INTRODUCTION

The FOSS Weather and Water Course focuses on Earth’s atmosphere, weather, and water. Students will delve into topics that may seem unrelated to weather, including a good dose of physics and a bit of chemistry. A good understanding of meteorology as an earth science isn’t complete without an introduction to concepts that cross into these disciplines.

Understanding weather is more than reading data from a weather center. Students need to grapple with ideas about atoms and molecules, changes of state, and heat transfer before they can launch into the bigger ideas involving air masses and fronts, convection cells and winds, and the development of severe weather.

Earth’s atmosphere is composed of a variety of gases, with nitrogen and oxygen the most abundant. But Earth wouldn’t be the same if it weren’t for one keystone gas, water vapor, a relatively small and variable component of the atmosphere. Without water vapor and its liquid and solid forms, both on the surface and in the atmosphere, there would be no weather. There would be neither clouds nor precipitation. If precipitation didn’t occur, we wouldn’t have runoff to create the streams and rivers that erode mountains, deposit deltas, and replenish lakes and oceans. An atmosphere without water vapor would be an alien and hostile place. The importance of water on Earth is a major element of this course.
## Investigation Summary

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<th>Focus Questions</th>
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<td>What is weather? How can we measure the weather?</td>
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<tr>
<td><strong>Where’s the Air?</strong></td>
<td></td>
<td>1. The Air around Us 2. Earth’s Atmosphere</td>
<td>What is air? What is the atmosphere?</td>
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<tr>
<td><strong>Air Pressure and Wind</strong></td>
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<td>1. Air-Pressure Inquiry 2. Pressure Maps</td>
<td>How does pressure affect air? What happens when two areas of air have different pressures?</td>
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<td>Inv. 3</td>
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<tr>
<td>Inv. 4</td>
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</tbody>
</table>
### Module Matrix

<table>
<thead>
<tr>
<th>Content</th>
<th>Writing/Reading</th>
<th>Assessment</th>
</tr>
</thead>
</table>
| • Weather is the condition of Earth’s atmosphere at a given time in a given place.  
  • Severe weather has the potential to cause death and destruction in the environment.  
  • Meteorology is the science of weather, and meteorologists are the people who study Earth’s weather.  
  • Weather and climate are different. | **Science Notebook Entry**  
  Questions about weather  
  Weather observations  
  *Weather Chart*  
  **Science Resources Book**  
  “Severe Weather” (optional)  
  “Naming Hurricanes” (optional)  
  “Mr. Tornado” (optional)  
  “Traditional Weather Tools” (optional) | **Embedded Assessment**  
  Quick writes  
  **Benchmark Assessment**  
  Survey (optional) |
| • Air is matter; it occupies space, has mass, and can be compressed.  
  • The atmosphere is the layers of gases surrounding Earth.  
  • Weather happens in the troposphere, the layer of the atmosphere closest to Earth’s surface.  
  • The troposphere is a mixture of nitrogen (78%), oxygen (21%), and other gases (1%), including argon, carbon dioxide, and water vapor. | **Science Notebook Entry**  
  *Air Investigation*  
  *Earth’s Atmosphere Questions*  
  **Science Resources Book**  
  “What’s in the Air?”  
  “A Thin Blue Veil” (optional) | **Embedded Assessment**  
  Scientific practices  
  **Science Notebook entry**  
  **Benchmark Assessment**  
  *Investigations 1–2 I-Check* |
| • Pressure exerted on a gas reduces its volume and increases its density.  
  • Wind is a large-scale movement of air.  
  • Air tends to move from regions of high pressure to regions of low pressure.  
  • Air pressure is represented on a map by contour lines called isobars. | **Science Notebook Entry**  
  *Pressure in a Jar*  
  “What Is Air Pressure?”  
  Questions  
  *Surface Air-Pressure Map*  
  **Science Resources Book**  
  “What Is Air Pressure?” | **Embedded Assessment**  
  Response sheet  
  Scientific practices  
  **Benchmark Assessment**  
  *Investigation 3 I-Check* |
| • Density is the ratio of a mass to its volume.  
  • If two solutions have equal volumes but differ in mass, the one with the greater mass is more dense.  
  • As matter heats up, it expands, causing the matter to become less dense.  
  • Convection is the circulation of fluid (liquid or gas) that results from energy transfer; relatively warm masses rise and relatively cool masses sink. | **Science Notebook Entry**  
  *Liquid Layers*  
  *Straw Column*  
  *Calculating Density of Layers*  
  *Density Practice* (optional)  
  *Layering Hot and Cold Water Convection Chamber*  
  **Science Resources Book**  
  “Density”  
  “Density with Dey” (optional)  
  “Convection” (optional) | **Embedded Assessment**  
  Response sheet  
  Scientific practices  
  **Science Notebook entry**  
  **Benchmark Assessment**  
  *Investigation 4 I-Check* |
## Investigation Summary

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<tbody>
<tr>
<td>6 Sessions 1 Session</td>
<td>Active Inv.</td>
<td>Latitude</td>
<td>How does weather differ between locations? How does the Sun affect the temperature of locations on Earth? What factors affect the surface temperature on Earth?</td>
</tr>
<tr>
<td>Assessment</td>
<td></td>
<td>Solar Angle</td>
<td></td>
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<td></td>
<td></td>
<td>Heating Earth</td>
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</table>

<table>
<thead>
<tr>
<th>Air Flow</th>
<th>Time</th>
<th>Parts</th>
<th>Focus Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Sessions</td>
<td>Active Inv.</td>
<td>Conduction</td>
<td>How does the atmosphere heat up?</td>
</tr>
<tr>
<td></td>
<td>Reading</td>
<td>1. Conduction</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 Sessions</td>
<td>2. Local Winds</td>
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</tr>
<tr>
<td></td>
<td>Assessment</td>
<td>3. Global Winds</td>
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</tr>
<tr>
<td></td>
<td>1 Session</td>
<td></td>
<td>How does energy from the Sun affect wind on Earth? What affects the direction of global winds?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Water in the Air</th>
<th>Time</th>
<th>Parts</th>
<th>Focus Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 Sessions 1 Session</td>
<td>Active Inv.</td>
<td>Is Water Really There?</td>
<td>Is there water vapor in the air? How does energy transfer when water changes phase? What causes clouds to form?</td>
</tr>
<tr>
<td>Assessment</td>
<td>1. Is Water Really There?</td>
<td></td>
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<tr>
<td></td>
<td>2. Phase Change and Energy Transfer</td>
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<td></td>
<td>3. Clouds and Precipitation</td>
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</tbody>
</table>
### Module Matrix

