INTRODUCTION

This module provides grade 2 students with physical sciences core ideas dealing with matter and its interactions as well as with engineering design. The anchor phenomenon for this module is matter in two of its phases—solid and liquid. The driving questions for the module are how are solid and liquid materials similar and different? and how do the properties of solid and liquid materials relate to how they can be used and how they can change?

Students build on the science concepts of matter and its interactions developed in kindergarten using new tools to enrich observations. Students observe, describe, and compare properties of solids and liquids. They conduct investigations to find out what happens when solids and water are mixed and when liquids and water are mixed. They use their knowledge of solids and liquids to conduct an investigation on an unknown material (toothpaste). They gain firsthand experience with reversible changes caused by heating or cooling, and read about changes caused by heating that are irreversible.

Throughout the Solids and Liquids Module, students engage in science and engineering practices to collect data to answer questions, and to define problems in order to develop solutions. Students gain experiences that will contribute to the understanding of crosscutting concepts of patterns; cause and effect; scale, proportion, and quantity; systems and system models; energy and matter; structure and function; and stability and change.

The NGSS Performance Expectations bundled in this module include:

**Physical Sciences**
- 2-PS1-1
- 2-PS1-2
- 2-PS1-3
- 2-PS1-4

**Engineering, Technology, and Applications of Science**
- K–2 ETS1-1
- K–2 ETS1-2
- K–2 ETS1-3

**NOTE**
The three modules for grade 2 in FOSS Next Generation are
- Solids and Liquids
- Pebbles, Sand, and Silt
- Insects and Plants
<table>
<thead>
<tr>
<th>Investigation Summary</th>
<th>Guiding and Focus Questions for Phenomena</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inv. 1: Solids</strong></td>
<td><em>What are some observable properties of solid materials?</em>&lt;br&gt;How can we use those properties to make useful objects?&lt;br&gt;How can solid objects be described?&lt;br&gt;What are solid objects made of?&lt;br&gt;Can two or more objects have the same property?&lt;br&gt;What are the properties of successful towers?&lt;br&gt;What solid objects are outdoors?</td>
</tr>
<tr>
<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>
<td></td>
</tr>
<tr>
<td><strong>Inv. 2: Liquids</strong></td>
<td><em>What are some observable properties of liquids?</em>&lt;br&gt;How are liquids different from each other?&lt;br&gt;How can liquids be described?&lt;br&gt;How do liquids change in containers?&lt;br&gt;Where are liquids outdoors?</td>
</tr>
<tr>
<td>Students investigate liquids in a variety of settings to become familiar with their properties. They learn 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>
<td></td>
</tr>
<tr>
<td><strong>Inv. 3: Bits and Pieces</strong></td>
<td><em>How are solid particles and liquids the same and different?</em>&lt;br&gt;Are these materials solid or liquid?&lt;br&gt;How can mixtures of particles be separated?&lt;br&gt;How do particles of solids move in bottles?&lt;br&gt;What is a general rule for using screens to separate a mixture of small objects?&lt;br&gt;Are there little pieces of solid material outdoors?</td>
</tr>
<tr>
<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>
<td></td>
</tr>
<tr>
<td><strong>Inv. 4: Solids, Liquids, and Water</strong></td>
<td><em>What can happen when solids and liquids are mixed with water?</em>&lt;br&gt;What is the effect of heating or cooling materials?&lt;br&gt;What happens when solids are mixed with water?&lt;br&gt;What happens when liquids are mixed with water?&lt;br&gt;Is toothpaste solid or liquid?&lt;br&gt;How do properties of materials change when they are heated or cooled?&lt;br&gt;What happens when you mix water with solid plant material collected outdoors?</td>
</tr>
<tr>
<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>
<td></td>
</tr>
</tbody>
</table>
### Content Related to Disciplinary Core Ideas

- Solid is one state or phase of matter.
- Objects are described and identified by their properties.
- Objects are made of one or more materials.
- Natural and human-made objects occur outdoors.

### Reading/Technology

**Science Resources Book**
- "Everything Matters"
- "Solid Objects and Materials"
- "Towers"
- "Bridges"

**Videos**
- *Clothing and Building Materials*
- *Properties of Materials*

### Assessment

**Embedded Assessment**
- Science notebook entries
- Performance assessments

**Benchmark Assessment**
- Investigation 1 I-Check

**NGSS Performance Expectations**
- 2-PS1-1; 2-PS1-2; 2-PS1-3
- K–2 ETS1-1; K–2 ETS1-2
- K–2 ETS1-3

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### Content Related to Disciplinary Core Ideas

- Liquid is one common state of matter.
- 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.

