligence and the freedom of recreation. With persistence, you will reap rewards. You will be pleased to see students’ comportment develop into proper field-study habits, and you may be amazed by the transformation of students with behavior issues in the classroom who become your insightful observers and leaders in the schoolyard environment.

Teaching outdoors is the same as teaching indoors—except for the space. You need to manage the same four core elements of teaching: time, space, materials, and students. Because of the different space, new management procedures are required. Students can get farther away. Materials have to be transported. The space has to be defined and honored. Time has to be budgeted for getting to, moving around in, and from the outdoor study site. All these and more issues and solutions are discussed in the Taking FOSS Outdoors chapter in the Teacher Resources.

FOSS is very enthusiastic about this dimension of the program and looks forward to hearing about your experience using the schoolyard as a logical extension of your classroom.
Science-Centered Language Development

The FOSS active investigations, science notebooks, FOSS Science Resources articles, and formative assessments provide rich contexts in which students develop and exercise thinking and communication. These elements are essential for effective instruction in both science and language arts—students experience the natural world in real and authentic ways and use language to inquire, process information, and communicate their thinking about scientific phenomena. FOSS refers to this development of language process and skills within the context of science as science-centered language development.

In the Science-Centered Language Development chapter in the Teacher Resources, we explore the intersection of science and language and the implications for effective science teaching and language development. We identify best practices in language-art instruction that support science learning and examine how learning science content and engaging in scientific practices support language development.

Language plays two crucial roles in science learning: (1) it facilitates the communication of conceptual and procedural knowledge, questions, and propositions, and (2) it mediates thinking—a process necessary for understanding. 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 enhancing reading comprehension, writing expository text, and exercising 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 (speak and listen, as in the Wrap-Up/Warm-Up activities), write, and read about the concepts explored in each investigation.

There are many ways to integrate language into science investigations. The most effective integration depends on the type of investigation, the experience of students, the language skills and needs of students, and the language objectives that you deem important at the time. The Science-Centered Language Development chapter is a library of resources and strategies for you to use. The chapter describes how literacy strategies are integrated purposefully into the FOSS investigations, gives suggestions for additional literacy strategies that both enhance students' learning in science and develop or exercise English-language literacy skills, and develops science vocabulary with scaffolding strategies for supporting all learners. The last section covers language-development strategies specifically for English learners.

Embedded even deeper in the FOSS pedagogical practice is a bolder, philosophical stance. Because language arts commands the greatest amount of the instructional day's time, FOSS has devoted a lot of creative energy defining and exploring the relationship between science learning and the development of language-arts skills. FOSS elucidates its position in the Science Centered-Language Development chapter.
FOSSWEB AND TECHNOLOGY

FOSS is committed to providing a rich, accessible technology experience for all FOSS users. FOSSweb is the Internet access to FOSS digital resources. It provides enrichment for students and support for teachers, administrators, and families who are actively involved in implementing and enjoying FOSS materials. Here are brief descriptions of selected resources to help you get started with FOSS technology.

Technology to Engage Students at School and at Home

**Multimedia activities.** The multimedia simulations and activities were designed to support students’ learning. They include virtual investigations and student tutorials that you can use to support students who have difficulties with the materials or who have been absent.

**FOSS Science Resources.** The student reading book is available as an audio book on FOSSweb, accessible at school or at home. In addition, as premium content, *FOSS Science Resources* is available as an eBook. The eBook supports a range of font sizes and can be projected for guided reading with the whole class as needed.

**Home/school connection.** Each module includes a letter to families, providing an overview of the goals and objectives of the module. Most investigations have a home/school activity providing science experiences to connect the classroom experiences with students’ lives outside of school. These connections are available in print in the *Teacher Resources* binder and on FOSSweb.

**Student media library.** A variety of media enhance students’ learning. Formats include photos, videos, an audio version of each student book, and frequently asked science questions. These resources are also available to students when they log in with a student account.

**Recommended books and websites.** FOSS has reviewed print books and digital resources that are appropriate for students and prepared a list of these media resources.

**Class pages.** Teachers with a FOSSweb account can easily set up class pages with notes and assignments for each class. Students and families can access this class information online.
Technology to Support Teachers

Teacher-preparation video. The video presents information to help you prepare for a module, including detailed investigation information, equipment setup and use, safety, and what students do and learn through each part of the investigation.