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</table>
| ● Latitude is a factor that affects local weather and climate.  
● The angle at which light from the Sun strikes the surface of Earth is the solar angle.  
● The lower the solar angle is, the less intense the light is on Earth’s surface.  
● The Sun is the major source of energy that heats the atmosphere, and solar energy is transferred by radiation.  
● Heat is the increase of kinetic energy of particles. | **Science Notebook Entry**  
Climate Factors—
Latitude A and B  
Light Angle  
Earth-Material Temperatures Chart  
Earth-Material Temperatures Graph  
Earth-Material Temperatures Questions  
**Science Resources Book**  
"Seasons" (optional)  
“Thermometer: A Device to Measure Temperature” (optional) | **Embedded Assessment**  
Scientific practices  
Science notebook entry  
**Benchmark Assessment**  
Investigation 5 I-Check |
| ● Energy can move from one material to another by conduction.  
● Differential heating of Earth’s surface by the Sun can create high- and low-pressure areas.  
● Local winds blow in predictable patterns determined by local differential heating.  
● Convection cells and Earth’s rotation determine prevailing winds on Earth. | **Science Notebook Entry**  
Heat Conduction  
Sea Breeze  
Land Breeze  
Global Winds  
**Science Resources Book**  
“Heating the Atmosphere”  
“Laura’s Big Day” (optional)  
“Wind on Earth” | **Embedded Assessment**  
Science notebook entries  
**Benchmark Assessment**  
Investigation 6 I-Check |
| ● Water changes from gas to liquid by condensation.  
● Water changes from liquid to gas (vapor) by evaporation.  
● Temperature change, which is evidence of energy transfer, accompanies evaporation.  
● Dew point is the temperature at which air is saturated with water vapor and vapor condenses into liquid.  
● Increasing the pressure of a given volume of air increases the temperature of air. | **Science Notebook Entry**  
Answer the focus question  
Dew-Point Questions  
Pressure/Temperature Demonstration  
**Science Resources Book**  
"Observing Clouds" (optional) | **Embedded Assessment**  
Scientific practices  
Response sheet  
Science notebook entry  
**Benchmark Assessment**  
Investigation 7 I-Check |
### Investigating Scales: Weather and Climate

#### Overview

- **Meteorology**
  - Students pull together all the physical science concepts they’ve learned in the course to explain weather. They interpret radiosonde data from weather balloons and use a weather map to write and deliver a TV-style weather report.

- **The Water Planet**
  - Students learn that the water cycle is complex and involves water everywhere in the global environment. They explore what causes ocean currents, and how proximity to the ocean can affect climate.

- **Climate over Time**
  - Students refine the distinction between weather and climate and are introduced to the concept of climate change. They explore the relationship between greenhouse gases and global average temperature, and consider implications of climate change. Students consider human involvement in increasing greenhouse gases, including actions that may mitigate climate change.

#### Investigation Summary

<table>
<thead>
<tr>
<th>Investigation</th>
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<th>Focus Questions</th>
</tr>
</thead>
</table>
| **Meteorology** | **Active Inv.** 5 Sessions | 1. Weather Balloons 2. Weather Maps | Why are data from weather balloons important?  
What information can you get from a weather map? |
| **The Water Planet** | **Active Inv.** 5 Sessions **Assessment** 1 Session | 1. Water-Cycle Simulation 2. Ocean Currents 3. Ocean Climate | What is the water cycle?  
What affects the direction that ocean water flows?  
How does the ocean affect climate on land? |
| **Climate over Time** | **Active Inv.** 4 Sessions **Reading** 1 Session **Assessment** 1 Session | 1. Climate Change 2. The Role of Carbon Dioxide 3. Climate in the News 4. Identify Key Ideas | How have climates changed over time?  
How do greenhouse gases in the atmosphere affect Earth’s temperature?  
What are the effects of a slight rise in global temperatures?  
What is the difference between weather and climate? |
### Module Matrix

<table>
<thead>
<tr>
<th>Content</th>
<th>Writing /Reading</th>
<th>Assessment</th>
</tr>
</thead>
</table>
| • Weather balloons travel high in the atmosphere and collect physical data using a radiosonde. | **Science Notebook Entry**  
  Answer the focus question  
  **Weather report**  
  **Science Resources Book**  
  "Weather Balloons and Upper-Air Soundings" (optional)  
  "Severe Weather"  
  "Animal Rains" (optional)  
  **Embedded Assessment**  
  Scientific practices  
  Quick write  
  Science notebook entry | **Embedded Assessment**  
  **Quick write**  
  **Science notebook entry**  
  **Scientific practices**  
  **Benchmark Assessment**  
  **Investigations 8–9 I-Check** |
| • Data from weather-balloon radiosondes can be used to determine dew point and the likelihood of clouds forming. | **Science Notebook Entry**  
  **Answer the focus question**  
  **My Water Cycle**  
  **Climate Factors—Ocean Distance A**  
  **Climate Factors—Ocean Distance B**  
  **Science Resources Book**  
  "Earth: The Water Planet"  
  "Ocean Currents and Gyres"  
  "El Niño"  
  **Embedded Assessment**  
  **Quick write**  
  **Science notebook entry**  
  **Scientific practices**  
  **Benchmark Assessment**  
  **Investigations 8–9 I-Check** |                                                                                 |
| • Weather is the condition of the atmosphere at a specific time and location; climate is the average weather in a region over a long period of time. | **Science Notebook Entry**  
  **Answer the focus question**  
  **Greenhouse Gases in the Atmosphere**  
  **Headline Activity**  
  **Science Resources Book**  
  "Climates: Past, Present, and Future"  
  **Embedded Assessment**  
  **Science notebook entry**  
  **Scientific practices**  
  **Benchmark Assessment**  
  **Posttest** |                                                                                 |
WEATHER AND WATER — Overview

A FRAMEWORK FOR K–12 SCIENCE EDUCATION

The Weather and Water Course for grades 6–8 emphasizes the use of models and evidence to construct explanations for weather phenomena and climate based on earth and physical science properties. This course supports the following principles set forth in A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas (National Research Council, 2012).