### Reading/Technology

**Science Resources Book**
- "Liquids"

**Video**
- *All about Properties of Matter*

**Online Activity**
- "Falling Bottle Puzzle"

### Assessment

**Embedded Assessment**
- Performance assessment
- Science notebook entries

**Benchmark Assessment**
- Investigation 2 I-Check

**NGSS Performance Expectations**
- 2-PS1-1

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### Content Related to Disciplinary Core Ideas

- Solid materials can occur as masses of small particles.
- A mass of particulate matter can form piles and support a more dense 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.

### Reading/Technology

**Science Resources Book**
- "Pouring"
- "Comparing Solids and Liquids"

### Assessment

**Embedded Assessment**
- Science notebook entries
- Performance assessments

**Benchmark Assessment**
- Investigation 3 I-Check

**NGSS Performance Expectations**
- 2-PS1-1; 2-PS1-2

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### Content Related to Disciplinary Core Ideas

- Some solids change when mixed with water.
- 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; changes can be reversible or irreversible.

### Reading/Technology

**Science Resources Book**
- "Mix It Up!"
- "Heating and Cooling"
- "Is Change Reversible?"

**Video**
- *Solids and Liquids*

**Online Activity**
- "Change It!"

### Assessment

**Embedded Assessment**
- Science notebook entries
- Performance assessment

**Benchmark Assessment**
- Investigation 4 I-Check

**NGSS Performance Expectations**
- 2-PS1-1; 2-PS1-2; 2-PS1-3; 2-PS1-4
FOSS COMPONENTS

Teacher Toolkit for Each Module

The FOSS Next Generation Program has three modules for grade 2—Solids and Liquids; Pebbles, Sand, and Silt; and Insects and Plants.

Each module comes with a Teacher Toolkit for that module. 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
- Framework and NGSS
- Materials
- Technology
- Investigations (four in this module)
- Assessment

INVESTIGATION 1 — Solids

Tell students:

- Some of the properties of your objects will be useful in building part of your tower and some won’t. Your job is to think about which properties of objects are useful in the build of the base of the tower, which ones will work well in the middle, and which objects might work at the top.

5. Review the challenge.

- Magnet, ruler, and magnet clip so that students can feel how the tower will stand up when the wind blows. These objects should be held firmly to the magnets on the table. This is likely that someone will look away a child's leg. Show students how tall 45 cm is by measuring from the floor up a child's leg. Many second grade lengths will be about that height.


- Distribute the bags of construction materials and centers to each group for the building lesson. Group games in other centers, offering minimal guidance for pairs that are having difficulty getting started.

- What would make a good base for the tower?
- How can you attach objects to make the tower taller?
- What is the planned height of the tower?

7. Offer assistance (optional).

- Allow plenty of time for students to make the materials before offering assistance. After 15 minutes or so, students will need assistance. Keep your end in mind, call students to ask, “Can you help us think about how to solve this design challenge?”

- What would make a good base on the bottom?
- Which materials have good properties for making the middle and top of the tower?

- Students describe properties of objects/materials that make them useful for this challenge. Students describe properties of objects/materials that make them useful for this challenge.


- Conduct 30-second interviews with students as they construct their towers. Ask questions such as:
  - What are some of the properties of the objects that make a good base for the tower?
  - Which materials have good properties for making the middle and top of the tower?

- Students describe properties of objects/materials that make them useful for this challenge.

- Which materials have good properties for making the middle and top of the tower?

- Students describe properties of objects/materials that make them useful for this challenge.


- At any time, students can use a meter stick to measure their towers. Ask questions such as:
  - What to look for:
    - Students describe properties of objects/materials that make them useful for this challenge.
    - Students describe properties of objects/materials that make them useful for this challenge.