Science-notebook masters and teacher masters. All notebook masters and teacher masters used in the modules are available digitally on FOSSweb for downloading and for projection during class. These sheets are available in English and Spanish.

Assessment masters. The benchmark assessment masters for grades 1–6 (I-Checks) are available in English and Spanish.

Focus questions. The focus questions for each investigation are formatted for classroom projection and for printing onto labels that students can glue into their science notebooks.

Equipment photo cards. The cards provide labeled photos of equipment supplied in each FOSS kit.

Materials Safety Data Sheets (MSDS). These sheets have information from materials manufacturers on handling and disposal of materials.

Teacher Resources chapters. FOSSweb provides PDF files of all chapters from the Teacher Resources binder.

- Assessment
- Science Notebooks
- Science-Centered Language Development
- Taking FOSS Outdoors
- FOSSweb and Technology

Streaming video. Some video clips are part of the instruction in the investigation, and others extend concepts presented in a module.

Resources by investigation. This digital listing provides online links to notebook sheets, assessment and teacher masters, and multimedia for each investigation of a module for projection in the classroom.

Interactive whiteboard resources. You can use these slide shows and other resources with an interactive whiteboard.

Investigations eGuide. The eGuide is the complete FOSS Investigations Guide component of the Teacher Toolkit in an electronic web-based format, allowing access from any Internet-enabled computer.

NOTE
The Spanish masters are only available on FOSSweb and on one of the CDs provided in the Teacher Toolkit.
UNIVERSAL DESIGN FOR LEARNING

The roots of FOSS extend back to the mid-1970s and the Science Activities for the Visually Impaired and Science Enrichment for Learners with Physical Handicaps projects (SAVI/SELPH). As those special-education science programs expanded into fully integrated settings in the 1980s, hands-on science proved to be a powerful medium for bringing all students together. The subject matter is universally interesting, and the joy and satisfaction of discovery are shared by everyone. Active science by itself provides part of the solution to full inclusion.

Many years later, FOSS began a collaboration with educators and researchers at the Center for Applied Special Technology (CAST), where principles of Universal Design for Learning (UDL) had been developed and applied. FOSS continued to learn from our colleagues about ways to use new media and technologies to improve instruction. Here are the UDL principles.

Principle 1. Provide multiple means of representation. Give learners various ways to acquire information and knowledge.


The FOSS Program has been designed to maximize the science-learning opportunities for students with special needs and students from culturally and linguistically diverse origins. FOSS is rooted in a 30-year tradition of multisensory science education and informed by recent research on UDL. Procedures found effective with students with special needs and students who are learning English are incorporated into the materials and strategies used with all students.

English Learners

The FOSS multisensory program provides a rich laboratory for language development for English learners. The program uses a variety of techniques to make science concepts clear and concrete, including modeling, visuals, and active investigations in small groups at centers. Key vocabulary is usually developed within an activity context with frequent opportunities for interaction and discussion between teacher and student and among students. This provides practice and application
of the new vocabulary. Instruction is guided and scaffolded through carefully designed lesson plans, and students are supported throughout. The learning is active and engaging for all students, including English learners.

Science vocabulary is introduced in authentic contexts while students engage in active learning. Strategies for helping all primary students read, write, speak, and listen are described in the Science-Centered Language Development chapter. There is a section on science-vocabulary development with scaffolding strategies for supporting English learners. These strategies are essential for English learners, and they are good teaching strategies for all learners.

Differentiated Instruction

FOSS instruction allows students to express their understanding through a variety of modalities. Each student has multiple opportunities to demonstrate his or her strengths and needs. The challenge is then to provide appropriate follow-up experiences for each student. For some students, appropriate experience might mean more time with the active investigations. For other students, it might mean more experience building explanations of the science concepts orally or in writing or drawing. For some students, it might mean making vocabulary more explicit through new concrete experiences or through reading to students. For some students, it may be scaffolding their thinking through graphic organizers. For other students, it might be designing individual projects or small-group investigations. For some students, it might be more opportunities for experiencing science outside the classroom in more natural, outdoor environments.