Scientific and Engineering Practices
Develop students’ abilities to do and understand scientific practices.

- Asking questions (for science) and defining problems (for engineering).
- Developing and using models.
- Planning and carrying out investigations.
- Analyzing and interpreting data.
- Using mathematics and computational thinking.
- Constructing explanations (for science) and designing solutions (for engineering).
- Engaging in argument from evidence.
- Obtaining, evaluating, and communicating information.

Crosscutting Concepts
Develop students’ understandings of concepts that bridge disciplinary core ideas and provide an organizational framework for connecting knowledge from different disciplines into a coherent and scientifically based view of the world.

- Patterns. Observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them.
- Cause and effect: Mechanism and explanation. Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts.
- Scale, proportion, and quantity. In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system’s structure or performance.
• **Systems and system models.** Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering.

• **Energy and matter: Flows, cycles, and conservation.** Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems’ possibilities and limitations.

• **Stability and change.** For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of the system are critical elements of study.

**Earth and Space Sciences**

**Core Idea ESS1: Earth’s Place in the Universe**

• Earth’s spin axis is fixed in direction over the short term but tilted relative to its orbit around the Sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year. (ESS1.B)

**Core Idea ESS2: Earth’s Systems**

• Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation as well as downhill flows on land. The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns. Global movements of water and its changes in form are propelled by sunlight and gravity. Variations in density due to variations in temperature and salinity drive a global pattern of interconnected ocean currents. (ESS2.C)

• Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns. Because these patterns are so complex, weather can be predicted only probabilistically. The ocean exerts a major influence on weather and climate by absorbing energy from the Sun, releasing it over time, and globally redistributing it through ocean currents. Greenhouse gases in the atmosphere absorb and retain the energy radiated from land and ocean surfaces, thereby regulating Earth’s average surface temperature and keeping it habitable. (ESS2.D)

**Core Idea ESS3: Earth and Human Activity**

• Humans depend on Earth’s land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water,
and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. Renewable energy resources, and the technologies to exploit them, are being rapidly developed. (ESS3.A)

- Typically, as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise. (ESS3.C)

- Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth’s mean surface temperature (global warming). Reducing human vulnerability to whatever climate changes do occur depends on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior and on applying that knowledge wisely in decisions and activities. (ESS3.D)

**Physical Sciences**

**Core Idea PS1: Matter and Its Interactions**

- Gases and liquids are made of molecules or inert atoms that are moving about relative to each other. In a liquid, the molecules are constantly in contact with each other; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and vibrate in position but do not change relative locations. The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter. (PS1.A)

**Core Idea PS3: Energy**

- The term “heat” as used in everyday language refers both to thermal energy (the motion of atoms or molecules within a substance) and energy transfers by convection, conduction, and radiation (particularly infrared and light). In science, heat is used only for this second meaning: it refers to energy transferred when two objects or systems are at different temperatures. Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. (PS3.A)

- The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment. Energy is transferred out of hotter regions or objects and into colder ones by the processes of conduction, convection, and radiation. (PS3.B)
NEXT GENERATION SCIENCE STANDARDS

This course supports the following principles set forth in the Next Generation Science Standards (2013).

Earth and Space Sciences

- MS-ESS1-1. Develop and use a model of the Earth-Sun-Moon system to describe the cyclic patterns of lunar phases, eclipses of the Sun and Moon, and seasons.
- MS-ESS2-4. Develop a model to describe the cycling of water through Earth’s systems driven by energy from the Sun and the force of gravity.
- MS-ESS2-5. Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions.
- MS-ESS2-6. Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.
- MS-ESS3-2. Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.
- MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
- MS-ESS3-4. Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth’s systems.
- MS-ESS3-5. Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.

Physical Sciences

- MS-PS1-4. Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.
- MS-PS3-4. Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.
WEATHER AND WATER — Overview

FOSS CONCEPTUAL FRAMEWORK

FOSS has conceptual structure at the course level. The concepts are carefully selected and organized in a sequence that makes sense to students when presented as intended. In the last decade, research has been focused on learning progressions. The idea behind a learning progression is that core ideas in science are complex and wide-reaching—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 as educators 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 the learning progressions involves identifying successively more sophisticated ways of thinking about core ideas over multiple years. “If mastery of a core idea in science is the ultimate educational destination, learning progressions are the routes that can be taken to reach that destination” (National Research Council, A Framework for K–12 Science Education, 2012).

The FOSS modules (grades K–6) and courses (grades 6–8) are organized into three domains: physical science, earth science, and life science. Each domain is divided into two strands, which represent a core scientific idea, as shown in the columns in the table: matter/energy and change, dynamic atmosphere/rocks and landforms, structure and function/complex systems. The sequence of modules and courses 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.

In addition to the science content framework, every course provides opportunities for students to engage in and understand scientific practices, and many courses explore issues related to engineering practices and the use of natural resources.
The science content used to develop the FOSS courses describes \textit{what} we want students to learn; the science and engineering practices describe \textit{how} we want students to learn. Scientific inquiry involves a number of habits of mind and philosophical orientations, and these, too, will develop in richness and complexity as students advance through their science studies. Scientific inquiry is a behavior, so it can be assessed only while it is in progress. Thus, assessment of inquiry is based on teacher observation. The indicators of inquiry in progress include students involved in the many aspects of active thinking, students motivated to learn, and students taking responsibility for their own learning.

### FOSS K–8 Module Sequences

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<th>LIFE SCIENCE</th>
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<td><strong>MATTER</strong></td>
<td><strong>ENERGY AND CHANGE</strong></td>
<td><strong>ROCKS AND LANDFORMS</strong></td>
</tr>
<tr>
<td>Matter</td>
<td>Energy and Electromagnetism</td>
<td>Water</td>
</tr>
<tr>
<td>Chemical Interactions</td>
<td>Force and Motion</td>
<td>Weather on Earth</td>
</tr>
<tr>
<td>Mixtures and Solutions</td>
<td>Motion, Force, and Models</td>
<td>Weather on Earth</td>
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<tr>
<td>Measuring Matter</td>
<td>Energy and Electromagnetism</td>
<td>Water</td>
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<tr>
<td>Solids and Liquids</td>
<td>Balance and Motion</td>
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</tr>
<tr>
<td>K Materials in Our World</td>
<td>Trees and Weather</td>
<td>Animals Two by Two</td>
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</tbody>
</table>
WEATHER AND WATER IN MIDDLE SCHOOL

Viewed from space, the sphere called Earth might be considered a planet of oceans and clouds with just a hint of solid rock. From this perspective we can understand why a study of Earth’s physical environment is usually divided into three parts: the solid Earth, including the crust and upper mantle (lithosphere), the deep mantle, and the dense core; the gaseous atmosphere surrounding the planet; and the defining water component, the hydrosphere.