- What are the towers widest?
- How can you attach objects to make the tower taller?
- What is the planned height of the tower?
- Where are the towers tallest?
- How can you attach objects to make the tower taller?
- What is the planned height of the tower?
- Where are the towers tallest?
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- Where are the towers tallest?
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**FOSS Components**

**FOSS Science Resources book.** One copy of the student book of readings is included in the *Teacher Toolkit*.

**Teacher Resources.** These chapters can be downloaded from FOSSweb and are also in the bound *Teacher Resources* book.

- FOSS Program Goals
- Planning Guide—Grade 2
- Science and Engineering Practices—Grade 2
- Crosscutting Concepts—Grade 2
- Sense-Making Discussions for Three-Dimensional Learning—Grade 2
- Access and Equity
- Science Notebooks in Grades K–2
- Science-Centered Language Development
- FOSS and Common Core ELA—Grade 2
- FOSS and Common Core Math—Grade 2
- Taking FOSS Outdoors
- Science Notebook Masters
- Teacher Masters
- Assessment Masters

**Equipment Kit for Each Module or Grade Level**

The FOSS Program provides the materials needed for the investigations, 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 three uses before you need to resupply. Teachers may be asked to supply small quantities of common classroom materials. Delta Education can assist you with materials management strategies for schools, districts, and regional consortia.
**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 Investigations Guide. Students read the articles in the book as they progress through the module. The articles cover specific concepts, usually after the concepts have been introduced in the active investigation.

The articles in FOSS Science Resources and the discussion questions provided in 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.

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**NOTE**

FOSS Science Resources: Solids and Liquids is also provided as a big book in the equipment kit.

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**Comparing Solids and Liquids**

Shape and size are two properties of solid objects. The shape and size don’t change unless you do something to the objects. Solids can be rigid, like a bat. When something is rigid, you can’t bend it.

What is the difference between solids and liquids? They have different properties. Properties describe how something looks or feels.
Technology

The FOSS website opens new horizons for educators, students, and families, in the classroom or at home. Each module has digital resources for students and families—interactive simulations, virtual investigations, and online activities. For teachers, FOSSweb provides online teacher Investigations Guides; grade-level planning guides (with connections to ELA and math); materials management strategies; science teaching and professional development tools; contact information for FOSS Program developers; and technical support. In addition, FOSSweb provides digital access to PDF versions of the Teacher Resources component of the Teacher Toolkit, digital-only instructional resources that supplement the print and kit materials, and access to FOSSmap, the online assessment and reporting system for grades 3–8.

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 online activities.

Ongoing Professional Learning

The Lawrence Hall of Science and Delta Education strive to develop long-term partnerships with districts and teachers through thoughtful planning, effective implementation, and ongoing teacher support. FOSS has a strong network of consultants who have rich and experienced backgrounds in diverse educational settings using FOSS.
FOSS INSTRUCTIONAL DESIGN

FOSS is designed around active investigation that provides engagement with science concepts and science and engineering practices. Surrounding and supporting those firsthand investigations are a wide range of experiences that help build student understanding of core science concepts and deepen scientific habits of mind.

The Elements of the FOSS Instructional Design

- Active Investigation
- Using Formative Assessment
- Integrating Science Notebooks
- Taking FOSS Outdoors
- Engaging in Science–Centered Language Development
- Accessing Technology
- Reading FOSS Science Resources Books

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

- Active investigation in collaborative groups: firsthand experiences with phenomena in the natural and designed worlds
- Recording in science notebooks to answer a focus question dealing with the scientific phenomenon under investigation
- Reading informational text in FOSS Science Resources books
- Online activities to acquire data or information or to elaborate and extend the investigation
- Outdoor experiences to collect data from the local environment or to apply knowledge
- Assessment to monitor progress and inform student learning

In practice, these components are seamlessly integrated into a curriculum designed to maximize every student's opportunity to learn.

A learning cycle employs an instructional model based on a constructivist perspective that calls on students to be actively involved in their own learning. The model systematically describes both teacher and learner behaviors in a coherent approach to science instruction.

A popular model describes a sequence of five phases of intellectual involvement known as the 5Es: engage, explore, explain, elaborate, and evaluate. The body of foundational knowledge that informs contemporary learning-cycle thinking has been incorporated seamlessly and invisibly into the FOSS curriculum design.

Engagement with real-world phenomena is at the heart of FOSS. In every part of every investigation, the investigative phenomenon is referenced implicitly in the focus question that guides instruction and frames the intellectual work. The focus question is a prominent part of each lesson and is called out for the teacher and student. The investigation Background for the Teacher section is organized by focus question—the teacher has the opportunity to read and reflect on the phenomenon in each part in preparing for the lesson. Students record the focus question in their science notebooks, and after exploring the phenomenon thoroughly, explain their thinking in words and drawings.