There are several possible strategies for providing differentiated instruction. The FOSS Program provides tools and strategies so that you know what students are thinking throughout the module. Based on that knowledge, read through the extension activities for experiences that might be appropriate for students who need additional practice with the basic concepts as well as those ready for more advanced projects. Interdisciplinary extensions are listed at the end of each investigation. Use these ideas to meet the individual needs and interests of your students.
ORGANIZING THE CLASSROOM

Students in primary grades are usually most comfortable working as individuals with materials. The abilities to share, take turns, and learn by contributing to a group goal are developing but are not reliable as learning strategies all the time. Because of this egocentrism and the need for many students to control materials or dominate actions, the FOSS kit includes a lot of materials. To effectively manage students and materials, FOSS offers some suggestions.

Small-Group Centers

Some of the observations and investigations with solids and liquids are conducted with small groups at a learning center. Limit the number of students at the center to six to ten at one time. When possible, each student will have his or her own equipment to work with. In some cases, students will have to share materials and equipment and make observations together. Primary students are good at working together independently.

As one group at a time is working at the center on a FOSS activity, other students will be doing something else. Over the course of an hour or more, plan to rotate all students through the center, or allow the center to be a free-choice station.

Whole-Class Activities

Introducing and wrapping up the center activities require you to work for brief periods with the whole class. FOSS suggests for these introductions and wrap-ups that you gather the class at the rug or other location in the classroom where students can sit comfortably in a large group.

Guides for Adult Helpers

In the Teacher Resources binder, you will find duplication masters for center instruction sheets. Some of the investigation parts have a sheet. These sheets are intended as a quick reference for a family member or other adult who might be supervising the center. The sheets help that person keep the activity moving in a productive direction. The sheets can be laminated or slipped into a clear plastic sheet protector for durability.
When You Don’t Have Adult Helpers

Some parts of investigations are designed for small groups, with an aide or a student’s family member available to guide the activity and to encourage discussion and vocabulary development. We realize that there are many primary classrooms in which the teacher is the only adult present. Here are some ways to manage in that situation.

• Invite upper-elementary students to visit your class to help with the activities. They should be able to read the center instruction sheets and conduct the activities with students. Remind older students to be guides and to let primary students do the activities themselves.

• Introduce each part of the activity with the whole class. Set up the center as described in the Investigations Guide, but let students work at the center by themselves. Discussion may not be as rich, but most of the centers can be done independently by students once they have been introduced to the process. Be a 1-minute manager, checking on the center from time to time, offering a few words of advice or direction.

When Students Are Absent

If a student is absent for an activity, give him or her a chance to spend some time with the materials at a center. Another student might act as a peer tutor. Allow the student to bring home a FOSS Science Resources book to read with a family member. Each article has a few review items that the student can respond to verbally and in writing.
SAFETY IN THE CLASSROOM AND OUTDOORS

Following the procedures described in each investigation will make for a very safe experience in the classroom. You should also review your district safety guidelines and make sure that everything you do is consistent with those guidelines. Two posters are included in the kit: Science Safety for classroom use and Outdoor Safety for outdoor activities.

Look for the safety-note icon in the Getting Ready and Guiding the Investigation sections that will alert you to safety considerations throughout the module.

Materials Safety Data Sheets (MSDS) for materials used in the FOSS Program can be found on FOSSweb. If you have questions regarding any MSDS, call Delta Education at 800-258-1302 (Monday–Friday, 8 a.m.–6 p.m. EST).

Science Safety in the Classroom

General classroom safety rules to share with students are listed here.

1. Listen carefully to your teacher’s instructions. Follow all directions. Ask questions if you don’t know what to do.
2. Tell your teacher if you have any allergies. Let your teacher know if you have never been stung by a bee.
3. Never put any materials in your mouth.
4. Dress appropriately for the weather and the outdoor experience.
5. Know if there are any skin-irritating plants in your schoolyard, and do not touch them. Most plants in the schoolyard are harmless.
6. Return to the classroom with all of the materials you brought outside.