The solid portion of Earth, its crust or terra firma, provides the visible means of support for our structures—the schools, factories, skyscrapers, highways, reservoirs, swimming pools, amusement parks, and so on—in which and on which we spend our time. Solid is substantial. Solid is easy to understand.

Air is another story. We are not very conscious of the air we live in and breathe. Air provides a mostly invisible and more ethereal kind of support. Take a moment to turn your inner vision back to childhood and watch a jetliner take off. It seems like magic that such a massive thing can lift off and maintain itself in thin air. Paper airplanes skim through the air, kites hang on the wind, clouds hang seductively out of reach in the sky, and birds glide over rooftops. What’s holding them up? We are largely unaware of air. Air defines the sensory null condition—no taste, no smell, no sound, invisible, intangible. Given a gaily wrapped box of air, we might heft it, shake it, open it and peer in, give it a sniff, and proclaim that there is nothing inside. Wrong. The box is brim full . . . with air. We are conscious of air when it is windy. We can feel the force of air as it rushes by. Air becomes real and it becomes clear that it can do work as it lifts off your hat and carries it down the street. To students, that may not be air—that’s wind. These two things may need to be integrated conceptually.

Air provides the support for weather. Weather is physical conditions of the air and the interactions that take place in it. A study of Earth’s weather can’t happen without a closer look at the invisible layer of air called the atmosphere.

The hydrosphere is slippery, difficult to get a hold on, both conceptually and tangibly. The lithosphere is down here, the atmosphere is up there, but where is the hydrosphere? Part of it is easy to identify. Oceans, lakes, rivers, and swamps are clearly part of the hydrosphere because you can see masses of liquid water. But the hydrosphere also infiltrates both the lithosphere and the atmosphere. The invisible groundwater below and water vapor aloft are inextricably tied to the oceans, lakes, and
icecaps of the world. The dynamic nature of water on Earth is one of its charming and fascinating attributes. Water pokes its molecules into everybody’s business, and weather is no exception. To study weather is to understand the many characteristics of this marvelous substance.

**Is it weather or climate?** Weather is defined as the state of the atmosphere at a given time. A description of the weather includes observations and measurements of temperature, precipitation, air pressure, and cloud cover. Weather changes from day to day and season to season.

Climate differs from weather in that it is an aggregate of weather conditions over a long time. Climate helps describe a region. Climates change, but over years or centuries, not days.

A weather report gives you information about how to plan activities for today and tomorrow. A climatologist provides information about what kinds of crops to grow and when to plant them for the next 25 years.

Meteorologists and climatologists use many of the same tools to prepare weather and climate forecasts. But each has specialized instruments as well. Meteorologists use live satellite data and current local observations, using tools such as thermometers and barometers to forecast tomorrow’s weather. The climatologist accumulates seasonal and annual data for tens, hundreds, or even thousands of years. In addition to the meteorologist’s thermometers and barometers, climatologists use tree-ring growth, sediment cores, pollen preserved in amber, and air bubbles trapped in ice to produce climate models. Both meteorologists and climatologists depend on supercomputers to crunch their numbers, but the meteorologist works in terms of days, while the climatologist works with scales covering centuries.

**Weather as physics.** What makes weather? It all boils down to matter and energy. Matter is the stuff that makes up the universe. Energy is the ability to do work. Together, matter and energy are the basis for everything that exists and happens in the observable universe . . . including weather on Earth.

Heat is kinetic energy. Matter in motion has kinetic energy, and the kinetic energy of heat is the kinetic energy of atoms (and molecules). The higher the state of excitation in atoms, the more kinetic energy they possess, and the hotter the matter is. In short, heat is movement of atoms.

Temperature is a measure of the average kinetic energy of atoms in a material.Knowing the temperature of different substances can tell you which has more kinetic energy. This in turn lets you predict in which
direction energy will flow when two materials of different temperature are brought together. Heat (energy) always flows from warm to cold. The movement of energy from warm to cold is called energy transfer. What are the processes by which energy transfer occurs?

**Radiation.** Energy from the Sun travels through empty space as radiation. Electromagnetic radiation includes X-rays, ultraviolet and infrared rays, radio waves, and visible light. When an atom or molecule on Earth absorbs radiant energy, energy is transferred. This added energy causes the molecules to move more. The material heats up. Energy transfer by radiation happens at a distance. The energy source and energy receiver can be far apart.

**Conduction.** If there are no clouds, Earth’s surface receives a good dose of radiant energy, mostly in the infrared, visible, and ultraviolet wavelengths. Some of the radiation reflects back into space, but some is absorbed by (transferred to) molecules in Earth’s surface (rock, water, vegetation, etc.). Earth’s surface heats up.

Air molecules near Earth’s surface may come in contact with energized molecules in Earth’s surface. Energy can transfer to the air molecule. Transfer of energy from one molecule to another as a result of contact is called conduction. Conduction always involves transfer of energy between molecules that are in contact with each other.

**Convection.** When air comes in contact with a heated surface, like a concrete sidewalk, energy transfers to the air through conduction and radiation. Heat from the sidewalk transfers to the gas molecules. Kinetic energy of the molecules increases. Increased kinetic energy forces the molecules farther apart. The gas expands. This increases the volume of gas without increasing the number of molecules, so the gas becomes less dense.