In science, a phenomenon is a natural occurrence, circumstance, or structure that is perceptible by the senses—an observable reality. Scientific phenomena are not necessarily phenomenal (although they may be)—most of the time they are pretty mundane and well within the everyday experience. What FOSS does to enact an effective engagement with the NGSS is thoughtful selection of scientific phenomena for students to investigate.

**NOTE**
The anchor phenomena establish the storyline for the module. The investigative phenomena guide each investigation part. Related examples of everyday phenomena are incorporated into the readings, videos, discussions, formative assessments, outdoor experiences, and extensions.
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**: sharing prior knowledge, questioning, and planning;
- **activity**: doing and observing;
- **data management**: recording, organizing, and processing;
- **analysis**: discussing and writing explanations.

**Context: sharing, questioning, and planning.** Active investigation requires focus. The context of an inquiry can be established with a focus question about a phenomenon or challenge from you or, in some cases, from students. (Are these materials solid or liquid?) 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 out if toothpaste is a solid or liquid. 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 to lead students to a comprehensive understanding of concepts. Through investigations and readings, students gather meaningful data.

**Data management: recording, organizing, and 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 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 prior knowledge. Students share their explanations for phenomena, using evidence generated during the investigation to support their ideas. They conclude the active investigation by writing a summary of their learning as well as questions raised during the activity in their science notebooks.

**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 exhibitions of the assessment system.

You will find the duplication masters for grades 1–5 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-sized masters for grades 3–5 that can be filled in electronically and are suitable for display are available on FOSSweb. Student work is entered partly in spaces provided on the notebook sheets and partly on adjacent blank sheets in the composition book. Look to the chapter in Teacher Resources called Science Notebooks in Grades K–2 for more details on how to use notebooks with FOSS.

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**September 6–20**

**What are solid objects made of?**

<table>
<thead>
<tr>
<th>Object</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cylinder</td>
<td>wood</td>
</tr>
<tr>
<td>Triangle</td>
<td>plastic</td>
</tr>
<tr>
<td>Cube</td>
<td>plastic</td>
</tr>
<tr>
<td>Stick</td>
<td>fabric</td>
</tr>
<tr>
<td>Wire</td>
<td>wood</td>
</tr>
<tr>
<td>Screw</td>
<td>metal</td>
</tr>
</tbody>
</table>

The triangle is the color blue.
Reading in FOSS Science Resources

The FOSS Science Resources books, available in print and interactive eBooks, are primarily devoted to expository articles and biographical sketches. FOSS suggests that the reading be completed during language-arts time to connect to the Common Core State Standards for ELA. 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.

Recommended strategies to engage students in reading, writing, speaking, and listening using the articles in the FOSS Science Resources books are included in the flow of Guiding the Investigation. In addition, a library of resources is described in the Science-Centered Language Development chapter in Teacher Resources.

The FOSS and the Common Core ELA—Grade 2 chapter in Teacher Resources shows how FOSS provides opportunities to develop and exercise the Common Core ELA practices through science. A detailed table identifies these opportunities in the three FOSS modules for the second grade.

Engaging in Online Activities through FOSSweb

The simulations and online activities on FOSSweb are designed to support students’ learning at specific times during instruction. Digital resources include streaming videos that can be viewed by the class or small groups. Resources can be used to review the active investigations and to support students who need more time with the concepts.

The Technology chapter provides details about the online activities for students and the tools and resources for teachers to support and enrich instruction. There are many ways for students to engage with the digital resources—in class as individuals, in small groups, or as a whole class, and at home with family and friends.
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 predominantly diagnostic. Summative assessment looks at the learning after instruction is completed, and it measures achievement.

Formative assessment in FOSS, called embedded assessment, is an integral part of instruction, and occurs on a daily basis. You observe action during class in a performance assessment or review notebooks after class. Performance assessments look at students’ engagement in science and engineering practices or their recognition of crosscutting concepts, and are indicated with the second assessment icon. 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 specific items on an I-Check with the class provides additional opportunities 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. Bullet points in the Guiding the Investigation tell 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 for grades 1–2 are delivered after each investigation (I-Checks). The benchmark tools are carefully crafted and thoroughly tested assessments composed of valid and reliable items. The assessment items do not simply identify whether or not a student knows a piece of science content, but identify the depth to which students understand science concepts and principles and the extent to which they can apply that understanding.
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 might 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 classroom 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 returning from the outdoor study site. All these and more issues and solutions are discussed in the Taking FOSS Outdoors chapter in Teacher Resources.
Science-Centered Language Development and Common Core State Standards for ELA

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 Teacher Resources, we explore the intersection of science and language and the implications for effective science teaching and 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 identified in contemporary standards for English language arts.