Science Safety

1. Listen carefully to your teacher’s instructions. Follow all directions. Ask questions if you don’t know what to do.
2. Tell your teacher if you have any allergies.
3. Never put any materials in your mouth. Do not taste anything unless your teacher tells you to do so.
4. Never smell any unknown material. If your teacher tells you to smell something, move your hand over the material to bring the smell toward your nose.
5. Do not touch your face, mouth, ears, eyes, or nose while working with chemicals, plants, or animals.
6. Always wash your hands with soap and warm water after handling chemicals, plants, or animals.
7. Never mix any chemicals unless your teacher tells you to do so.
8. Report all spills, accidents, and injuries to your teacher.
9. Always wash your hands with soap and warm water after handling chemicals, plants, or animals.
10. Treat animals with respect, caution, and consideration.
11. Clean up your work space after each investigation.
12. Act responsibly during all science activities.
SCHEDULING THE MODULE

The Getting Ready section for each part of an investigation helps you prepare. It provides information on scheduling the activities and introduces the tools and techniques used in the activity. Be prepared—read the Getting Ready section thoroughly.

Below is a suggested teaching schedule for the module. The investigations are numbered and should be taught in order, as the concepts build upon each other from investigation to investigation. We suggest that a minimum of 9 weeks be devoted to this module. Take your time, and explore the subject thoroughly.

Active-investigation (A) sessions include hands-on work with solids and liquids, active thinking about experiences, small-group discussion, writing in science notebooks, and learning new vocabulary in context. The * indicates parts that involve students working at centers.

During Wrap-up/Warm-Up (W) session, students share notebook entries.

Reading (R) sessions involve reading FOSS Science Resources articles.

I-Checks are short summative assessments.

<table>
<thead>
<tr>
<th>Week</th>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
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<tbody>
<tr>
<td>1</td>
<td>START Inv. 1 Part 1</td>
<td>R/W</td>
<td>START Inv. 1 Part 2</td>
<td>A</td>
<td>R/W</td>
</tr>
<tr>
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<td>START Inv. 2 Part 1</td>
<td>A/W</td>
<td>START Inv. 2 Part 2</td>
<td>A/W</td>
<td>A</td>
</tr>
<tr>
<td>3</td>
<td>START Inv. 2 Part 2</td>
<td>A*/W</td>
<td>START Inv. 2 Part 3</td>
<td>A*/W</td>
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<td>A</td>
<td>START Inv. 3 Part 2</td>
<td>R/W</td>
<td>A</td>
</tr>
<tr>
<td>5</td>
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<td>A*/W</td>
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<td>A</td>
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<td>START Inv. 4 Part 2</td>
<td>A/W</td>
<td>A</td>
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<tr>
<td>7</td>
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<td>START Inv. 4 Part 3</td>
<td>A/W</td>
<td>A</td>
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<tr>
<td>8</td>
<td>START Inv. 4 Part 3</td>
<td>R/W</td>
<td>START Inv. 4 Part 4</td>
<td>A*</td>
<td>I-Check 3</td>
</tr>
<tr>
<td>9</td>
<td>START Inv. 4 Part 4</td>
<td>A</td>
<td>START Inv. 4 Part 5</td>
<td>A/W</td>
<td>A</td>
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## FOSS K–8 SCOPE AND SEQUENCE

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<tr>
<th>Grade</th>
<th>Physical Science</th>
<th>Earth Science</th>
<th>Life Science</th>
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<tbody>
<tr>
<td>6–8</td>
<td>Electronics, Chemical Interactions, Force and Motion</td>
<td>Planetary Science, Earth History, Weather and Water</td>
<td>Human Brain and Senses, Populations and Ecosystems, Diversity of Life</td>
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<td>4–6</td>
<td>Mixtures and Solutions, Motion, Force, and Models, Energy and Electromagnetism</td>
<td>Weather on Earth, Sun, Moon, and Planets, Soils, Rocks, and Landforms</td>
<td>Living Systems, Environments</td>
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<tr>
<td>3</td>
<td>Measuring Matter</td>
<td>Water</td>
<td>Structures of Life</td>
</tr>
<tr>
<td>1–2</td>
<td>Balance and Motion, Solids and Liquids</td>
<td>Air and Weather, Pebbles, Sand, and Silt</td>
<td>Insects and Plants, Plants and Animals</td>
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<tr>
<td>K</td>
<td>Materials in Our World</td>
<td>Trees and Weather</td>
<td>Animals Two by Two</td>
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