The less dense (lighter) gas begins to rise. As it rises, the molecules cool, and the gas becomes more dense. The more dense air starts to sink. When it returns to the hot surface, it will heat up again, and the cycle will repeat. The rising of warm air and sinking of cool air is convection. Convection occurs only in fluids, that is, liquids and gases. Convection is usually considered the third way energy is transferred in the atmosphere. However, it might be described more accurately as energy transportation. The processes by which energy transfers from one molecule to another are radiation and conduction. Convection is the elevator that carries energized molecules up and low-energy molecules down.
**Density.** One property of matter is density. Density is defined as the ratio of a material’s mass to its volume. Written as an equation,

\[
\text{Density} = \frac{\text{Mass}}{\text{Volume}}
\]

All matter, whether in liquid, gaseous, or solid form, has density. Different gases have different densities. The density of gases can change. Heating a volume of gas decreases its density; cooling the gas increases its density. Increasing the pressure on a volume of gas pushes its molecules closer together, increasing its density. Decrease the pressure? The density decreases.

The density of atmospheric gases and the conditions that affect density will be investigated in considerable depth. Gas density is one of the pivotal concepts in the study and understanding of weather.

**Weather as chemistry.** Chemistry deals with the properties, composition, and structure of elements and compounds, how they change, and the energy that chemical reactions release or absorb. Physics and chemistry are intertwined in much of the study of the atmosphere.

Early Greek philosophers proposed that everything on Earth was made of four elements: fire, air, earth, and water. Galileo Galilei (1564–1642) was the first person to actually weigh air. He demonstrated that anything traveling through air meets resistance, or is pushed back.

It wasn’t until the 17th century that individual gases in air began to be identified. The first was carbon dioxide. It was discovered by a Belgian scientist, Jan Baptista van Helmont (1579–1644). He observed that the substance given off by burning charcoal was the same as that produced by the fermentation of grape juice. He called this gas *spiritus sylvestre*, which means “wild spirit.”

Chemical studies of the atmosphere today focus on changes in the atmosphere caused by human influence. The increase in greenhouse gases such as carbon dioxide, the effects of acid rain, and the problems of air pollution in general all involve chemical methods and study.

**Weather as earth science.** Earth materials, that is, water, water vapor and other atmospheric gases, rock, and soil, are the ingredients in the stew we call weather. Energy from the Sun might be considered the fire used to cook up Earth’s unique version of weather. These ideas bring us back to the domain of earth science.

Earth is a planet of contrasting weather—freezing cold at the poles, hot and humid around the equator, and variations on the theme in the latitudes between. The mechanics of Earth in its orbit around the Sun
cause wide variation in the amount of energy that reaches any given location over the course of a day or a year.

Earth’s axis of rotation is an imaginary axle that passes through both the North and South Poles. This axis tilts at an angle of 23.5° from the plane of Earth’s orbit around the Sun. And the most important bit of information is that the North Pole always points to the North Star. Always. No matter where Earth is in its orbit around the Sun, the North Pole always points to the North Star. The Sun's light spreads across the surface of the planet when it arrives, resulting in differing solar angles and, as a result, uneven heating. This effect is most noticeable to us if we consider the difference between hours of daylight and average temperature at locations on Earth at different latitudes, also known as seasons.

Another factor involved in weather is differential heating. Different earth materials heat to different temperatures with the same amount of radiation from the Sun. It takes five times as much heat to raise a mass of water by 1 degree as the same mass of granite. Water also retains heat longer than other earth materials. This differential heating produces wind.
Why Study the Weather?

The student’s case. It’s been heard so many times . . . the middle schooler’s mantra: “Why do I have to learn this? What does this have to do with my life?” Students ask these questions, not to be argumentative, but because they are awakening to a larger world and feeling the first sting of realization that soon they will have to make their way in it. “I’ll need a job, and I’m not going to be a meteorologist. I really don’t want to do this.”

These questions betray the fact that middle schoolers have acquired a more complex worldview. They have progressed from a life guided by concrete experiences and events in the present to a more worldly view interwoven with powerful abstractions, extending from past to future. Now the curriculum can advance a level to take advantage of the new abilities of students. Students are ready to start grappling with some of the abstractions presented by the study of weather and water, most importantly, an understanding of the particulate nature of matter and the way energy affects particles, laying the groundwork for their physics and chemistry classes in years to come.

As students progress through adolescence, they become more able to make inferences. Many probably still need concrete experiences, such as watching gas expand and contract, or changing states of water from solid to liquid to gas and back again, to provide the basis for more complex, inferential thinking. Concrete experiences can certainly be extended farther into abstraction at this age than in earlier years. Students will be able to start explaining phenomena they can experience, such as wind and rain, with properties and concepts they cannot actually observe, such as the particulate structure of matter.

Young adolescents are often fairly confident about what they do know. Confusion usually sets in when they are asked the question, “How do you know it?” Knowing something involves two parts—being able to state what you know and being able to defend your knowledge with evidence.

By understanding the process of knowing, students can begin to view the investigations and activities in the Weather and Water Course in a new way. The purpose for layering colored salt water in a straw is not just to look pretty, but to help explore the concept of density and the broader implications of density for weather on Earth.

Explaining how you know something is a lot harder than just knowing it. This metacognitive process—thinking about your thinking—is difficult. Students will stumble and resist in the beginning. But by the end of the course, students should be more confident in their ability to find and observe evidence and to use the evidence to come up with
inferences. And, if they stop to think about it, they will be impressed by how their thinking has changed. They will no longer look at a cloud in the sky in the same way.

**The teacher’s case.** Middle school teachers know that middle school students are in a universe of turmoil. Bodies, emotions, and social relationships are at odds. One day (or minute) they will be composed and ready to learn—actually quite mature—and the next they will be hopelessly distracted and sensitive. On the settled days students will engage in analytical problem solving, grappling effectively with abstractions. But on the squirrely days students will have better success with concrete experiences. Middle schoolers need both, and successful teachers know how to manage the balance of learning modalities to maximize student success.

The *Weather and Water Course* challenges students to consider the air that surrounds us all at all times, and to contemplate the invisible structure and properties of this substance that results in weather. To the perception of a middle school student (and many adults), the weather just happens, and there’s no real way to predict it.

But weather happens all the time, and every student has experienced a scary weather event—a powerful windstorm that knocked down a relative’s tree, a lightning bolt that hit a neighbor’s house, or a storm that took their town by surprise, knocking out power lines. When it occurs to students that these events are explicable, you will have piqued their interest in learning more about the physical science and earth science concepts in this course.