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. We identify effective practices in language-arts instruction that support science learning and examine how learning science content and engaging in science and engineering practices support language development.

Specific methods to make connections to the Common Core State Standards for English Language Arts are included in the flow of Guiding the Investigation. These recommended methods are linked to the CCSS ELA through ELA Connection notes. In addition, the FOSS and the Common Core ELA chapter in Teacher Resources summarizes all of the connections to each standard at the given grade level.
DIFFERENTIATED INSTRUCTION FOR ACCESS AND EQUITY

Learning from Experience

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 Program). As this special-education science program expanded into fully integrated (mainstreamed) 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 and provides many opportunities at the same time for differentiated instruction.

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 continues to learn from our colleagues about ways to use new media and technologies to improve instruction. Here are the UDL guiding principles.

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


FOSS for All Students

The FOSS Program has been designed to maximize the science learning opportunities for all students, including those who have traditionally not had access to or have not benefited from equitable science experiences—students with special needs, ethnically diverse learners, English learners, students living in poverty, girls, and advanced and gifted learners. FOSS is rooted in a 30-year tradition of multisensory science education and informed by recent research on UDL and culturally and linguistically responsive teaching and learning. 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 during the initial instruction phase. In addition, the Access and Equity chapter in Teacher Resources (or go to FOSSweb to download this chapter) provides strategies and suggestions for enhancing the science and engineering experiences for each of the specific groups noted above.

Throughout the FOSS investigations, students experience multiple ways of interacting with phenomena and expressing their understanding through a variety of modalities. Each student has multiple opportunities to demonstrate his or her strengths and needs, thoughts, and aspirations.

The challenge is then to provide appropriate follow-up experiences or enhancements appropriate for each student. For some students, this might mean more time with the active investigations or online activities. For other students, it might mean more experience and/or scaffolds for developing models, building explanations, or engaging in argument from evidence.

For some students, it might mean making vocabulary and language structures more explicit through new concrete experiences or through reading to students. It may help them identify and understand relationships and connections through graphic organizers.

For other students, it might be designing individual projects or small-group investigations. It might be more opportunities for experiencing science outside the classroom in more natural, outdoor environments or defining problems and designing solutions in their communities.
English Learners

The FOSS Program provides a rich laboratory for language development for English learners. A variety of techniques are provided to make science concepts clear and concrete, including modeling, visuals, and active investigations in small groups. Instruction is guided and scaffolded through carefully designed lesson plans, and students are supported throughout.

Science vocabulary and language structures are introduced in authentic contexts while students engage in hands-on learning and collaborative discussion. Strategies for helping all students read, write, speak, and listen are described in the Science-Centered Language Development chapter. A specific section on English learners provides suggestions for both integrating English language development (ELD) approaches during the investigation and for developing designated (targeted and strategic) ELD-focused lessons that support science learning.
FOSS INVESTIGATION ORGANIZATION

Modules are subdivided into investigations (four in this module). Investigations are further subdivided into three to five parts. Each investigation has a general guiding question for the phenomenon students investigate, and each part of each investigation is driven by a specific focus question. The focus question, usually presented as the part begins, engages the student with the phenomenon and 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.

The investigation is summarized for the teacher in the At-a-Glance chart at the beginning of each investigation.

Investigation-specific scientific background information for the teacher is presented in each investigation chapter organized by the focus questions.

The Teaching Children about section makes direct connections to the NGSS foundation boxes for the grade level—Disciplinary Core Ideas, Science and Engineering Practices, and Crosscutting Concepts. This information is later presented in color-coded sidebar notes to identify specific places in the flow of the investigation where connections to the three dimensions of science learning appear. The Teaching Children about section ends with information about teaching and learning and a conceptual-flow graphic of the content.

The Materials and Getting Ready sections provide scheduling information and detail exactly how to prepare the materials and resources for conducting the investigation.

Teaching notes and ELA Connections 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. 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. ELA Connections boxes provide connections to the Common Core State Standards for English Language Arts.

**FOCUS QUESTION**

How can solids be described?

**SCIENCE AND ENGINEERING PRACTICES**
Planning and carrying out investigations

**DISCIPLINARY CORE IDEAS**
PS1A: Structure and properties of matter

**CROSSCUTTING CONCEPTS**
Cause and effect

**TEACHING NOTE**
This focus question can be answered with a simple yes or no, but the question has power when students support their answers with evidence. Their answers should take the form “Yes, because _____.”
The **Getting Ready** and **Guiding the Investigation** sections have several features that are flagged 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.

The **safety** icon alerts you to potential safety issues related to chemicals, allergic reactions, and the use of safety goggles.

The small-group **discussion** icon asks you to pause while students discuss data or construct explanations in their groups.

The **new-word** icon alerts you to a new vocabulary word or phrase that should be introduced thoughtfully.

The **vocabulary** icon indicates where students should review recently introduced vocabulary.

The **recording** icon points out where students should make a science-notebook entry.

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

The **technology** icon signals when the class should use a digital resource on FOSSweb.
The **assessment** icons appear when there is an opportunity to assess student progress by using embedded or benchmark assessments. Some are performance assessments—observations of science and engineering practices, indicated by a second icon which includes a beaker and ruler.

The **outdoor** icon signals when to move the science learning experience into the schoolyard.

The **engineering** icon indicates opportunities for an experience incorporating engineering practices.

The **math** icon indicates an opportunity to engage in numerical data analysis and mathematics practice.

The **crosscutting concepts** icon indicates an opportunity to expand on the concept by going to *Teacher Resources*, Crosscutting Concepts chapter. This chapter provides details on how to engage students with that concept in the context of the investigation.

The **EL note** provides a specific strategy to use to assist English learners in developing science concepts.

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

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*FOSS Investigation Organization*
ESTABLISHING A CLASSROOM CULTURE

Part of being a scientist is learning how to work collaboratively with others. However, 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 as 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, here are some suggestions.

Whole-Class Discussions

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.

At the beginning of the year, explain and discuss norms for sense-making discussions. You might start by together making a class poster with visuals to represent what it looks like, sounds like, and feels like when everyone is working and learning together. Model discussion protocols that give all students opportunities to speak and listen, such as think-pair-share. Review the norms before sense-making discussions, and leave time for reflecting on how well the group adhered to the norms. More strategies for developing oral discourse skills can be found in Sense-Making Discussions for Three-Dimensional Learning and the Science-Centered Language Development chapters in Teacher Resources on FOSSweb.

Collaborative Teaching and Learning

Collaborative learning requires a collective as well as individual growth mindset. A growth mindset is when people believe that their most basic abilities can be developed through dedication and hard work (see the research of Carol Dweck and her book *Mindset: The Psychology of Success*). As second-grade students learn to work together to make sense of phenomena and develop their inquiry and discourse skills, it’s important to recognize and value their efforts to try new approaches, to share their ideas, and ask questions. Remind students that everyone in the classroom is a learner, and that learning happens when we try to figure things out. Here are a few ways to help students develop a growth mindset for science and engineering.
• **Praise effort, not right answers.** When students are successful at a task, provide positive feedback about their level of engagement and effort in the practices, e.g., the efforts they put into careful observations, how well they reported their observations, the relevancy of their questions, how well they connected or applied new concepts, and their use of new vocabulary, etc. Also, try to provide feedback that encourages students to continue to improve their learning and exploring, e.g., is there another way you could try? Have you thought about _____? Why do you think _____?

• **Foster and validate divergent thinking.** During sense-making discussions, continually emphasize how important it is to share emerging ideas and to be open to the ideas of others in order to build understanding. Model for students how you refine and revise your thinking based on new information. Make it clear to students that the point is not for them to show they have the right answer, but rather to help each other arrive at new understanding. Point out positive examples of students expressing and revising their ideas. For example, Did you all notice how Carla changed her idea about _____?

Establishing a classroom culture that supports three-dimensional teaching and learning centers on collaboration. Helping students to work together in pairs and small groups, and to adhere to norms for discussions, are ways to foster collaboration. These structures along with the expectations that students will be negotiating meaning together as a community of learners, creates a learning environment where students are compelled to work, think, and communicate like scientists and engineers to help one another learn.

**Small-Group Centers**

Some of the observations and investigations with solids and liquids are conducted with small groups at a learning center. Review the section “Working at Learning Centers” before Part 1 in Investigations 2 and 3. 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. 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.
When You Don’t Have Adult Helpers

Some parts of investigations work better when there is an aide or a student’s family member available to assist groups with 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. You might invite upper-elementary students to visit your class to help with the activities. Remind older students to be guides and to let primary students do the activities themselves.