One of the main questions that will come up in this course is how to differentiate weather from climate. Further, students will begin to explore the science of and evidence for climate change. These students will be armed to participate in the ongoing discussions of our times: How bad will climate change be? How much of climate change is human-influenced? What can humans do to abate climate change? What are the consequences if nothing is done? These are heady questions for which the evidence is still mounting. Arming the next generation to actively engage in consequential scientific debate is one of the most profound impacts that science educators can have.
Can I Teach This? I’m Not a Meteorologist

FOSS assumes that teachers using this course possess no more than a minimal level of earth-science and physical-science content knowledge and a functional vocabulary of basic meteorology. Additional knowledge is an asset but is not a prerequisite for teaching the course effectively. The specific content dealt with in each investigation is discussed in the Scientific and Historical Background section of each chapter. Teachers may not have a thorough understanding of the material when they start the course, but they will have a pretty good understanding of the objects and principles at the end.

In the Weather and Water Course, students focus on the properties of air and how they explain the characteristics of the atmosphere. Students develop a particulate model of matter that explains how gases can be compressed and expanded. We then expand our study to fluids (liquids and gases) to explore more physical properties that can explain weather phenomena like wind. Energy transfer is critically important to understanding the mechanisms at play in the weather, so students develop comprehensive understanding of kinetic energy and energy transfer by convection, radiation, and conduction. Students then explore phase change to explain precipitation. With all these pieces in place, students are able to contemplate global weather patterns, changes to those patterns as indicated by climate change, and implications of those changes.

We have included reference materials in the kit that provide content update for teachers as well as students.

- *Wonders of Weather* (DVD)
- *Water Cycle* (poster)
- *Worldwide Weather* (poster)
- *Earth’s Atmosphere* (poster)
- *The First 30 km of the Atmosphere* (poster)

In addition to these resources, FOSSweb has extensive resources including animations, interactive simulations, videos, and links to recommended websites.
FOSS MIDDLE SCHOOL 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 course and how to teach the subject in a middle school classroom is presented here, along with the resources that will assist the effort. Each middle school Teacher Toolkit has three parts.

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

- Overview
- Materials
- Investigations (ten in this course)

Teacher Resources. This bound collection of resources contains these chapters.

- FOSS Middle School Introduction
- Assessment
- Science Notebooks in Middle School
- Science-Centered Language Development in Middle School
- FOSSweb and Technology
- Science Notebook Masters
- Teacher Masters
- Assessment Masters
- Notebook Answers

The chapters contained in Teacher Resources can also be found on FOSSweb as PDFs.

FOSS Science Resources. This is the student book of readings, images, and data that are integrated into the instruction.

Equipment Kit
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 five sequential uses (five periods in one day) before you need to restock. You will be asked to supply small quantities of common classroom items.
**FOSS Science Resources Books**

*FOSS Science Resources: Weather and Water* is a book of original readings developed to accompany this course, along with images and data to analyze during investigations. The readings are referred to as articles in the *Investigations Guide*. Students read the articles in the book as they progress through the course, sometimes during class and sometimes as homework. The articles cover a specific concept, usually after that concept has been introduced in an active investigation.

The articles in *FOSS Science Resources* and the discussion questions 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 course has an interactive site where students can find instructional activities, interactive simulations, virtual investigations, and other resources. FOSSweb provides resources for materials management, general teaching tools for FOSS, purchasing links, contact information for the FOSS Program, 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 *Teacher Resources* 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 courses 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.
FOSS INSTRUCTIONAL DESIGN

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

- Active investigation, including multimedia and 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

Courses are subdivided into investigations (eight to ten). Investigations are further subdivided into two to four parts. Each part of each investigation is driven by a focus question. The focus question, 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’ inquiry and makes the goal of each part explicit for teachers. Each part concludes with students preparing a written answer to the focus question in their notebooks.

Investigation-specific scientific and historical background information for the teacher is presented in each investigation chapter. The content discussion is divided into sections, each of which relates directly to one of the focus questions. This facilitates finding the exact information you need for each part of the investigation.

The Getting Ready and Guiding the Investigation sections have several features that are flagged or presented in the sidebar. 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 sidebar. An arrow points to the place in the lesson where the note applies. These notes constitute 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 is designed to help you understand the science content and pedagogical reasoning at work behind the instructional scene.
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 vocabulary icon indicates where students should record vocabulary in their science notebooks, often just before preparing for a benchmark assessment.

The recording icon points out where students should make a science notebook entry. Students can record on prepared notebook sheets or on plain sheets in a bound notebook.

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 reading icon signals when the class should read a specific article or refer to data in FOSS Science Resources. Some readings are critical to instruction and should take place in class. A reading guide is provided for each such reading.

The safety icon alerts you to a potential safety issue. It could relate to the use of a chemical substance, such as salt, requiring protective eyewear, or the possibility of an allergic reaction when students use latex or legumes.

The assessment icon appears when there is an opportunity to assess student progress or performance. The assessment methods are usually one of three kinds: observation of students engaged in scientific practices, review of a notebook entry, or review of students’ work on a prepared assessment tool.

The technology icon indicates when to have one or more computers available for accessing FOSSweb to use the multimedia resources. The multimedia is not optional.

The homework icon indicates science learning experiences that extend beyond the classroom. Some of the readings are suggested as homework. In that case, you will see two icons by that step.

The outdoor icon indicates science learning experiences that extend into the schoolyard.

To help with scheduling, 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, and 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 does pressure affect air? 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 the effect of solar energy on different materials. 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, they observe systems and interactions, and they 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.

Multimedia activities throughout the course provide students with opportunities to collect data, manipulate variables, and explore models and simulations beyond what can be done in the classroom. Seamless integration of the multimedia forms an integral part of students’ active investigations in FOSS.

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 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. They conclude the active investigation by writing a summary of their learning as well as questions raised during the activity in their notebooks.

**Science Notebooks**

Research and best practice have led us 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. And the student notebook entries stand as a credible and useful expression of learning. The artifacts in the notebooks form one of the core elements of the assessment system.

You will find the duplication masters for middle school presented in a notebook format. They are reduced in size (two copies to a standard sheet) for placement (glue or tape) in a bound composition book. Student work is entered partly in spaces provided on the notebook sheets and partly on adjacent blank sheets. Full-size masters that can be filled in electronically and are suitable for projection are available on FOSSweb.
Reading in Science Resources

Reading is a vital component of the FOSS Program. Reading enhances and extends information and concepts acquired through direct experience.

Readings are included in the FOSS Science Resources: Weather and Water book. Students read articles on weather phenomena, composition of the atmosphere, air pressure, density, energy transfer, wind, ocean currents, and climate, as well as historical and biographical material.

Some readings can be assigned as homework or extension activities, whereas other readings have been deemed important for all students to complete with a teacher’s support in class.

Each in-class reading has a reading guide embedded in Guiding the Investigation. The reading guide suggests breakpoints with questions to help students connect the reading to their experiences from class, and recommends notebook entries. Additionally, each of these readings includes one or more prompts that ask students to make additional notebook entries. These prompts should help students who missed the in-class reading to process the article in a more meaningful way. Some of the most essential articles are provided as notebook masters. Students can highlight the article as they read, add notes or questions, and add the article to their science notebooks.

Assessing Progress

The FOSS assessment system includes both formative and summative assessments. Formative assessment monitors learning during 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 one or two investigations. These I-Checks are actually hybrid tools: they provide summative information about students’ achievement, and because they occur soon after teaching an 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.

For more information on scaffolding literacy in FOSS, see the Science-Centered Language Development in Middle School chapter in Teacher Resources.
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.

### 17. Assess progress: response sheet

Give students *Response Sheet—Investigation 3* to assess their understanding of atmospheric pressure. Give students 10 minutes to work on their responses.

Collect the sheets and use a sample to consider students’ thinking.

**What to Look For**

- **Students correct the student in the story by explaining that the bottle was not squashed, but it changed shape due to air pressure.**
- **Students cite evidence that the bottle was not squashed by the hissing noise that indicates air entering the bottle to restore equilibrium.**
- **Students explain that the bottle appeared squashed because the air trapped at high elevation was at lower density (or air pressure), so when the air was transported to a lower elevation, it was being compressed by the surrounding air, which was at a higher density (or air pressure).**

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 at the beginning of the course (survey), at the end of the course (posttest), and after one or two investigations (I-Checks). The benchmark tools are carefully crafted and thoroughly tested assessments.
The assessment items do not simply identify whether a student knows a piece of science content. They also 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 formative as well as summative assessment.

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.

**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 in Middle School chapter in *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-arts 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. Science provides a real and engaging context for developing literacy, and language-arts skills and strategies support conceptual development and scientific practices. 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.

The chapter describes how literacy strategies are integrated purposefully into the FOSS investigations, and gives suggestions for additional literacy strategies. The Science-Centered Language Development in Middle School chapter is a library of resources and strategies for you to use.
MANAGEMENT STRATEGIES

FOSS has tried to anticipate the most likely learning environments in which science will be taught and designed the curriculum to be effective in those settings. The most common setting is the 1-hour period (45–55 minutes) every day, one teacher, in the science room. Students come in wave after wave, and they all learn the same thing. Some teachers may have two preps because they teach seventh-grade and eighth-grade classes. The Weather and Water Course was designed to work effectively in this traditional hour-a-day format.

The 1-hour subdivisions of the course adapt nicely to the block-scheduling model. It is usually possible to conduct two of the 1-hour sessions in a 90-minute block because of the uninterrupted instructional period. A block allows students to set up an experiment and collect, organize, and process the data all in one sequence. Block scheduling is great for FOSS; students learn more, and teachers are responsible for fewer preps.

Interdisciplinary teams of teachers provide even more learning opportunities. Students will be using mathematics frequently and in complex ways to extract meaning from their inquiries. It has been our experience, however, that middle school students are not skilled at applying mathematics in science because they have had few opportunities to use these skills in context. In an interdisciplinary team, the math teacher can use student-generated data to teach and enhance math skills and application.

The integration of other subject areas, such as language arts, into the science curriculum is also enhanced when interdisciplinary teams are used.

Managing Time

Time is a precious commodity. It must be managed wisely in order to realize the full potential of your FOSS curriculum. The right amount of time should be allocated for preparation, instruction, discussion, assessment, research, and current events. Start from the premise that there will not be enough time to do everything, so you will have to budget selectively. Don’t scrimp on the prep time, particularly the first time you use the curriculum. Spend enough time with the Investigations Guide to become completely familiar with the lesson plans. Take extra time at the start of the course to set up your space efficiently; you will be repaid many times over later. As you become more familiar with the FOSS Program and the handling of the materials, the proportion of time devoted to each aspect of the program may shift, so that you are spending more and more time on instruction and enrichment activities.
Effective use of time during the instructional period is one of the keys to a great experience with this course. The *Investigations Guide* offers suggestions for keeping the activities moving along at a good pace, but our proposed timing will rarely exactly match yours. The best way we know for getting in stride with the curriculum is to start teaching it. Soon you will be able to judge where to break an activity or push in a little enrichment to fill your instructional period.

**Managing Space**

The *Weather and Water Course* will work in the ideal setting: flat-topped tables where students work with materials in groups of four; theater seating for viewing multimedia (darkened); eight computers networked and linked to the Internet along the far wall; and a library at the back. But we don’t expect many teachers to have the privilege of working in such a space. So we designed FOSS courses to work effectively in a number of typical settings, including the science lab and regular classroom. We have described, however, the minimum space and resources needed to use FOSS. Here’s the list, in order of importance.

- A computer with Internet access, and a large-screen display monitor or projector.
- Flat tables or desks appropriate for students to work in groups of four.
- Standard metric measuring tools and classroom supplies, including an electronic balance.
- A whiteboard, blackboard, overhead, or chart paper and marking pens.
- A surface for materials distribution.
- A place to clean and organize equipment.
- A place to store safety goggles that students can get to easily.
- A convenient place to store the kit.
- A computer lab or multiple computers.

Once the minimum resources are at hand, take a little time to set up your science area. This investment will pay handsome dividends later since everyone will be familiar with the learning setup.

- Organize your computer and make sure the multimedia is running smoothly.
- Position your LCD and/or overhead projector(s) where everyone can see comfortably.
Management Strategies

- Think about the best organization of furniture. This may change from investigation to investigation.
- Plan where to set up your materials stations.
- Know how students will keep notes and record data, and plan where students will keep their notebooks.