Managing Materials

The Materials section lists the items in the equipment kit and any teacher-supplied materials. It also describes things to do to prepare a new kit and how to check and prepare the kit for your classroom. Individual photos of each piece of FOSS equipment are available for printing from FOSSweb, and can help students and you identify each item. (Photo equipment cards are available in English and Spanish formats.)

For whole-class activities, FOSS Program designers suggest using a central materials distribution system. You organize all the materials for an investigation at a single location called the materials station. As the investigation progresses, one member of each group gets materials as they are needed, and another returns the materials when the investigation is complete. You place the equipment and resources at the station, and students do the rest. Students can also be involved in cleaning and organizing the materials at the end of a session.

When Students Are Absent

When a student is absent for a session, 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 or 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 icon in the Getting Ready and Guiding the Investigation sections that will alert you to safety considerations throughout the module.

Safety Data Sheets (SDS) for materials used in the FOSS Program can be found on FOSSweb. If you have questions regarding any SDS, call Delta Education at 1-800-258-1302 (Monday–Friday, 8:00 a.m.–5:00 p.m. ET).

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.
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, wave 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 protect your eyes. Wear safety goggles when necessary. Tell your teacher if you wear contact lenses.
7. Always wash your hands with soap and warm water after handling chemicals, plants, or animals.
8. Never mix any chemicals unless your teacher tells you to do so.
9. Report all spills, accidents, and injuries to your teacher.
10. Treat animals with respect, caution, and consideration.
11. Clean up your work space after each investigation.
12. Act responsibly during all science activities.

Outdoor 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. Let your teacher know if you have never been stung by a bee.
4. Stay within the designated study area and with your partner or group. When you hear the “freeze” signal, stop and listen to your teacher.
5. Never look directly at the Sun or at the sunlight being reflected off a shiny object.
6. Know if there are any skin-irritating plants in your schoolyard, and do not touch them. Most plants in the schoolyard are harmless.
7. Respect all living things. When looking under a stone or log, lift the side away from you so that any living thing can escape.
8. If a stinging insect is near you, stay calm and slowly walk away from it. Tell your teacher if you are stung or bitten.
9. Never release any living things into the environment unless you collected them there.
10. Always wash your hands with soap and warm water after handling plants, animals, and soil.
11. Return to the classroom with all the materials you brought outside.
SCHEDULING THE MODULE

On the next page 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.

Active-investigation (A) sessions include hands-on work with materials and tools, 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.

Reading (R) sessions involve reading FOSS Science Resources articles. Reading can be completed during language-arts time to make connections to Common Core State Standards for ELA (CCSS ELA).

During Wrap-Up/Warm-Up (W) sessions, students share notebook entries and engage in connections to CCSS ELA. These sessions can also be completed during language-arts time.

I-Checks are short summative assessments at the end of each investigation. See the Assessment chapter for more details.
### Scheduling the Module

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<th>Day 3</th>
<th>Day 4</th>
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**NOTE**

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 and review the teacher preparation video on FOSSweb.
SOLIDS AND LIQUIDS — Overview

FOSS CONTACTS

General FOSS Program information
www.FOSSweb.com
www.DeltaEducation.com/FOSS

Developers at the Lawrence Hall of Science
foss@berkeley.edu

Customer Service at Delta Education
www.DeltaEducation.com/contact.aspx
Phone: 1-800-258-1302, 8:00 a.m.–5:00 p.m. ET

FOSSmap (online component of FOSS assessment system)
http://FOSSmap.com/

FOSSweb account questions/access codes/help logging in
techsupport.science@schoolspecialty.com
Phone: 1-800-258-1302, 8:00 a.m.–5:00 p.m. ET

School Specialty online support
loginhelp@schoolspecialty.com
Phone: 1-800-513-2465, 8:30 a.m.–6:00 p.m. ET

FOSSweb tech support
support@fossweb.com

Professional development
www.FOSSweb.com/Professional-Development

Safety issues
www.DeltaEducation.com/SDS
Phone: 1-800-258-1302, 8:00 a.m.–5:00 p.m. ET
For chemical emergencies, contact Chemtrec 24 hours per day.
Phone: 1-800-424-9300

Sales and replacement parts
www.DeltaEducation.com/FOSS/buy
Phone: 1-800-338-5270, 8:00 a.m.–5:00 p.m. ET