Managing Students

A typical class of middle school students is a wonderfully complex collection of personalities, including the clown, the athlete, the fashion statement, the worrier, the achiever, the pencil sharpener, the show-off, the reader, and the question-answerer. Notice there is no mention of the astrophysicist, but she could be in there, too. Management requires delicate coordination and flexibility—some days students take their places in an orderly fashion and sit up straight in their chairs, fully prepared to learn. Later in the week, they are just as likely to have the appearance of migrating waterfowl, unable to find their place, talkative, and constantly moving.

FOSS employs a number of strategies for managing students. Often a warm-up activity is a suitable transition from lunch or the excitement of changing rooms to the focused intellectual activities of the Weather and Water Course. Warm-ups tend to be individual exercises that review what transpired yesterday with a segue to the next development in the curriculum. This gives students time to get out their notebooks, grind points on their pencils, settle into their space, and focus.

Students most often work in groups in this course. Groups of four are generally used, but at other times, students work in pairs.

Suggestions for guiding students’ work in collaborative groups are described later in this chapter.

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 and share the science notebook entries made for that day. The science notebooks should be a valuable tool for students to share in order to catch up on missed classes.

Allow the student to bring home FOSS Science Resources to read with a family member. Each article has a few review items that the student can respond to verbally or in writing.

And finally, encourage the student to use the resources on FOSSweb at school or at home for the missed class.
Managing Technology

The Weather and Water Course includes a multimedia component. The multimedia is not optional. For this reason, it is essential that you have in your classroom at minimum one computer, a large-screen display monitor or projection system, and a connection to the Internet. Sometimes you will use multimedia to make presentations to the entire class. Sometimes small groups or individuals will use the multimedia program to work simulations and representations.

The important attribute of the multimedia component is that it is interactive. Students can manipulate variables to see what happens. They can ask the important question What would happen if . . . , and then find out, using the multimedia simulations.

Option 1: the computer lab. If you have access to a lab where all students can work simultaneously as individuals, pairs, or small groups, schedule time in the lab for your classes. Plan on a session in the computer lab for Investigation 2.

Option 2: classroom computers. With four to eight computers in the science classroom, you can set up a multitasking environment with half the students working on the multimedia and half engaged in reading or small-group discussions. Then swap roles. This could take one or two periods, depending on the activity.

Option 3: learning centers. If you have access to only one computer system, plan to use it with the whole class with a projection system for large-group viewing, followed by opportunities for small groups of students to explore the simulations. Try to organize your classroom for several activities, one of which will be a computer station.

Option 4: home access. Students can access FOSSweb from home by visiting www.FOSSweb.com and accessing the class pages with the account information you provide for student use.
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 continues 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 learning English are incorporated into the materials and procedures 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.

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 the vocabulary more explicit through new concrete experiences or through reading to the 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. And for some students, it might be more opportunities for experiencing science outside of 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 course. 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. Opportunities to extend the investigation are listed at the end of each investigation. Use these ideas to meet the individual needs and interests of your students.
WORKING IN COLLABORATIVE GROUPS

Collaboration is important in science. Scientists usually collaborate on research enterprises. Groups of researchers often contribute to the collection of data, the analysis of findings, and the preparation of the results for publication.

Collaboration is expected in the science classroom, too. Some tasks call for everyone to have the same experience, either taking turns or doing the same things simultaneously. At other times, group members may have different experiences that they later bring together.

Research has shown that students learn better and are more successful when they collaborate. Working together promotes student interest, participation, learning, and self-confidence. FOSS investigations use collaborative groups extensively.

No single model for collaborative learning is promoted by FOSS. We can suggest, however, a few general guidelines that have proven successful over the years.

For most activities in middle school, collaborative groups of four in which students take turns assuming specific responsibilities work best. Groups can be identified completely randomly (first four names drawn from a hat constitute group 1), or you can assemble groups to ensure diversity. Thoughtfully constituted groups tend to work better.

Groups can be maintained for extended periods of time, or they can be reconfigured more frequently. Five to eight weeks seems about optimum, so students might work in two groups throughout an entire course.

Functional roles within groups can be determined by the members themselves, or they can be assigned in one of several ways. Each member in a collaborative group can be assigned a number or a color. Then you need only announce which color or number will perform a certain task for the group at a certain time. Compass points can also be used: the person seated on the east side of the table will be the Reporter for this investigation.

The functional roles used in the investigations follow. If you already use other names for functional roles in your class, use those in place of these in the investigations.

**Getters** are responsible for materials. One person from each group gets equipment from the materials station, and another person later returns the equipment.
One person is the **Starter** for each task. This person makes sure that everyone gets a turn and that everyone has an opportunity to contribute ideas to the investigation.

The **Recorder** collects data as it happens and makes sure that everyone has recorded information on his or her science notebook sheets.

The **Reporter** shares group data with the class or transcribes it to the board or class chart.

Getting started with collaborative groups requires patience, but the rewards are great. Once collaborative groups are in place, you will be able to engage students more in meaningful conversations about science content. You are free to “cruise” the groups, to observe and listen to students as they work, and to interact with individuals and small groups as needed.
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 that you do is consistent with those guidelines. Two posters are included in the kit, Science Safety and Outdoor Safety, for classroom use.

Look for the safety icon in the Getting Ready and Guiding the Investigation sections, which will alert you to safety considerations throughout the course.

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. to 6 p.m. EST).

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

1. Always follow the safety procedures outlined by your teacher. Follow directions, and ask questions if you’re unsure of what to do.
2. Never put any material in your mouth. Do not taste any material or chemical unless your teacher specifically tells you to do so.
3. Do not smell any unknown material. If your teacher tells you to smell a material, wave a hand over it to bring the scent toward your nose.
4. Avoid touching your face, mouth, ears, eyes, or nose while working with chemicals, plants, or animals. Tell your teacher if you have any allergies.
5. Always wash your hands with soap and warm water immediately after using chemicals (including common chemicals, such as salt and dyes) and handling natural materials or organisms.
6. Do not mix unknown chemicals just to see what might happen.
7. Always wear safety goggles when working with liquids, chemicals, and sharp or pointed tools. Tell your teacher if you wear contact lenses.
8. Clean up spills immediately. Report all spills, accidents, and injuries to your teacher.
9. Treat animals with respect, caution, and consideration.
10. Never use the mirror of a microscope to reflect direct sunlight. The bright light can cause permanent eye damage.
## FOSS K–8 SCOPE AND SEQUENCE

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